Ground Water Supply Protection and Management Plan for the Eastern Shore of Virginia

May 5, 1992

Prepared For:

Eastern Shore of Virginia
Ground Water Study Committee
Accomac, Virginia 23301

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EASTERN SHORE OF VIRGINIA GROUND WATER STUDY COMMITTEE

GROUND WATER SUPPLY PROTECTION AND MANAGEMENT PLAN FOR THE EASTERN SHORE OF VIRGINIA

RESOLUTION OF ADOPTION

BE IT RESOLVED that the **Ground Water Supply Protection and Management Plan for the Eastern Shore of Virginia** is hereby adopted by the Eastern Shore of Virginia Ground Water Study Committee.

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Duly adopted by the Eastern Shore of Virginia Ground Water Study Committee on May 5, 1992.

Certification: C. D. Fleming Jr.
C.D. Fleming Jr., Chairman
Eastern Shore of Virginia
Ground Water Study Committee

State of Virginia
County of Accomack

The foregoing instrument was acknowledged before me on this 5th day of May, 1992, by C.D. Fleming, Jr., Chairman of the Eastern Shore of Virginia Ground Water Study Committee.

Wanda Taylor
Notary Public

My Commission expires: 7-31-95

ACKNOWLEDGEMENTS

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SECTION 1: INTRODUCTION

OVERVIEW

Ground water resource protection and management on the Eastern Shore of Virginia (see Figure 1-1 for locus map) requires the involvement and cooperation of many levels of government as well as a commitment from the private sector. The private sector plays an important role because ground water withdrawals for operations such as industrial processing and agricultural irrigation greatly exceed public water supply needs. If development progresses in the Counties of Accomack and Northampton, however, the ratio of public to private water use is expected to rise.

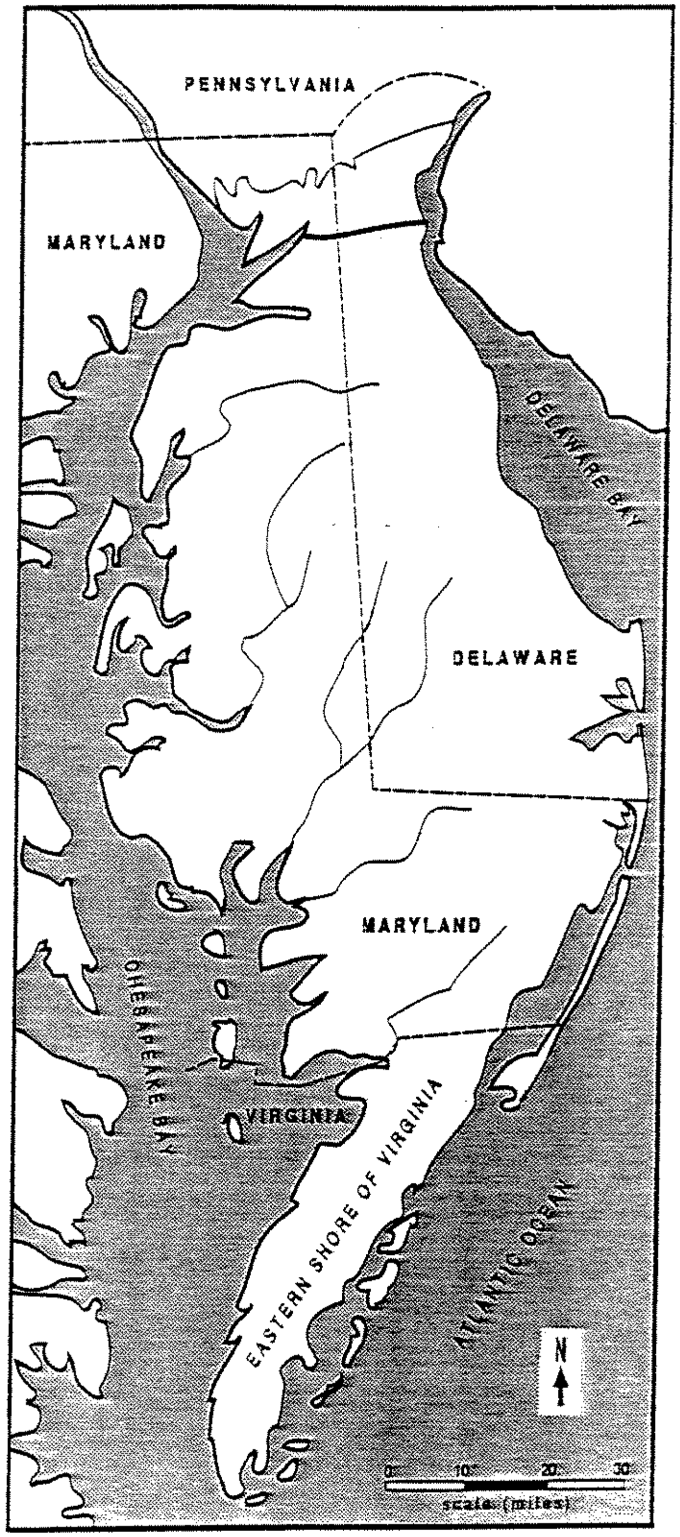
The majority of ground water is withdrawn from deeper confined aquifers found on the Eastern Shore. The water quality in these aquifers is generally very good. Ground water in the unconfined, shallow aquifer is of poorer quality than that found in deeper aquifers, and is used primarily for individual private wells and for irrigation. Septic systems, agriculture, and commercial and industrial development have all been identified as potential sources contributing contaminants to the shallow aquifer, primarily in the form of nitrogen. The current low density of development found on the Eastern Shore allows for the establishment of land use controls and cooperative efforts to protect water quality by private and public institutions.

A major concern on the Eastern Shore is overpumping of water from the deeper confined aquifers. Although the volume of water stored in the aquifers and the recharge that infiltrates naturally over the land surface has been calculated within a range of uncertainty of a factor of two to support the current rates of water withdrawal, for the Eastern Shore as a whole, further salt water intrusion may occur. In fact, Virginia State Water Control Board data from selected test wells indicate decreases in water levels and increases in salinity adjacent to the largest industrial withdrawal wells. Moreover, if the existing facilities increase their pumping rates to the maximum volumes allowed in their permits, several areas of the Eastern Shore are predicted to experience increasing problems of well interference, salt water intrusion, and a deterioration of water quality.

Several management scenarios are available to ensure that there is adequate water in the future to meet anticipated demands and to protect both the shallow and deep aquifer systems from a deterioration in water quality.

This study summarizes available information on water withdrawals, land use threats, and current control mechanisms on the Eastern Shore. Recommendations are proposed to develop a comprehensive ground water protection and supply management plan which will maintain an adequate supply of water and sustain high water quality for the future needs of the region.

Figure 1-1: Locus Map of the Eastern Shore of Virginia



EXECUTIVE SUMMARY

The Eastern Shore of Virginia is an 80 mile long peninsula that comprises about 696 square miles of area, located at the southern tip of the Delmarva Peninsula and within the Eastern Coastal Plain Province. The Eastern Shore is bounded on all sides by water, except to the north which is bordered by the Maryland mainland. The Atlantic Ocean is to the east and the Chesapeake Bay to the west and south.

Ground water is the only source of supply for domestic, industrial, and agricultural water use. A total population of approximately 47,000 use this ground water. Most of the production wells are set to draw water at various levels in the semi-confined aquifer (called the Yorktown-Eastover) found at about 300 feet below mean sea level. The water table aquifer (called the Columbia) is used extensively for agricultural irrigation and private wells.

Accomack and Northampton Counties are the administrative units that govern the Eastern Shore and control all land use activities in conjunction with nineteen small towns. The Accomack-Northampton Planning District Commission has commissioned the development of a Ground Water Management and Supply Protection Plan that will provide a comprehensive and practical series of options, alternatives and specific actions to promote compatibility between the Eastern Shore's water resources and the counties land use plans.

In 1976 the Virginia State Water Control Board designated the Eastern Shore of Virginia a "Ground Water Management Area". The Eastern Shore was the second area in Virginia to be declared a ground water management area. This declaration was based on the findings that:

- Ground water level declines have been observed in two sections of Accomack County;
- Interference between wells has been observed in the same two sections of Accomack County;
- Some evidence of localized ground water contamination has been observed in the water table aquifer of Accomack County but not in the confined aquifers;
- Even though the ground water supplies in Accomack County are not overdrawn and are not expected to be in the near future, it should be recognized that they may overdraw in some areas in the future if water withdrawals are not distributed throughout the region. Further, saltwater intrusion has not been observed to date but may occur in the future if heavy ground water withdrawals are concentrated in any one area.

The major impact of the Ground Water Management Area designation is that all water users that withdraw in excess of 10,000 gallons per day (gpd) are subject to a state permit process. Ten major existing industrial and municipal withdrawals became grandfathered and did not have to submit extensive permit applications. Currently, there are no regulations controlling agricultural water use, except for the reporting of water use on an annual basis.

The aquifers on the Eastern Shore are strongly influenced by the lithology. Annual precipitation of 42 inches per year provides the recharge to the aquifers. The upper aquifer, called the Columbia Aquifer, is unconfined, and is roughly 80 to 100 feet thick. This aquifer is used primarily for private on-site domestic wells, and agricultural irrigation. Approximately 2 million gallons per day are withdrawn by private on-site wells for domestic use. Some portion of the 8.7 million gallons per day withdrawn for irrigation comes from the Columbia aquifer.

Anywhere from 12 - 24 inches per year of precipitation recharges the Columbia aquifer on the Eastern Shore of Virginia. At an average recharge rate of 17 inches per year, approximately 324 million gallons per day recharge the Columbia aquifer. Most of this water flows from the middle of the peninsula and discharges to the Chesapeake Bay and the Atlantic Ocean. A small percentage contributes to the recharge of the deeper confined aquifer.

Water quality in the Columbia aquifer is threatened by the many land uses that discharge, leach or dispose of contaminants to the ground water. Nitrate-nitrogen is the primary contaminant of concern to the Columbia aquifer. Sources include: septic systems; agricultural fertilizers; manure storage and animal disposal; septage lagoons; and landfills. In addition, pesticides and underground storage tanks are also threats. The average nitrogen concentration in the ground water was calculated to be 2.0 milligrams per liter. The national drinking water standard for nitrogen is 10 milligrams per liter. On average, the shallow ground water quality is considered very good however, those areas located down gradient from major nitrogen users or disposers will experience much higher nitrogen concentrations.

The next water bearing zone is the Yorktown-Eastover Formation, a confined aquifer consisting of coarse shelly sands found in three layers separated by clay confining units. This aquifer can range in depth from 80 to 800 below the land surface, though most wells are pumping from layers between 150 and 300 feet deep. The clay confining layers that separate the Columbia aquifer from the Yorktown-Eastover serve to protect the aquifer from many of the water quality threats. They also act to impede the amount and rate of recharge to the aquifer. It is estimated that only 1.2 inches of precipitation recharge the Yorktown-Eastover aquifer. Based upon the ground water modelling studies conducted, approximately 11 million gallons per day is recharge to the Yorktown-Eastover. However, it should be noted that this recharge value is based on average conditions across the entire Eastern Shore, and depending upon specific site conditions can vary by a factor of two in either direction. Additional study is necessary to better define the recharge rate to the Yorktown-Eastover aquifer.

Industrial withdrawals and public water supply wells are exclusively screened in the Yorktown-Eastover aquifer, while wells used for agriculture and private household use are withdraw from the upper aquifer. Currently 4.5 million gallons per day are withdrawn from this aquifer for industrial use and public water supply, Permits from the Virginia State Water Control Board would allow withdrawals of up to 15.6 million gallon per day from this aquifer. If this were to occur, problems of well interferences and salt water intrusion, already observed near the largest industrial water users, will be greatly enhanced.

Local planning and elected officials on the Eastern Shore have been concerned for a number of years about the quality and availability of ground water. The State Water Control Board of Virginia has conducted several studies and developed a network of ground water monitoring wells on the Eastern Shore to document problems. In addition, through cooperative studies, the U.S. Geological Survey has developed reports and modelled the hydrogeology. The results of these investigations all agree that the major issues are:

- Agriculture, water quality and quantity;
- Animal wastes;
- Development impacts, septic systems, underground tanks;
- Well interference, industrial and public water supply wells,
- Salt water intrusion;
- Adequate water supply, future demands, all uses.

Each of these activities/concerns have an impact on water use and quality for either the upper aquifer, the lower aquifer or both.

A land use buildout study was conducted to assess the maximum potential for development within the spine recharge area. The findings show that under current zoning, the number of single-family dwelling units that could potentially be developed within the spine recharge area is greater than the total number of existing units county-wide. This has serious implications for future wastewater disposal,water supply and agricultural use. Buildout conditions were modelled for impacts on ground water quality due to nitrogen contamination. The area with the most likely impacts will be in WPA (B) in the vicinity of Holly Farms (Tysons Foods).

The Ground Water Supply Protection and Management Plan For the Eastern Shore of Virginia provides a review of each of these threats including land use impacts under future buildout conditions. In addition, the recharge areas to the major pumping wells have been delineated. An aquifer recharge zone was mapped based upon hydrogeologic information that suggests that the source of recharge to the confined aquifer is located along the spine of the peninsula.

Based upon the analyses conducted and the review of existing information, the study proposes the following actions:

Recommendations for Water Quality Protection

- Pursue water conservation measures with major industrial users.
- Create an overlay protection zoning district to protect the spine recharge area to the Yorktown-Eastover aquifer;
- Restrict the siting of new mass drainfields in the spine recharge area;
- Review and revise county zoning and subdivision regulations;
- Require the registration of currently unregulated underground storage tanks;
- Incorporate ground water protection requirements into site plan review;
- Develop a private well ordinance to control the siting and construction of new wells;
- Support the implementation of agricultural nutrient management plans;
- Implement the provisions of the Chesapeake Bay Program.

Recommendations for Water Quantity Management

- Revise State Ground Water Act and Regulations to allow for reevaluation of existing permits;
- Develop an Eastern Shore Water Management District to manage water withdrawals;
- Control the siting and development of new water supply wells to prevent well interference and reduce the threat of salt water intrusion;
- Continue the accurate reporting of agricultural water withdrawals, by well location and depth.
- Continue the consideration of mandatory permitting of agricultural withdrawals after review of reporting data.
- Protect open space and undeveloped land in the spine recharge area.

General Recommendations

- Implement a land use/water quality data base;
- Develop a public education program on ground water.

Continued Research and Investigation

- Investigate the nature of recharge to the Yorktown-Eastover aquifer;
- Research dilute salt water issues;
- Conduct additional hydrogeologic studies to better define the geology;
- Evaluate pesticide use on the Eastern Shore;

• Support additional agricultural nutrient management research;
• Revise the nitrogen model used in the study over time.

The Eastern Shore of Virginia is situated over a very valuable ground water resource that is the sole source of water supply to the inhabitants and is also necessary for both industrial and agricultural use. Protection of the water quality and quantity will require the implementation of many actions designed to maintain water quality, prevent against over use of the aquifer and provide for the future needs to accommodate growth on the Eastern Shore.

PURPOSE OF PROJECT

This project prepared by Horsley Witten Hegemann, Inc. (HWH), was guided and funded by the Eastern Shore of Virginia Ground Water Study Committee. The committee was formed for the purpose of assisting local governments and residents of the Eastern Shore to understand, protect and manage their ground water resources. In addition to serving as an informational and educational resource, the Committee initiates special studies concerning the protection and management of the Eastern Shore. This Ground Water Resources Protection and Management Plan is one of several ways in which the Committee intends to carry out its goals.

The Committee consists of 2 members from each county's Board of Supervisors, one citizen appointee by each Board of Supervisors, the County Administrator from each county, and the Executive Director of the Accomack-Northampton Planning District Commission.

This report responds to three aspects of the Committee's purpose:

1. The report provides management information by identifying the quantity of ground water available for use, and explaining the potential for de-watering of the ground water aquifers, salt water intrusion, and contamination.

2. The report provides recommendations regarding ground water quality protection; identification and protection of ground water recharge areas; nitrate-nitrogen loading to the water table; land application of pesticides; and hazardous material storage.

3. The report, combined with public forums, maps, and background information on the hydrogeologic cycle and ground water conditions on the Eastern Shore, advises the public as to their role in protecting ground water and identification of threats to water quality and quantity.

An additional goal of this project is to improve coordination among those municipalities, state and local governments, and private sectors responsible for the protection, management, and research regarding the Eastern Shore ground water supply.

WATER RESOURCES ON THE EASTERN SHORE OF VIRGINIA

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SECTION 2: WATER RESOURCES ON THE EASTERN SHORE

Ground water is the only source of drinking water on the Eastern Shore, and is therefore considered the most important water resource. However, an understanding of the water system as a whole is necessary to understand future land use and development decisions designed to protect water supplies. This section provides an overview of the water resources on the Eastern Shore of Virginia. Soil types and the geology which influence water quality and quantity are also discussed.

TOPOGRAPHY AND SOILS

Accomack and Northampton Counties lie in the Coastal Plain Province of Virginia. The soils of the two counties are predominantly comprised of sand, clay, and shell fragments, deposited during the Miocene Era (Fennema and Newton, 1982). The resulting land is one of the most productive in the entire Atlantic Coastal Plain.

The region is generally flat, with a central plateau. Maximum elevation of the plateau is 45 feet above mean sea level, and the slope rarely exceeds two percent. From the central northeast-southwest trending divide, the land gradually slopes toward the Chesapeake Bay and Atlantic Ocean shorelines.

Soil characteristics greatly influence the activities which may take place on the land above them, and thus play a significant role in planning and development. For example, layout and grading of roadways, excavations for foundations of new buildings, and the operation of septic tanks are all affected by soil suitability. Factors such as permeability, depth, natural fertility, and drainage are important when considering agricultural potential and future development sites. Soil drainage is particularly important on the Eastern Shore where the primary method of disposing domestic waste water is by septic systems. If the soil is not suited for wastewater disposal, waste water must be transported to an area of suitable soil, or else be treated in a central treatment facility.

According to the Soil Survey of Northampton County (Soil Conservation Service,1989 and 1990) and the Accomack County Comprehensive Plan (1989), there are five major soil associations on the Eastern Shore of Virginia. A soil association is an area of land made up of two or more geographically associated soils which occur in a similar pattern. The following paragraphs summarize the Soil Conservation Service's characteristics of these soil associations:

Bojac-Munden-Molena
This association makes up 48% of the two counties. It is nearly level to steep, moderately well drained to somewhat excessively drained, loamy and sandy soils; on broad flats, side slopes, and escarpments. Of the five associations, this one is the best for development. However, there are some development limitations due to erosion, wetness, and shallowness of sorts. Munden soil, in particular, is considered excellent for development. Septic tank suitability is moderate, generally limited by poor drainage.

Nimmo-Munden-Dragston
Covering 15% of the two counties, this association is nearly level, moderately well drained to poorly drained, consisting of loamy soils found on broad flats and depressions. The association is not always suitable for development. Septic tank suitability is severe due to a seasonal high water table and poor drainage.

Chincoteague-Magotha
Covering 28% of the two counties, this association is nearly level, very poorly drained to poorly drained, silty and loamy soils, found in tidal marshes. Not suitable for development, the soils are best utilized as wetland wildlife habitat and as spawning grounds for shellfish and finfish. This association is frequently flooded, has a moderate natural fertility, and is well suited for salt-tolerant plants.

Nimmo-Arapahoe
Located in the northwest portion of Accomack County only, this association covers 5% of the two counties. It is level, poorly drained, and suitable for development and agriculture if properly drained. The Soil Conservation Service on the Eastern Shore, however, considers the area where these soils lie to be undevelopable.

Fisherman-Beaches-Camocca
Covering 4% of the two counties, this association is nearly level to steep, moderately well drained and poorly drained, sandy soils and beaches, found on flats and low dunes and depressions. Because of the location in wetland resource areas, the soil association is not suitable for development.

Figure 2-1 displays the locations of these soils.

The soil types located on the mainland of the peninsula (except Nimmo-Arapahoe) are categorized as prime farmland. This category constitutes 68% of the land in the counties of Northampton and Accomack. Water bearing capacity of these soils is moderate, and the natural fertility is low. Typically these soils are acidic. They are well suited to cultivated crops, soybeans, small grains, vegetables, and ornamentals (SCS, 1989).

In general, the two counties contain soils that are less than ideal for proper septic system functioning, generally due to a seasonal high water table. The Accomack County Comprehensive Plan maintains that the Bojac-Munden-Molena soil associations are well drained and suitable for development and agricultural lands. These soil types constitute 44% of Northampton County's land, and 52% of Accomack County, and thus are the most prevalent soils. It should be noted that the entire town of Chincoteague, Accomack County's most developed magisterial district, is underlain by the Fisherman-Beaches-Camocca formation, which is described as unsuitable for development because of poor drainage and susceptibility to a seasonal high water table, flooding, and instability (SCS, 1989). Chincoteague receives its water from several wells on the mainland near the NASA Wallops facility, and so does not need to be as concerned about ground water contamination problems within the town. However, any residents using private wells should be wary of the quality of their water, given the number of septic systems in this poorly suited soil.

SURFACE WATER

Surface water includes ponds, streams, creeks, bays, and lagoons. The Eastern Shore is unique compared to mainland Virginia in that there are no major streams or other surface water supplies which can serve as a source of drinking water. This point underscores the importance of protecting the ground water supply, because alternative sources for drinking water do not exist. Surface water systems are, however, interconnected with ground water. The water table on the Eastern Shore of Virginia is shallow, and surface water and ground water play an important interactive role.

Although not used for drinking water, surface water systems are important for shellfish, finfish, and other wildlife on the Eastern Shore. These animals benefit the general economy of the area: the finfish industry grossed over one million dollars in 1986, and the sale of shellfish in 1986 was

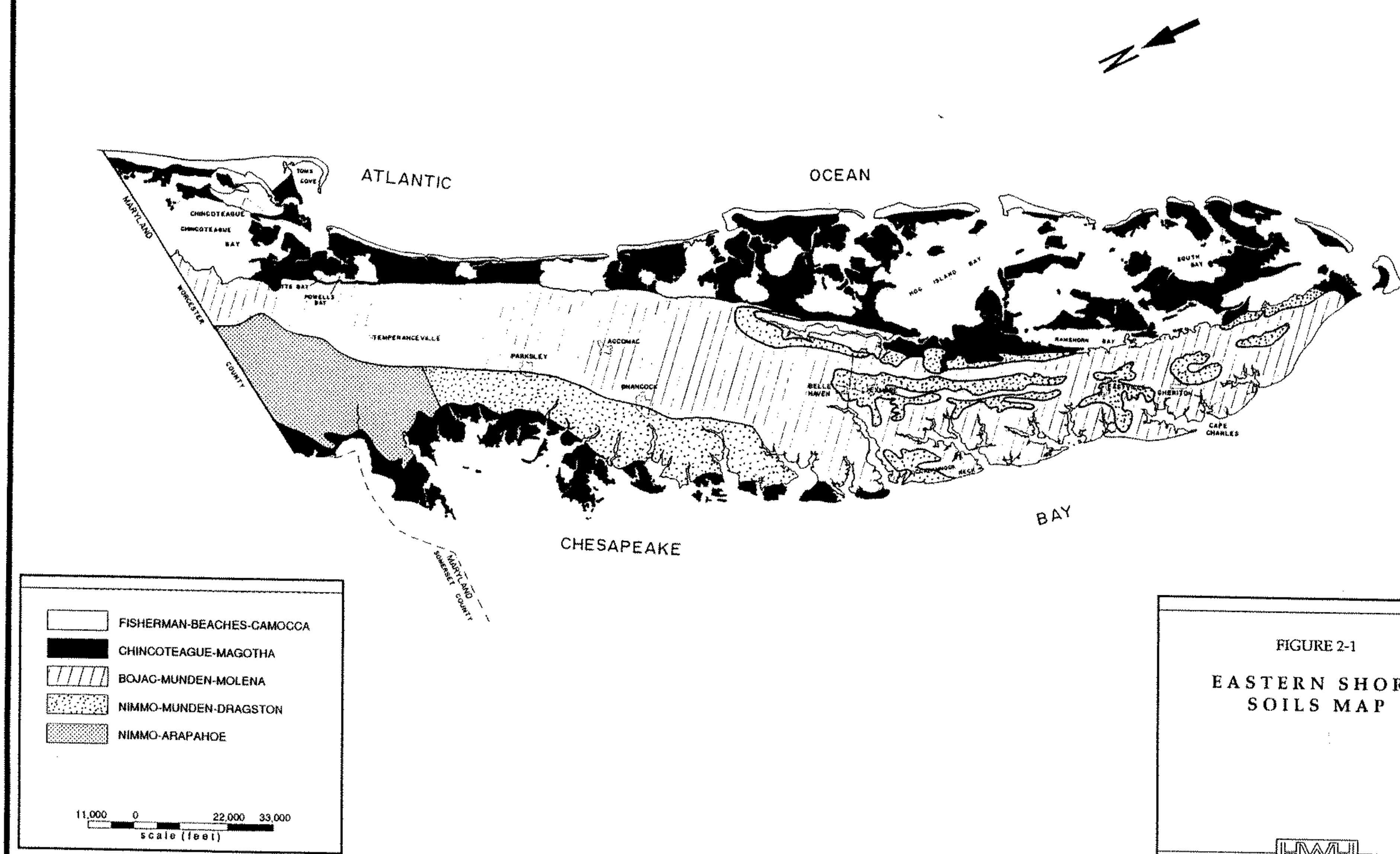

FIGURE 2-1

EASTERN SHORE
SOILS MAP

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valued at over nine million dollars, according to the Accomack County Comprehensive Plan (1989). The Virginia State Water Control Board and the Virginia Department of Health Shellfish Sanitation monitor the overall quality of surface water to protect public health in recreational contact and to insure that the waters can sustain aquatic life.

As a result of flat topography and well-drained soils, the peninsula has no large fresh water lakes or waterways. Instead, there are several creeks which, in the lower reaches, are tidal estuaries fed by narrow branches. The Chesapeake Bay side of the peninsula receives the majority of surface runoff, where the creeks are more pronounced. On the Atlantic Ocean side, the barrier islands create a bay and lagoon system, and this side has smaller creeks. In Accomack County, 12 creeks feed into the ocean side, and 19 creeks ebb and flow into the Bay. In Northampton County, there are 21 watersheds, with 15 on the Bay side.

Currently, a water quality monitoring project of tidal creeks in Northampton County is underway. It is a collaborative effort between the Citizens for a Better Eastern Shore (CBES), The University of Virginia, the Virginia Coast Reserve of the Nature Conservancy, the Eastern Shore Working Waterman's Association, and the Virginia Student Environmental Health Project (STEHP). The project will provide baseline information on the status of aquatic habitats and surface water resources of Northampton County. All data derived in the project will eventually be accessible to the general public, and a report completed by the end of 1991 will be submitted to the local board of supervisors and the planning district commission. Recommended actions are expected to result from the presentation of the report.

Hydrologic Units

The USDA Soil Conservation Service has grouped together the 52 watersheds on the Eastern Shore Peninsula to form fourteen (14) hydrologic units. These are essentially larger management units which have common drainage areas. Figure 2-2 indicates the boundaries of the hydrologic units. The following is a breakdown according to county and village. The units beginning with the letter "C" are on the west (Bay) side of the peninsula, and the "D" units are on the east (Ocean) side. Lower numbers are farther south than higher numbers.

Table 2-1: Towns and Villages Located by Hydrologic Units

<u>Accomack County:</u>
C04: [Belle Haven, Bloxom, Craddockville, Davis Wharf, Middlesex, half of Painter, and half of Pungoteague]
C05: [Harborton, half of Melfa, and half of Pungoteague]
C06: [Onancock and half of Onley]
C07: [Greenbush, Hallwood, Horsey, Leemont, Mappsville, Mears, Nelsonia, Parksley, Sanford, Saxis, Tasley, and half of Withams]
C08: [New Church, Oak Hall, and half of Withams]
D03: [Keller, half of Painter, Quinby, and half of Wachapreague]
D04: [Accomac, Centerville, Locustville, half of Melfa, half of Onley, and half of Wachapreague]
D05: [Temperanceville and half of Wallops Island]
D06: [Atlantic, Chincoteague, Greenbackville, Horntown, Half of Wallops Island, Wallops Station, and Wattsville]

<u>Northampton County:</u>
C01: [Dalbys]
C02: [Cape Charles, Cheriton, and Chesapeake]

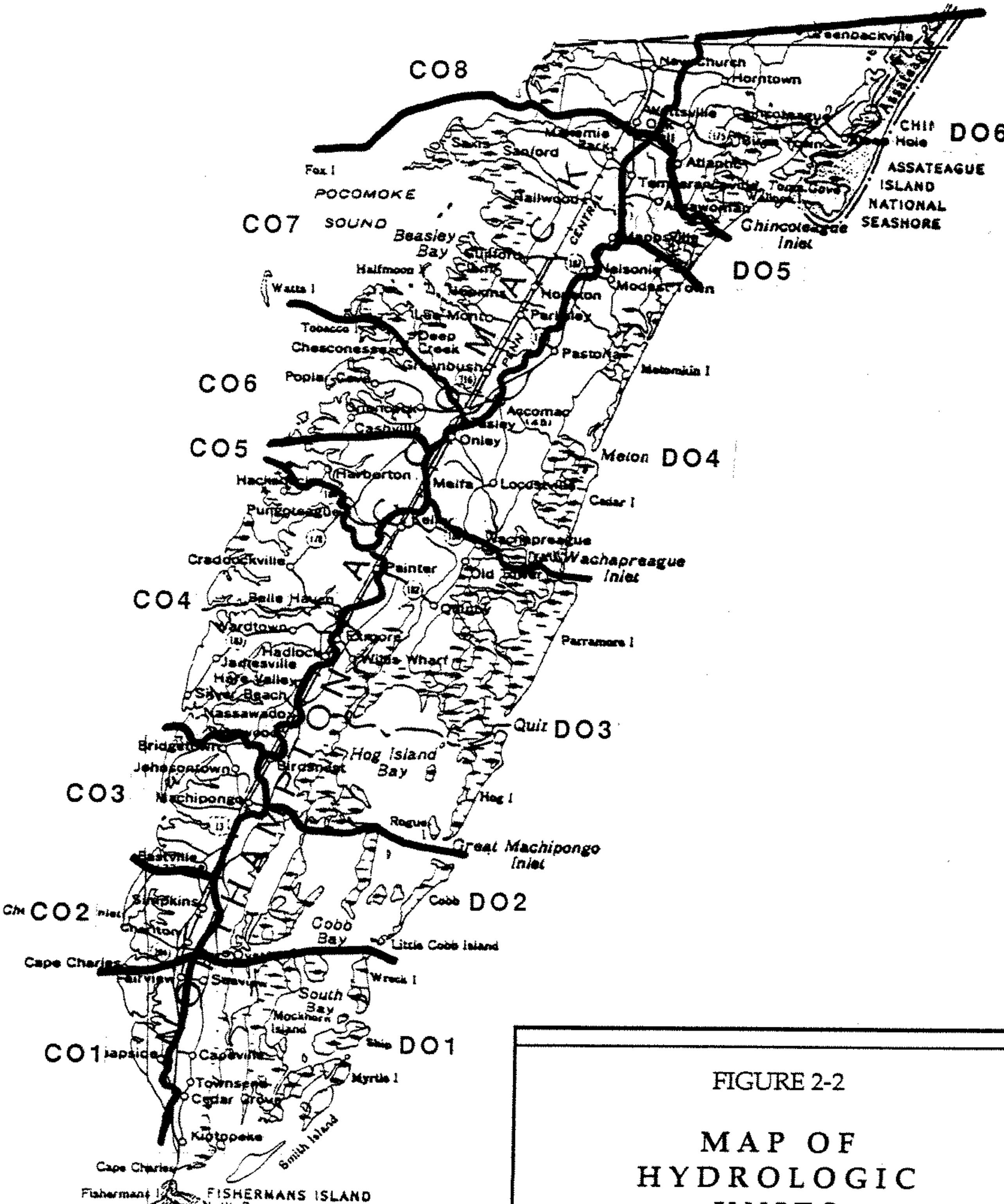

FIGURE 2-2

MAP OF HYDROLOGIC UNITS

C03: [Bridgetown, Churchneck, half of Eastville, and Machipongo]
C04: [Bayford, Birdsnest, half of Exmore, Jamesville, half of Nassawadox, and Silver Beach]
D01: [Capeville, Seaview, and Townsend]
D02: [Half of the Town of Eastville]
D03: [Half of Exmore, half of Nassawadox, Weirwood, and Willis Wharf]

Farm Ponds

In the two counties, over 325 excavated "farm ponds" supply about 85% of the water used for irrigation (Cooperative Extension Agents Jim Belote, Fred Diem, personal communication, 1991). It is unknown how many of these ponds are used as storage areas for water that has been pumped from wells. Farm pond locations, as supplied by the Accomack-Northampton Planning District Commission, are shown in Figure 2-3. Some of the locations in Figure 2-3 have multiple ponds. While it is unclear which of these ponds intersect the water table, the use of surface water for irrigation, rather than well water, reduces the stress on the use of the deeper ground water supply However, farm pond construction by creek damming may destroy valuable wetland habitat and negatively effect downstream productivity (Paul Gapcynski, William & Mary, Virginia Institute of Marine Science [VIMS], Eastern Shore Natural Resources Symposium speech 4/11/91). Two studies conducted by VIMS have shown no negative effects on downstream productivity (letter from J. Rodney Lewis, SCS, 7/8/91).

Ditches have also been constructed on the Eastern Shore to connect creeks in order to increase drainage (Fennema and Newton, 1982). This has the effect of increasing surface water runoff rates. Additionally, several dams have been built in estuaries below and at the head of tide water to supply irrigation water.

Tidal Wetlands

Both Accomack and Northampton Counties contain numerous tidal wetlands. Wetlands are some of the most ecologically productive systems in the world, and are sensitive to land development and use. Tidal wetlands serve as water filters, mitigate the impact of storms, and provide habitat for a variety of wildlife, aquatic life, and plants. Accomack County has 70,000 acres of vegetated tidal wetlands, divided between salt marshes along the Atlantic Ocean shoreline, and brackish marshes on the Chesapeake Bay shoreline. Accomack County also contains extensive non-vegetated intertidal flats on the ocean side. Non-vegetated tidal wetlands are located between mean high water and mean low water and are adjacent to tidal marshes. Tidal wetlands in Northampton County are located on both the ocean and bay sides, and total 35,000 acres.

GROUND WATER

Introduction

The Eastern Shore of Virginia depends entirely upon ground water supplies for its municipal and industrial water needs. Virtually no streams or rivers exist on the peninsula, nor are there surface water lakes or reservoirs of appreciable size.

Ground water serves the water supply needs of the Eastern Shore today, and will continue to do so in the foreseeable future. As a result of this dependence on ground water, protection of the resource, both in terms of water quantity and water quality, takes on an added importance.

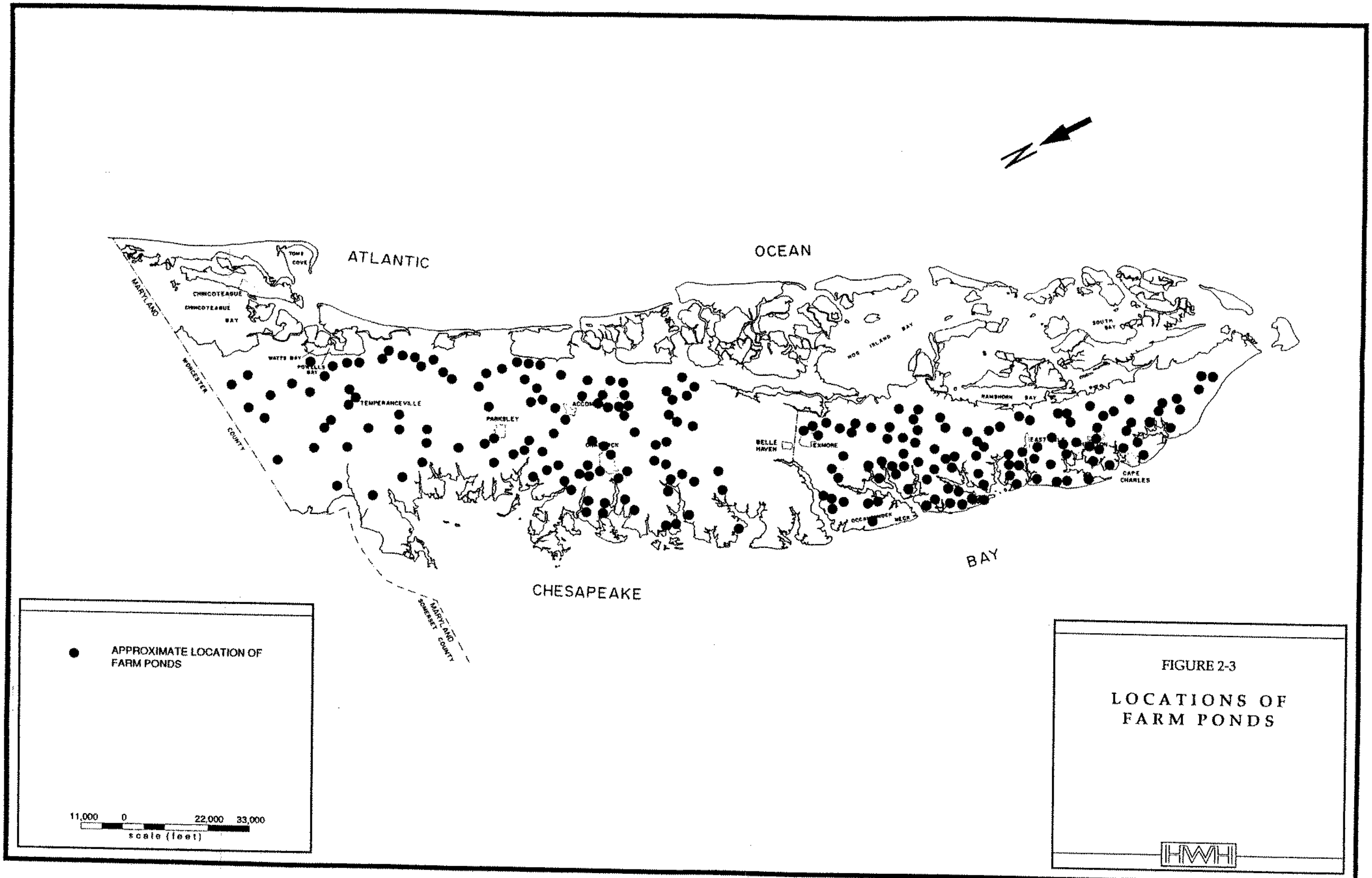

FIGURE 2-3

LOCATIONS OF FARM PONDS

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Ground water on the Eastern Shore is derived from precipitation falling on the land surface of the two counties. Some of that water is intercepted by vegetation and is transpired or evaporated directly back to the atmosphere. A portion runs off as overland flow while some penetrates the soil and is used (transpired) by plants. Part of the precipitation moves through the unsaturated zone and recharges the unconfined (Columbia) aquifer. Figure 2-4 below illustrates the hydrologic cycle. Most water in the Columbia aquifer flows laterally from the center of the peninsula, contributing to the baseflow of small streams or is held in temporary storage in ponds before discharging to the Atlantic Ocean or Chesapeake Bay. A much smaller portion of water in the unconfined aquifer continues its vertical migration through the clays and silts that separate the Columbia from the underlying Yorktown-Eastover aquifer, recharging the confined aquifer system. See Figure 2-5.

Tangier Island, a small island that is part of Accomack County and is located ten miles off the coast of Virginia in the Chesapeake Bay, also obtains drinking water from ground water sources. The island has a separate hydrogeologic system from the mainland, and was not studied in detail in this report.

Figure 2-4: Hydrologic Cycle

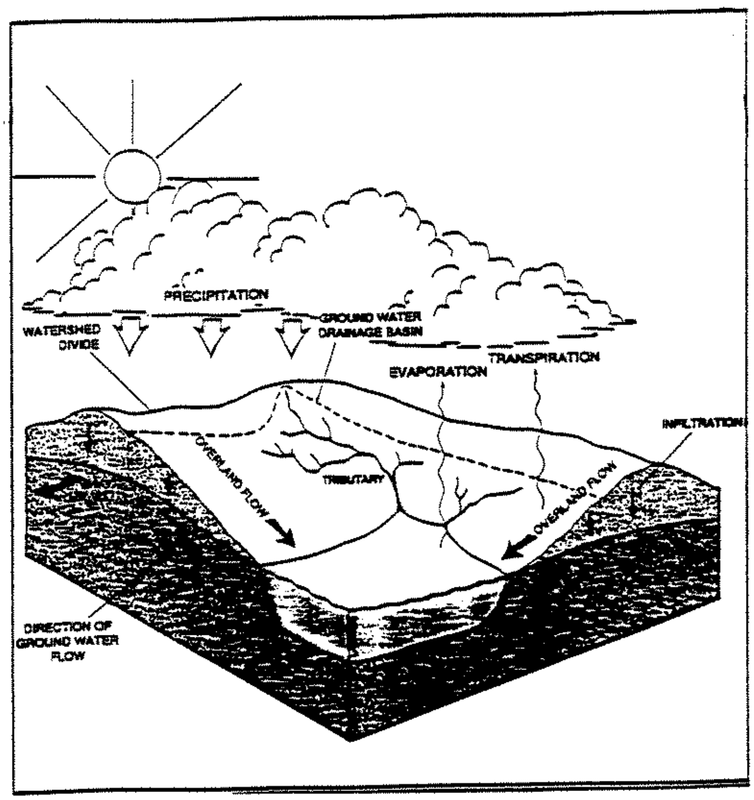
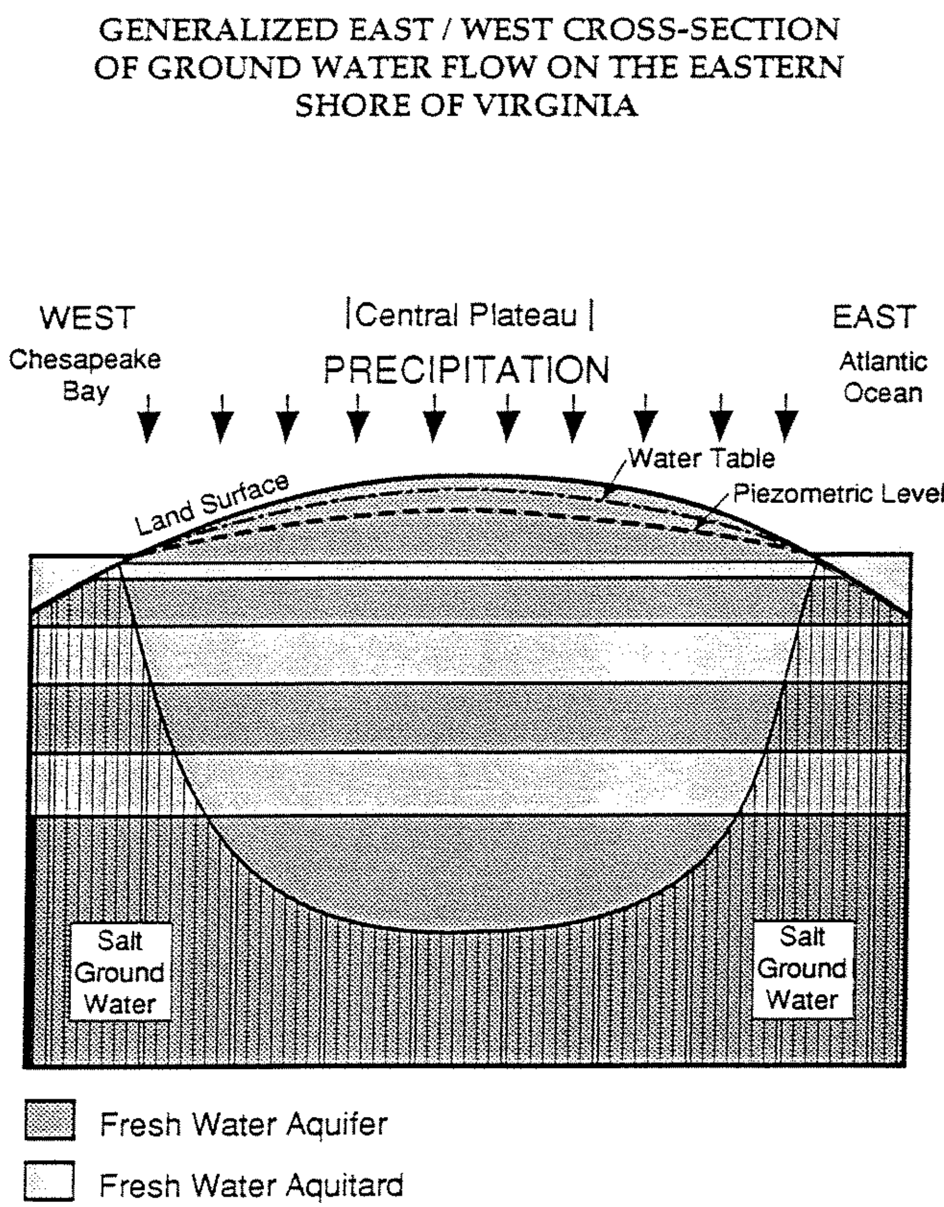


Figure 2-5 Generalized East/West Cross Section



Hydrogeology of the Eastern Shore Aquifers

The most important geologic formations with regard to ground water supply are the Columbia and the Yorktown-Eastover. The Columbia was deposited during the Pleistocene (10,000 to 15,000 years before present). The sediments are primarily sands with interfingering clay and silt beds. From a water budget calculation, it was determined that between 12 and 26 inches per year recharges the unconfined system (see Appendix F). Much of that recharge flows laterally through the Columbia aquifer and discharges to the Chesapeake Bay, streams and estuaries as well as the ocean. Some water passes through the 20- to 100-foot thick confining unit of silty clay below the Columbia and enters the other aquifer of importance to the Eastern Shore, the Yorktown-Eastover Formation.

The Yorktown-Eastover was deposited during the Miocene era, between 5 and 23 million years before present. This deposit consists of three layers of aquifer separated by confining units. Recharge to the confined system from the unconfined Columbia aquifer at steady state, pre-pumping conditions is estimated from analytical modelling at approximately 0.10 feet per year (See Appendix E). The Upper, Middle, and Lower aquifers are comprised primarily of fine to coarse shelly sands. Thickness of the permeable sections vary from as little as 10 feet to as thick as 120 feet. The aquifer deposits possess moderate permeability with transmissivities ranging from less than 1,000 gpd/ft (130 ft^2/day) to as high as 40,000 gpd/ft (5300 ft^2/day) (F&ME, 1990; Fennema and Newton, 1982). Transmissivity is the measurement of how much water moves through the aquifer, and is measured by multiplying the permeability of the aquifer by its thickness. The three aquifers are separated by confining units composed of clays and silts of much lower permeability. These units range from less than 10 feet to as much as 70 feet in thickness.

In addition to the Columbia and Yorktown-Eastover aquifers three major paleochannels (coarse sediments deposited in stream channels that cut through the older sedimentary deposits) have been identified on the Eastern Shore (Colman and others, 1990), created by the downcutting of streams during several periods of low sea level during the Pleistocene. Two of these channels cross the main body of the Eastern Shore peninsula, at Exmore and at Eastville. The third major channel crosses south of the peninsula near Cape Charles and Fisherman's Island. The streams that formed the channels cut into the Yorktown-Eastover Formation as much as 200 feet, depositing sands and gravels in the central portion of the channel overlying those sediments with less permeable sands, silts and clays (Colman and others, 1990). The width of the paleochannels is less certain but is mapped in Colman and others (1990) as roughly 1-2.5 miles wide.

Summary of Existing Technical Reports

Available technical reports, including journal articles, consultant's reports, State Water Control Board and U.S. Geologic Survey publications were reviewed for this project to better understand the previous investigations of the Eastern Shore.

The technical literature can be divided into three principal categories. The first include those reports presenting basic geologic and hydrologic data. Such reports are fundamentally compilations of data with descriptive commentary and include many of the U.S. Geological Survey papers and Virginia Division of Mineral Resources reports. For example, Teifke (1973) provides a thorough examination of the geology of the entire coastal plain of Virginia, including the Eastern Shore. The publication is a very useful one with its detailed rock type descriptions from borehole logging as well as its discussion of depositional environments for the formations that make up the region. Sinnott and Tibbitts (1968) offer a comprehensive overview of the geology and hydrology of the Eastern Shore in particular, along with well and water quality data.

The second type of report comes from independent researchers and consultants. These reports (e.g., F&ME, 1990) focus on local aspects of Eastern Shore hydrogeology. Their main utility in terms of the objectives of a ground water protection program lies in the raw data they provide from drilling logs and water quality analyses along with data from test pumping that can be used to obtain aquifer coefficients.

The third type of report is more interpretive in form, applying the basic data to the issues involving the hydrogeology of the Eastern Shore. Many of the Virginia State Water Control Board Planning Bulletins fall into this category. A series of Planning Bulletins, No. 45 (1975), No. 309 (1977) and No. 332 (1982), have charted the efforts of the Board to detail the hydrogeologic conditions of the Eastern Shore in both a conceptual and quantitative manner, along with discussions of how that understanding can contribute to solutions to ground water problems. Bulletin No. 45 offers a comprehensive view of hydrogeologic conditions on the Eastern Shore as they existed almost twenty years ago. That report identified the following key issues: (1) ground water level declines in the confined Yorktown-Eastover aquifer, (2) well interference, (3) salt water intrusion, and (4) ground water contamination that continue to trouble the area. Bulletin No. 309 (Ball, 1977) acted on a specific recommendation of Bulletin No. 45 to construct a two-dimensional numerical flow model of the confined aquifer of the Eastern Shore to apply a more quantitative approach to the understanding and management of the resource. That trend towards a quantified view of the hydrogeology was continued in Bulletin No. 332 (Fennema and Newton, 1982) which augmented Bulletin No. 45's basic information, incorporating borehole geophysical data, water quality information from established research stations and test pumping results. That report presented a series of extremely useful cross-sectional correlations along and transverse to the axis of the peninsula. A forthcoming report from the U.S. Geological Survey (Richardson, in press) continues the move towards quantification of the hydrogeologic conditions of the Eastern Shore with a three-dimensional saltwater/freshwater interface numerical model of the area.

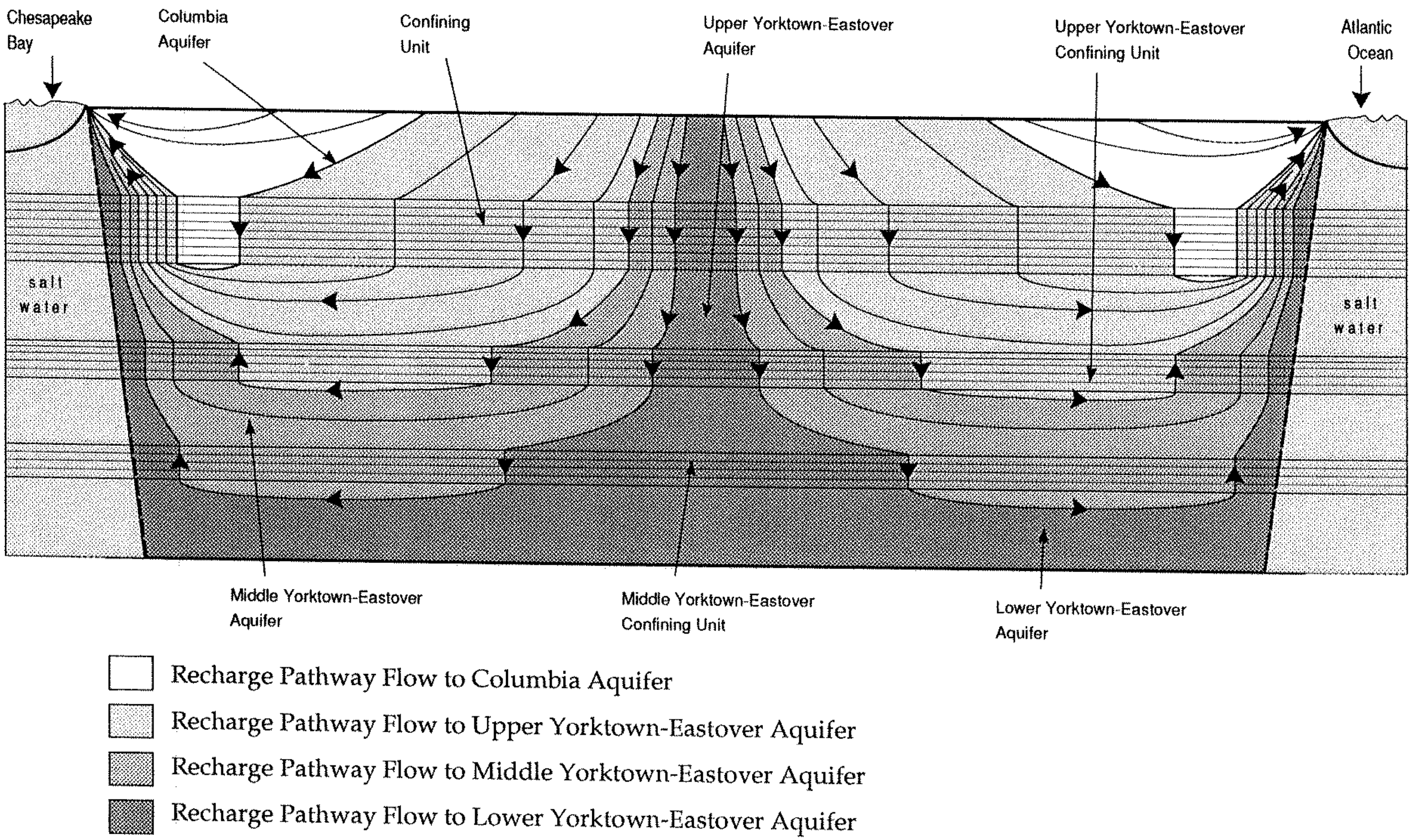
Flow and Recharge Patterns on the Eastern Shore

A conceptual understanding of the flow patterns and locations of the recharge areas on the peninsula is crucial to protecting those areas of most importance to the water supply of Accomack and Northampton counties. That conceptual model must take a three-dimensional approach which incorporates vertical components of flow to account adequately for the hydrogeologic conditions on the Eastern Shore. The key element of that model with respect to protecting the long term quality and quantity of the ground water on the Eastern Shore is the role played by the central spine of the peninsula. The center portion functions as the primary recharge source for the heavily used confined Yorktown-Eastover aquifer, and the center portion's protection is of utmost importance to the continued viability of the confined aquifer as a source of water.

The overall flow and recharge patterns can perhaps best be illustrated through the use of several models developed during the course of this project. The models are cross-sectional views of the peninsula used to observe where ground water is recharged and discharged by the various aquifer systems and the nature of flow within and between aquifers and confining units. The models used were generated numerically by McDonald-Morrissey Associates in conjunction with HWH. United States Geological Survey MODFLOW code was used to model input parameters of aquifer and confining unit thickness, permeability, recharge rates, etc., consistent with those found in the literature for the Eastern Shore. Several steady state model runs were performed to gain a better conceptual view of the ground water flowpaths and recharge areas under different pumping scenarios. While numerical in form, the runs of the model serve best as aids in developing a correct conceptual notion of ground water conditions on the Eastern Shore. Figure 2-6 describes the flow system of ground water under pre-pumping conditions on the peninsula. This figure is for conceptual purposes only and does not represent a quantitative estimate of the recharge area.

FIGURE 2-6.

Conceptual Hydrogeologic Model of Non-Pumping Ground Water Conditions on the Eastern Shore of Virginia



Precipitation falling on or across the peninsula recharges the unconfined Columbia aquifer. Much of that water moves laterally within the unconfined unit and discharges to the ocean or Chesapeake Bay. A portion continues vertically downward through the confining unit until it reaches the Yorktown-Eastover aquifer. The model shows that the deepest portion of the Yorktown-Eastover aquifer (the lower Yorktown-Eastover) receives its recharge from a very narrow strip along the central spine of the peninsula. Once in the lower Yorktown-Eastover aquifer, water moves laterally and then upward through the confining layers, finally to discharge into the Atlantic Ocean or Chesapeake Bay. The Middle and Upper Yorktown-Eastover aquifers receive their recharge in a similar manner, but from a broader area on either side of the peninsula, reflecting both the higher permeabilities of those units as well as their relative stratigraphic positions. That is, there are fewer confining units to go through before the water reaches the aquifers.

The model demonstrates the fact that recharge to the confined Yorktown-Eastover aquifer under pre-pumping conditions occurs at the center of the peninsula. Precipitation falling on the sides of the peninsula moves laterally through the Columbia aquifer, not vertically downward through the confining layer. Much of the water recharged to the Columbia, therefore, discharges to the Atlantic Ocean and the Chesapeake Bay, not the Yorktown-Eastover aquifer.

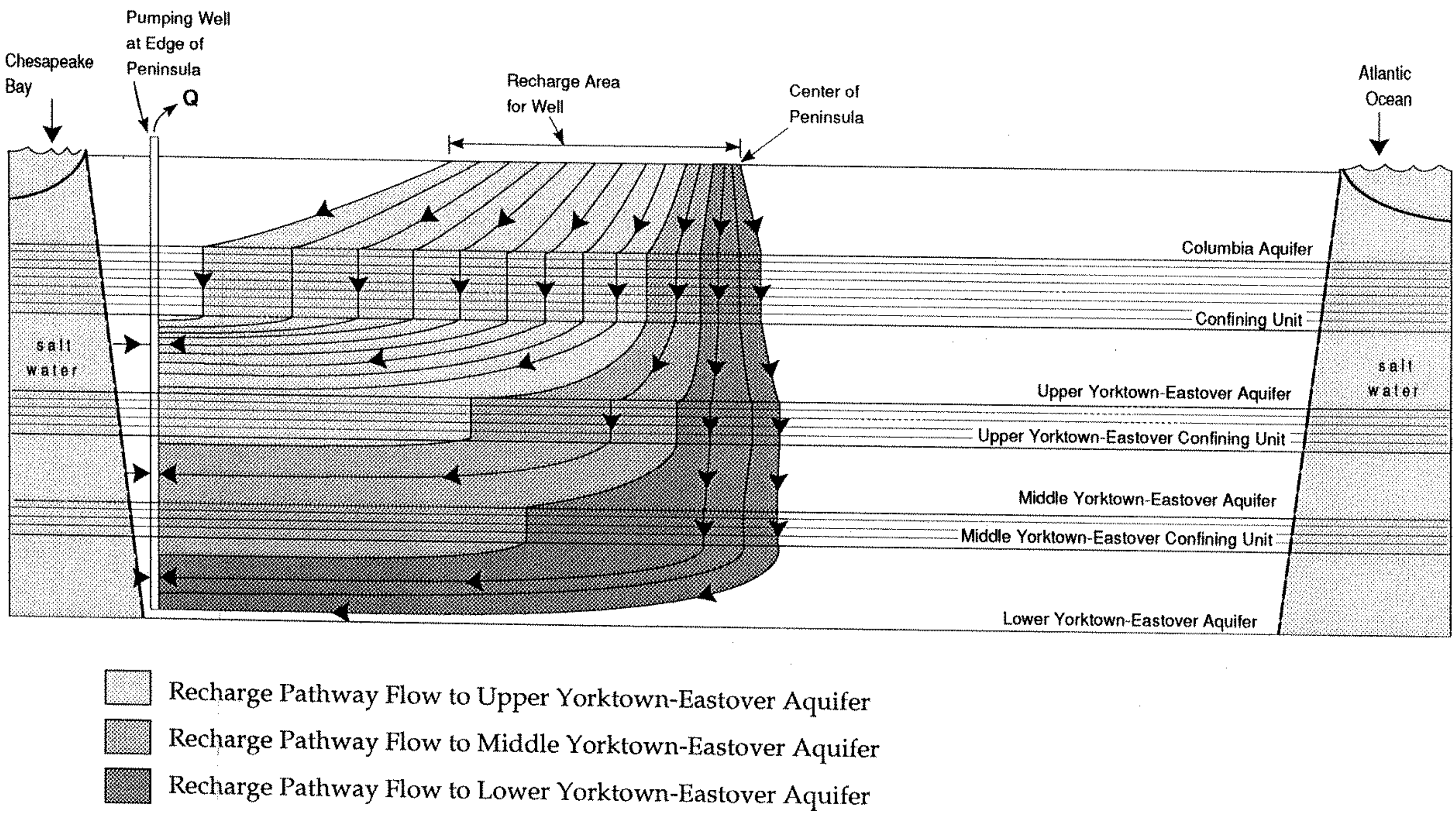
Figure 2-7 conceptually illustrates a scenario of steady state pumping conditions, detailing the pathlines of ground water movement to a pumping well located at the edge of the peninsula. In a somewhat non-intuitive manner, this cross-sectional numerical model shows that the surface area of land immediately around the well contributes nothing to its yield. Precipitation falling on the Eastern Shore in the immediate vicinity of the well will recharge the Columbia aquifer, but the majority of flow in those areas does not pass through the confining layer to recharge the Yorktown-Eastover aquifer and contribute to the yield of the well. In this cross-sectional model, recharge from precipitation to the Columbia aquifer around the wellhead will discharge to the ocean. The recharge source of a water supply on the side of the peninsula is primarily derived from the central area of the land, albeit skewed towards the direction of the well to some degree. In this model, the deepest section of the Lower Yorktown-Eastover aquifer actually obtains its water from beyond the midpoint of the peninsula in this pumping scenario.

As the distance between a pumping well and the center of the peninsula spine increases, a well will derive its water supply from more than one area. Part of its recharge will continue to come from the center of the peninsula, but part will come from other areas of the Columbia, induced by the gradients created by pumping. A detailed quantification of precisely where these areas might be was not possible under the scope of this project. With a properly constructed and calibrated three dimensional model, particle tracking routines could be used on the final head distribution to determine to a much higher degree of precision the origin of the water discharged by a well. This would offer a superior quantification of the proportion of water derived from downward leakage through the confining layer near the well relative to water derived from recharge at the center of the peninsula. Unfortunately, such a three-dimensional flow model does not yet exist for the Eastern Shore, and its construction is beyond the scope of this project. The numerical cross-sectional model was created for conceptualizing purposes, and it serves only to emphasize the importance of the center of the peninsula to the quantity and quality of water available to the confined aquifer system. While other areas of the Columbia undoubtedly contribute to the water supply of wells screened in the Yorktown-Eastover aquifer, even for wells located at the sides of the Eastern Shore, the key recharge area is the center of the land mass.

The numerical modelling which generated the conceptual hydrogeologic model for the Eastern Shore illustrates a concept vital to the development of wellhead and aquifer protection strategies on the Eastern Shore. ***Simply stated, the most important area to protect in order to assure continued good quality and large quantities of ground water throughout the Eastern Shore is the center of the***

Figure 2-7

Conceptual Hydrogeologic Model of the Eastern Shore of Virginia with a Pumping Well at the Edge of the Peninsula Screened in the Yorktown-Eastover Aquifer



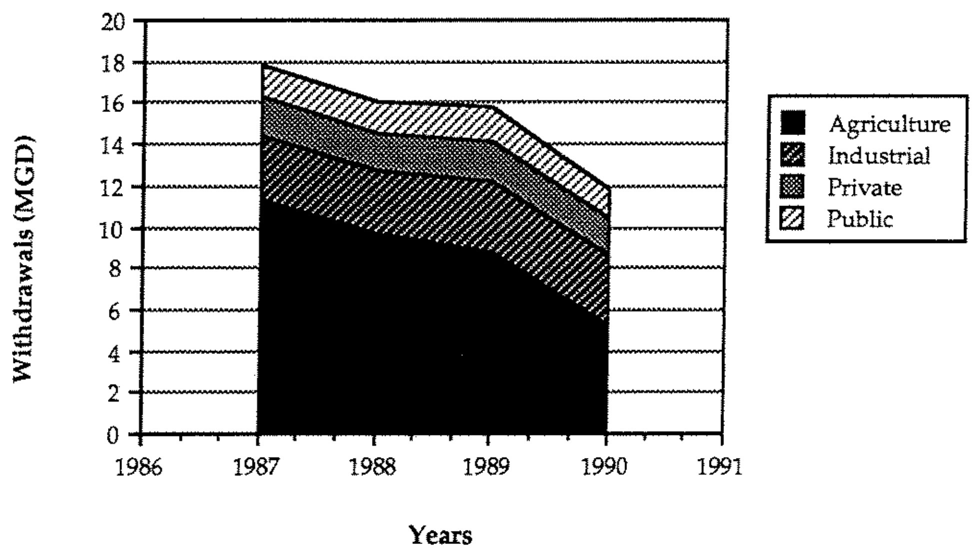
peninsula. Under pumping conditions, the important role of the central portion of the peninsula in maintaining adequate aquifer protection is even more apparent. A protection scheme that does not emphasize the center portion of the Eastern Shore, taking into consideration the three-dimensional character of the flow paths, will prove misleading and ineffective.

WATER USE

A water budget for the Eastern Shore of Virginia has been established by comparing known water withdrawals to the rate of recharge to the aquifer. This budget will help identify water quality and salt water intrusion problems as well as predict the overall future of the ground water supply of the Eastern Shore of Virginia.

This section identifies major water users, which include public, industrial, private, crop irrigation, and poultry categories. In Section 6, the water budget is analyzed with respect to the hydrogeologic conditions of the peninsula.

Figure 2-8: Water Use by Category



Crop Irrigation

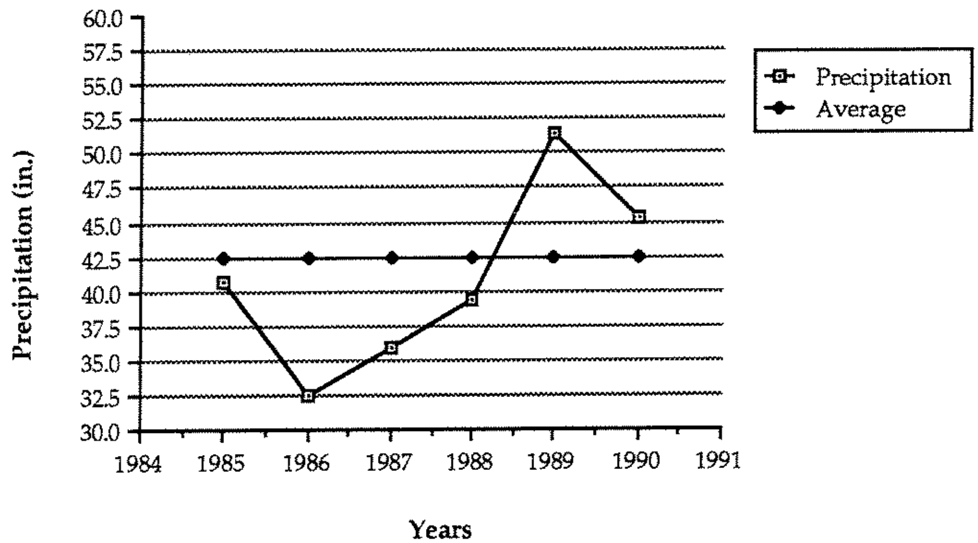
Agriculture is the most water-intensive land use on the Eastern Shore. The State Water Control Board estimates the gallons of water used for irrigation based upon a voluntary survey which is completed by farmers. As of 1991, this survey will no longer be voluntary, and it is expected that the estimations will become more comprehensive if not more accurate. The following (Table 2-2) is a summary of agricultural water use (in millions of gallons per day - MGD) according to the Virginia State Water Control Board. Table 2-3 provides greater detail of this chart.

Table 2-2: Agriculture Water Use by County (MGD)

	1987	1988	1989	1990
Accomack	6.04	6.46	6.86	2.56
Northampton	5.17	3.08	1.94	2.62

Crop irrigation involves a seasonal use of water, but the figures have been annualized to give an average daily withdrawal over the course of each year. Total irrigation did decrease from 1987 to 1989, and this coincides with an increase in rainfall, as shown in Figure 2-9.

Figure 2-9: Yearly Precipitation
Painter, Virginia, 1985-1990



Source: National Oceanic and Atmospheric Administration

Earlier in this section, it was estimated that surface water farm ponds supply approximately 85% of the irrigating water. The State Water Control Board includes source information in its survey. Table 2-4 summarizes the findings. According to the state survey, ground water contributes much more than the 15% that is estimated by the Extension Service, and a small amount of public water is also used.

Table 2-3: Irrigation Estimates, 1987-1990

Year	Geographic Area	Numbers Farms	Reporting Nurseries	Reported Acreage Irrigated	% of acreage in VA	Reported Water Applied (MG)	% of water applied in VA	Annualized Rate (mgd)	Ave. appl. (in.)	Rainfall (in.) Apr.-Sept. *
1987	Accomack	72	12	9588	21.9	2204	22.2	6.037	8.5	12.61
	Northampton	30	3	7122	16.2	1888	19.1	5.173	9.8	
	Virginia	520	47	43866	100	9916	100	27.168	8.3	
1988	Accomack	118	18	10397	26	2357	25.7	6.457	8.3	22.43
	Northampton	42	8	5760	14.4	1125	12.3	3.083	7.2	
	Virginia	430	75	39945	100	9181	100	25.152	8.5	
						1324		3.628		
1989	Accomack	43	11	10182	41.3	2502	48	6.855	9	30.27
	Northampton	41	4	5563	22.5	707	13.6	1.938	4.7	
	Virginia	278	46	24669	100	5211	100	14.278	7.8	
1990	Accomack	31		4210		935		2.56	8.18	27.21
	Northampton	24		4829		956		2.62	7.29	

Source: Virginia State Water Control Board - VA Crop Irrigation Water Use Reports for 1987-1989, 1990 figures unpublished from the SWCB. Rainfall data from NOAA, not SWCB.

Table 2-4: Accomack-Northampton Planning District Irrigation With Source Detail

	1987		1988		1989	
Water Source	Acres Irrigated	Millions Gallons	Acres Irrigated	Millions Gallons	Acres Irrigated	Millions Gallons
Surface Water	4,666	1,552	5,361	1,072	6,420	1,136
Ground Water	8,802	2,198	9,318	2,334	8,141	1,956
Mixed Source	2,510	172	1,479	77	1,082	116
Public Supply	664	171	0	0	104	1
Total	16,621	4,092	16,157	3,482	15,747	3,210

Source: Virginia State Water Control Board

Public and Industrial Water Use

Nonagricultural facilities which withdraw in excess of 300,000 gallons of ground water per month are required to obtain a withdrawal permit from the Virginia State Water Control Board (SWCB). The effect of the permit is to put a limit on the amount each facility can withdraw. The permitted amount allotted to each system may include a grandfathered amount plus an amount based upon historical use. Generally these wells are dug into the deep aquifer. The following is a summary of withdrawals in millions of gallons per day. Table 2-7 lists facilities which have permits and their withdrawals from 1985 to 1990. Some listed in the database as currently withdrawing water do not have a permitted rate of withdrawal, according to the SWCB. Those facilities without a permit have a "+" symbol in the "Permitted" column of Table 2-7 .

Table 2-5: Summary of Permitted Public and Industrial Water Use (MGD)

	1985	1986	1987	1988	1989	1990	Permitted (1991)
Public	1.3	1.3	1.4	1.4	1.5	1.2	4.5
Industrial	3.4	3.1	3.2	3.1	3.4	3.3	11.1
Total	4.7	4.4	4.6	4.5	4.9	4.5	15.6

Six incorporated towns have central water supplies. Together they withdrew approximately 1.03 millions of gallons a day in 1990. Table 2-6 lists the withdrawal amounts for each municipal supply.

Table 2-6: Major Municipal Withdrawals

Town	1990 Withdrawal (MGD)	Permitted Amount (MGD)
Cape Charles	0.134	0.261
Chincoteague	0.447	1.340
Eastville	0.060 (1989)	+
Exmore	0.166	0.320
Onancock	0.161	0.234
Parksley	0.060	0.100

Table 2-7: Average Annual Water Withdrawals, Eastern Shore, VA 1985-1990

Well No.	TOWN/FACILITY	LATITUDE	LONGITUDE	1985	1986	1987	1988	1989	1990	PERMITTED*
PUBLIC SUPPLIES										
Accomack County										
100-00041	Accomack Co. Nursing Home	374528	753721	0.0160	0.0150	0.0145	0.0145	0.0166	0.0181	0.0294
100-00039	Captain's Cove #1	380010	752534	0.0190	0.0180	0.0189	0.0117	0.0112	0.0081	+
100-00031	Captain's Cove #2	375949	752500				0.0062	0.0043	0.0044	
	Captain's Cove #5 (out of service)	375911	752528							
100-00265	Chincoteague #3	375626	752725	0.0270	0.0400	0.0751	0.0827	0.0280	0	
	Chincoteague #3A same meter as #5	375626	752725					0.0084		
	Chincoteague #3B	375626	752725					0.0084	0.0552	
	Chincoteague #3C	375626	752725					0.0084	0.0496	
100-00028	Chincoteague #4	375633	752721	0.1850	0.1840	0.1795	0.1572	0.1711	0.1392	1.34
100-00032	Chincoteague #5	375626	752723	0.0390	0.0410	0.0314	0.0126	0.0056	0.004	
100-00320	Chincoteague #6	375641	752714	0.1590	0.1340	0.1752	0.1729	0.1713	0.1349	
100-00493	Chincoteague #7A	375550	752754	0.0660	0.0790	0.0510	0.0354	0.0549	0.0351	
100-00494	Chincoteague #7B	375557	752749				0.0354	0.0435	0.0286	
100-00495	Chincoteague #7C (closed - high iron)	375604	752742				0.0000			
	NASA-Wallops Island #3	375144	753034					0.0138	0.0057	
100-00568	NASA-Wallops Island	375035	752545					0.0099	0.0209	
	NASA-Wallops Island Well #4	375128	753045					0.0048	0.0098	
100-00002	Onancock	374233	754430				0.0782	0.0871	0.0971	0.2388
100-00004	Onancock	374233	754432	0.0990	0.0960	0.1186	0.0052	0.0044		
100-00036	Onancock	374234	754430				0.0469	0.0435	0.0486	
100-00037	Onancock	374259	754453				0.0075	0.0049	0.0054	
100-00038	Onancock	374259	754454				0.0076	0.0098	0.0101	
100-00001	Parksley #1 all wells, same	374703	753901			0.0816	0.0728	0.0738	0.0575	0.1
100-00013	Parksley #2 meter	374703	753902							
100-00014	Parksley #3 (not in service since 1984)	374704	753859							
100-00439	VA-Landing Campground	372844	754742		0.0090	0.0133	0.0111	0.0088	0.0079	+
100-00207	Wallops Island Main Base	375626	752807	0.1720	0.2050	0.1196	0.1420	0.1994	0.1009	0.263
	Wallops Island Station	375135	753034	0.0710	0.0150	0.0247	0.0220	0.0099		0.127
Northampton County										
165-00042	America House Motor 1 meter for 2 wells	370816	755808	0.0140	0.0110	0.0116	0.0089	0.0076		0.0209
165-00260	America House Motor Inn #1	370815	755810				0.0063	0.0076	0.0032	
165-00028	Cape Charles (Does not exist??)	371605	760017				0.0000		0	0.261
165-00048	Cape Charles #1	371605	760022	0.1570	0.2050	0.1852	0.1100	0.0766	0.0105	
165-00123	Cape Charles #2	371607	760011				0.0509	0.1536	0.1231	
	Cherrystone Holiday Trav-L-Park	371719	760043	0.0600						0.06
165-00030	Eastville #3	372117	755640				0.0000	0.0000		
165-00031	Eastville	372116	755640	0.0450	0.0490	0.0447	0.0000	0.0000		
165-00036	Eastville	372117	755640				0.0000	0.0000		

Table 2-7: Average Annual Water Withdrawals, Eastern Shore, VA 1985-1990

Well No.	TOWN/FACILITY	LATITUDE	LONGITUDE	1985	1986	1987	1988	1989	1990	PERMITTED*
165-00038	Eastville (backup)	372106	755620				0.0000	0.0000		
165-00014	Exmore #2	373230	754917	0.0670	0.1030	0.0675	0.0570	0.0509	0.1111	0.32
165-00015	Exmore #1	373230	754917	0.0410	0.0630	0.0773	0.0673	0.0667	0.055	
165-00026	Eastville #2 (#5)	372117	755640				0.0591	0.0580		+
165-00001	Northampton-Accomack Hospital	372835	755145	0.0190	0.0120	0.0000	0.0748	0.0749	0.1039	0.1
165-00025	Northampton-Accomack Hospital	372835	755145	0.0490	0.0580	0.0782	0.0003	0.0024	0.0015	
	Brown & Root	371500	760000							1.1
	DiCanio Residential Communities	371314	760009							0.28
165-00259	*DiCanio Chesapeake .*	371333	760006							0.022
165-00054	*Peaceful Beach, Kirkwood #1*	373114	755660							0.229
165-00055	*Peaceful Beach Campground #2*	373114	755660							
165-00063	*Peaceful Beach Campground #3*	373114	755660							
	Peaceful Beach, Kirkwood	373100	755630	0.0000	0.0000	0.0000	0.0000	0.0000		
Public Supply Total				**1.2430**	**1.2640**	**1.2594**	**1.2414**	**1.4148**	**1.1140**	**4.4617**
INDUSTRIAL SUPPLIES										
Accomack	**County**									
100-00006	Byrd Foods #1	374537	754004	0.0370	0.0060	0.0031	0.0027	0.0071	0.0101	0.6
100-00054	Byrd Packing Co.	374531	754011							
100-00367	Byrd Foods #3	374534	754007							
100-00368	Byrd Packing Co.	374536	754003							
100-00369	Byrd Packing Co.	374536	754003							
100-00009	Holly Farms #4	375318	753344			0.2045	0.2296	0.1901	0.2512	1.8
100-00010	Holly Farms #3	375311	753339			0.1998	0.1972	0.1692	0.1179	
100-00011	Holly Farms #2	375304	753332			0.2412	0.1785	0.1863	0.1598	
100-00012	Holly Farms #1	375256	753324	0.6870	0.7170	0.1619	0.1009	0.0924	0.1061	
100-00196	Holly Farms #5	375330	753355			0.0838	0.1153	0.1953	0.1581	
100-00566	Holly Farms #6	375257	753321				0.0175	0.0364	0.026	
100-00258	New Church Energy Assoc.	375833	753218	0.0970	0.1570	0.0759	0.1435	0.1991	0.1767	0.336
100-00365	New Church Energy Assoc.	375838	753218		0.0300	0.1099	0.0361	0.0775		
100-00020	Perdue Foods #4A	374403	753937	0.1060	0.0770	0.0221	0.0196	0.0618	0.224	2.6379
100-00026	Perdue Foods #2	374419	753910	0.4640	0.4710	0.4468	0.4001	0.5064	0.4974	
100-00029	Perdue Foods #3	374429	753922	0.4450	0.4100	0.4336	0.4328	0.3956	0.4156	
100-00030	Perdue Productions #1	374408	753859	0.2510	0.2140	0.2038	0.1929	0.2280	0.244	
100-00195	Perdue Foods #4	374421	753937	0.2310	0.1970	0.1622	0.0928	0.1429	0.1157	
100-00531	Perdue, Inc. #5	374425	753933			0.3217	0.3273	0.3763	0.3683	
100-00843	Eastern Shore Seafood (pump start 2/91)	375122	753336							0.3
100-00237	Shore Seafood #1	375513	754348	0.3230	0.1990	0.0000	0.0000	0.0734	0.0941	+
100-00238	Shore Seafood #2	375512	754348				0.0000	0.0243	0.0941	
	Shore Seafood #3	375512	754348					0.0734	0.0941	

Table 2-7: Average Annual Water Withdrawals, Eastern Shore, VA 1985-1990

Well No.	TOWN/FACILITY	LATITUDE	LONGITUDE	1985	1986	1987	1988	1989	1990	PERMITTED*
	Shore Seafood #4	375512	754348					0.1005	0.0941	
100-00229	Taylor Packing Co.	375232	753528	0.2070	0.1030	0.0680	0.0630	0.0440		0.5488
100-00346	Taylor Packing Co. #1	375233	753528							
100-00347	Taylor Packing Co. #2	375233	753528							
100-00348	Taylor Packing Co. #3	375233	753528							
Northampton County										
165-00108	American Original Foo same meter /#123	373045	754828	0.1190	0.1140		0.0000	0.1155	0.0617	0.45
165-00116	American Original Foods Obs. #123	373046	754825				0.0000			
165-00117	American Orig. Foods Obs. #122	373046	754825				0.1562			
165-00110	Bayshore Concrete #1	371544	760119	0.0790	0.0820	0.0727	0.0382	0.0209	0.0166	0.125
165-00111	Bayshore Concrete #3	371542	760124				0.0069	0.0141	0.0151	
165-00142	Bayshore Concrete Prod. #2	371539	760114				0.0251	0.0197	0.0178	
165-00141	Bayshore Concrete	371539	760114				0.0054	0.0019	0.004	
165-00045	C&D Seafood #2	371711	755524	0.0610	0.0460	0.0380	0.0286	0.0260	0.0297	0.152
165-00064	C&D Seafood #1									
165-00018	Custis Enterprises	372150	755522							0.441
165-00019	Custis Enterprises	372150	755522							
165-00005	Exmore Foods #7	373203	754917							2.002
165-00029	Exmore Foods #8	373160	754917							
165-00039	Exmore Foods #9	373210	754913							
165-00047	KMC Foods (clustered wells)	371746	755728						0.0033	1.6
165-00023	KMC Foods #4 (Labor Camp)	371746	755728	0.2390	0.1860	0.2748	0.2156	0.0161		
165-00024	KMC Foods #5	371731	755730							
165-00105	KMC Foods Plant Well	371732	755736							
165-00158	KMC Foods Inc.	371726	755729							
	Sea Watch International (HAS)	372219	755530	0.0660	0.0430	0.0335	0.0383	0.0389	0.0341	0.15
Industrial Total				**3.4120**	**3.0520**	**3.1573**	**3.0641**	**3.4331**	**3.4296**	**11.1427**
GRAND TOTAL				**4.6550**	**4.3160**	**4.4167**	**4.3055**	**4.8479**	**4.5436**	**15.6044**

Source: VA Water Control Board Records 1985-1990; Virginia Newton, SWCB geologist

* Permitted = Grandfathered rights + permitted withdrawals

Tangier Island supplies water for its population of 659 by means of 5 private water systems. These wells are not used for industrial purposes, only by residential and commercial facilities. According to the Eastern Shore Water Supply Plan (1988), the five wells were interconnected in 1987, and a storage tank was built in the case of emergency. Many pipes to the wells are old and leak, and it is difficult to determine flow from these wells since they are not metered. It was estimated in 1988 that the water demand for the town was .065 MGD. It is unknown how many wells exist on the island; the State says 11 and a well driller claims there are 14 wells Since Tangier Island is separate from the aquifer system on the mainland, and the water is withdrawn from a much greater depth (approximately 1,000 feet deep),this study did not focus in detail on the ground water situation on the island.

Five permitted water withdrawal facilities are currently inactive. Their permitted amounts total just over 4 million gallons per day. Table 2-8 lists those inactive facilities and their permitted withdrawal rates.

Table 2-8: Permitted Withdrawal Rates for Inactive Facilities

Facility	Permitted Amount (MGD)
Exmore Foods	2.002
Custis Enterprises	0.441
Peaceful Beach, Kirkwood	0.229
DiCanio	0.302
Brown & Root	1.100
TOTAL	4.074

In addition, there are numerous schools, hotels, restaurants, small industries, trailer parks, churches, and migrant labor camps that have private wells. Populations of community, non-community, and non-transient non-community facilities were obtained from the Virginia Department of Health. Water use by category was estimated using wastewater flow rates from Laak (1986), assuming that eighty percent of water use becomes wastewater (see page 8-3). Calculations show that these facilities use 140,000 gallons per day.

From the Eastern Shore Department of Health, it was determined that a maximum of 3,058 people can occupy the area's migrant labor camps. Because these camps become the worker's residence during the duration of the season, average water use per person is estimated at 55 gallons per person per day. Therefore, the estimation of total labor camp water use is 168,000 gallons per day. Conservatively, if the labor camps were all in operation at the same time, the total water consumption from all these private facilities (schools, churches, etc.) amounts to 308,000 gallons per day, or 0.308 MGD. Cumulatively, these facilities withdraw close to the permitted pumping rate for the Town of Exmore.

Industrial withdrawals exceed that of the public facilities. The two poultry industries, Perdue Inc. and Holly Farms (Tyson Foods) account for forty-two percent (42%) of the total permitted amount for industry. The following graphs compare withdrawals to permitted amounts. Figure 2-13 shows the seasonal fluctuations in water use during 1990.

Private Water Use

With only seven towns having public water systems, the majority of residents on the Eastern Shore of Virginia obtain their drinking water from private domestic wells. Some of these wells are shallow and withdraw water only several feet below the water table. The Virginia Water Project

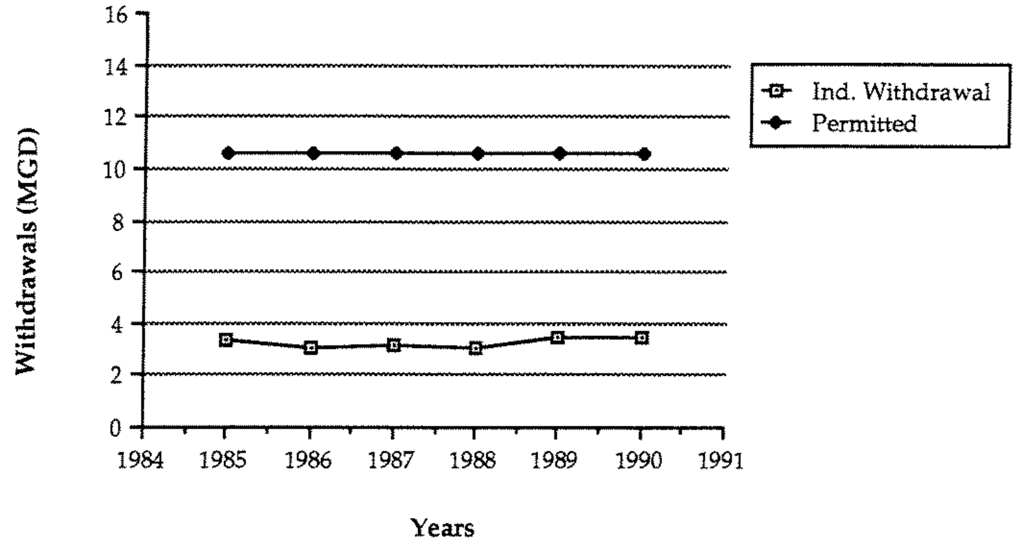
Inc. (1988) estimates that on the Eastern Shore, the number of year-round housing units with individual drilled wells, individual dug wells, or some other private water source is 14,035. At a per household use of 165 gallons per day, private water use exceeds 2.3 million gallons per day. Another method of estimating private water use involves subtracting the number of people served by public water systems as listed by the SWCB (13,246), and multiplying the remaining 1990 US Census population (31,518) by an average of 55 gallons per day. By this method, private water use is 1.7 million gallons per day.

Poultry

The State Water Control Board estimates that a chicken uses 0.09 gallons of water per day (SWCB, Bulletin #60, 1983). With a 1990 production of 21 million chickens and an average 45 day life span, on any given day there were 2.6 million chickens, and these consumed a total of 234,000 gallons per day (0.234 MGD). This is roughly close to the permitted withdrawal rate for the Town of Onancock.

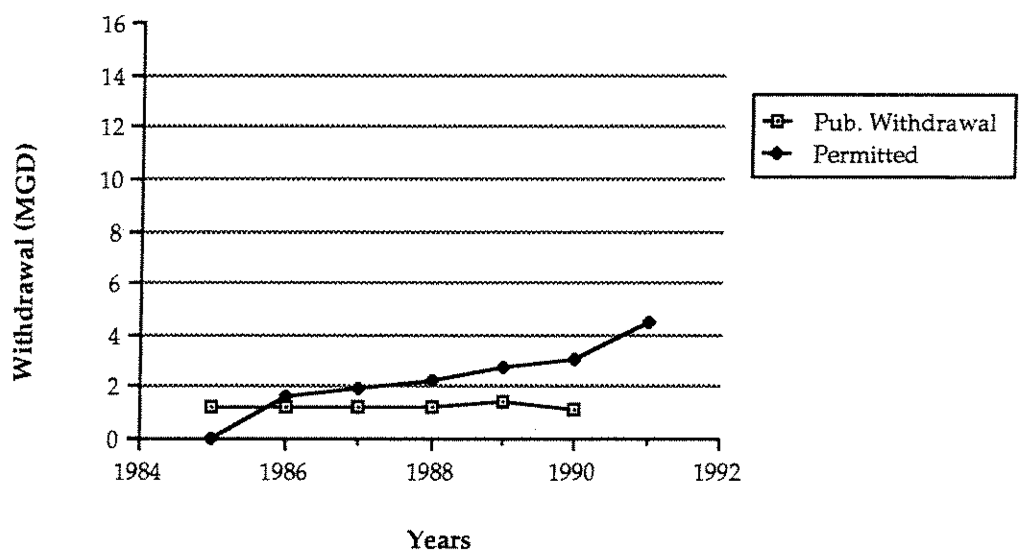
While it would seem safe to assume that chickens consume the same quantity of water today as they did in 1983, current practices may have increased the poultry water use. In the summer of 1991, temperatures hovering around 100°F for several days in a row caused widespread mortality among chickens on the Delmarva Peninsula. Chicken growers reported trying the technique of misting the chickens with water and blowing fans on them to keep their body temperatures down (*The Washington Post*, July 25, 1991, Section B). This new procedure may or may not use significant quantities of water, and it may be unique to rarely hot years; nevertheless, it may account for an increase in water consumption attributed to poultry.

Figure 2-10: Industrial Water Withdrawals vs. Permitted Amounts
Eastern Shore of Virginia, 1985-1990



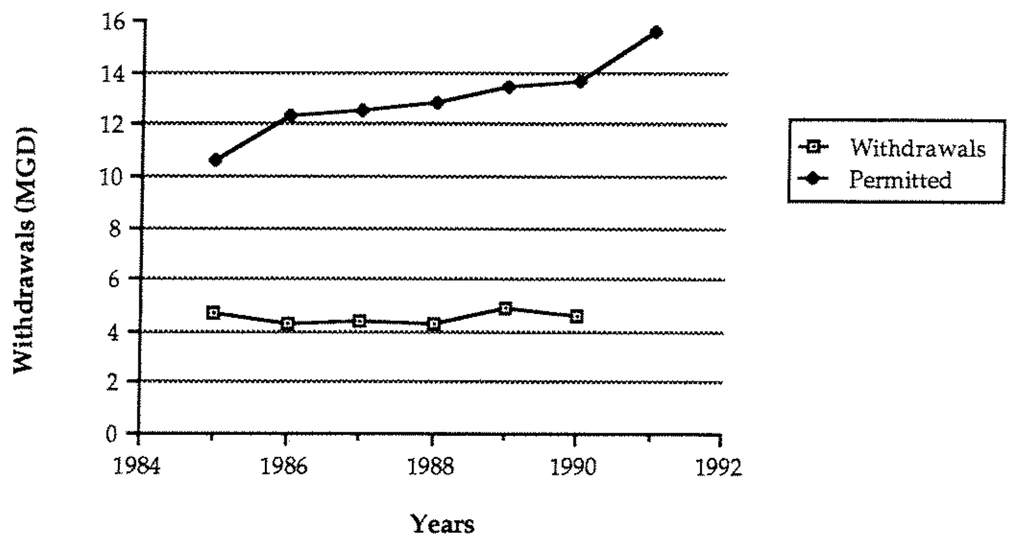
Source: Virginia State Water Control Board
* Note: All of the industrial withdrawals were permitted prior to 1985.

Figure 2-11: Public Water Withdrawals vs. Permitted Amounts
Eastern Shore of Virginia, 1985-1990



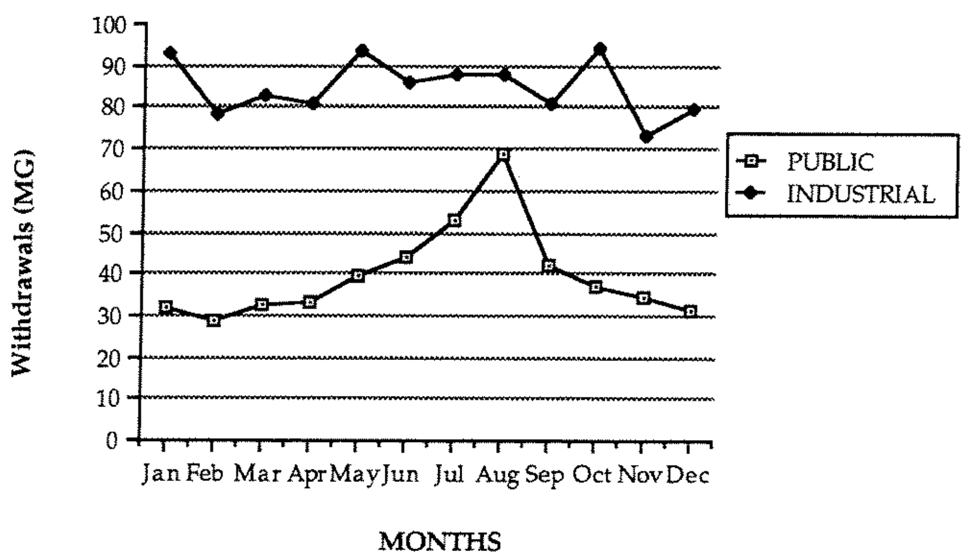
Source: Virginia State Water Control Board

Figure 2-12: Public and Industrial Withdrawals vs. Total Permitted
Eastern Shore of Virginia, 1985-1990



Source: Virginia State Water Control Board

Figure 2-13: Public and Industrial Water Withdrawals by Month, 1990
Eastern Shore of Virginia



Source: Virginia State Water Control Board

CONTAMINATION THREATS

3

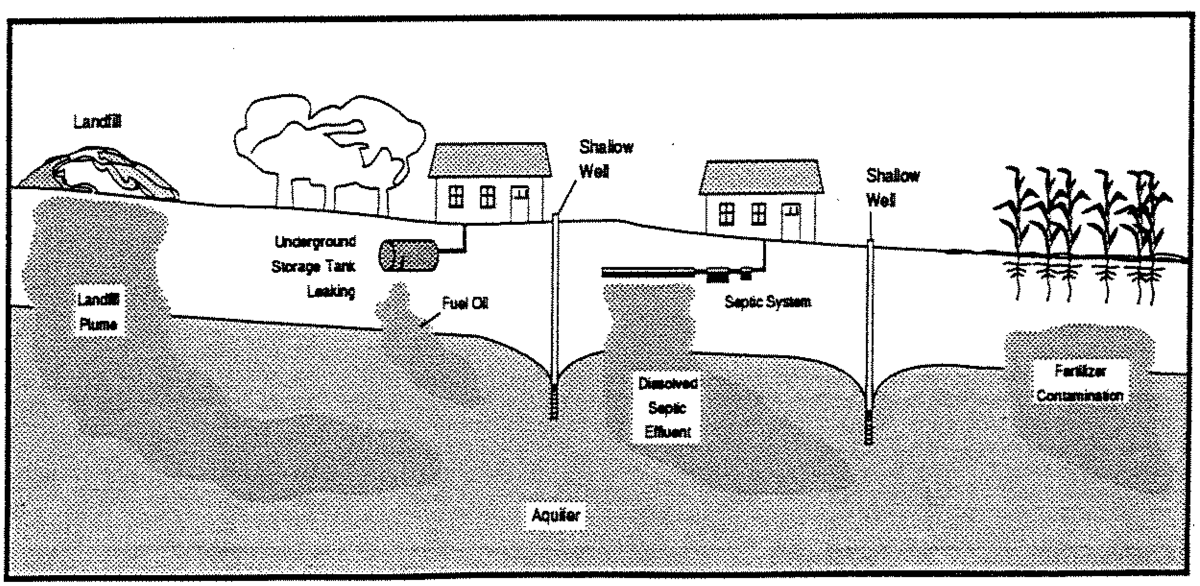
SECTION 3 - CONTAMINATION THREATS

In order to formulate an effective ground water protection strategy, it is necessary to analyze past, existing, and potential land uses. Sources of contamination must be assessed in order to be able to answer questions about present conditions and to make predictions about the long-term viability of the water supply. Because monetary resources are often limited, localities must prioritize their efforts by addressing those contaminant sources of most concern. In this section, several categories of potential contaminants such as waste water disposal, agriculture, industry, solid waste disposal, and septage disposal are examined.

Almost all of the ground water quality threats identified in the following section will have an impact on the Columbia aquifer on the Eastern shore. These land use threats discharge contaminants directly to the land surface or shallow ground water system. Only where public water supplies receive recharge from the Columbia aquifer would these threats be possible sources of contamination to those drinking water supplies. Many older wells serving private homes were drilled into the Columbia aquifer, and the threats outlined here are pertinent to owners of those wells.

Sources of contaminants can be broken down into two general categories: point source and non-point source. Point sources refer to easily-identified sources of contamination that typically concentrate waste discharges into a single point, such as sewage treatment plants and certain industrial discharges. Nonpoint sources refer to widespread sources of contamination which present significant threats to ground water quality. Road runoff drainage is an example of a nonpoint source of contamination to ground water. Many of these sources exist without specific discharge permits and water quality monitoring requirements. Individually, each source may not represent a serious threat to ground water supplies, but cumulatively they may. Most of the potential contamination on the Eastern Shore falls into the non-point source category.

Figure 3-1: Typical Sources of Contamination to Ground Water



WASTE WATER DISPOSAL

The majority of residents (92%) on the Eastern Shore of Virginia use private septic systems for discharge of household waste water (HWH calculations based on 1990 US Census). Two towns on the mainland of Virginia's Eastern Shore have public sewage systems. Larger facilities, such as industries, restaurants, and hospitals have permitted treatment facilities or are able to discharge waste into mass drainfields.

Public Sewage Systems

At present, there are only three incorporated towns with public sewage facilities. The towns of Onancock, Cape Charles, and Tangier Island have facilities which serve approximately 659 residents on Tangier Island and 1,398 in Cape Charles. It is unclear how many additional residents are served outside of Onancock's town population of 1,434. According to the Northampton Country Comprehensive Plan (1990), the Exmore/Willis Wharf area is planning to construct a central sewer system which would serve approximately 2,684 people. In addition, sewering is anticipated for the DeCanio property, and Northampton County now requires central sewage facilities for any large-scale development (County Planner, John Humphrey,1990).

The three sewage systems are designed to discharge at rates ranging from 100,000 to 250,000 gallons per day. It is estimated that town facilities are the largest sewage discharge systems in the two counties, other than the two poultry industries, Perdue Inc. and Holly Farms.

Table 3-1: Public Sewage Facilities

Facility	Receiving Stream	Design Flow (MGD)
Onancock	N. Branch of Onancock Creek	0.25
Tangier Island	Chesapeake Bay	0.10
Cape Charles	Cape Charles Harbor	0.25

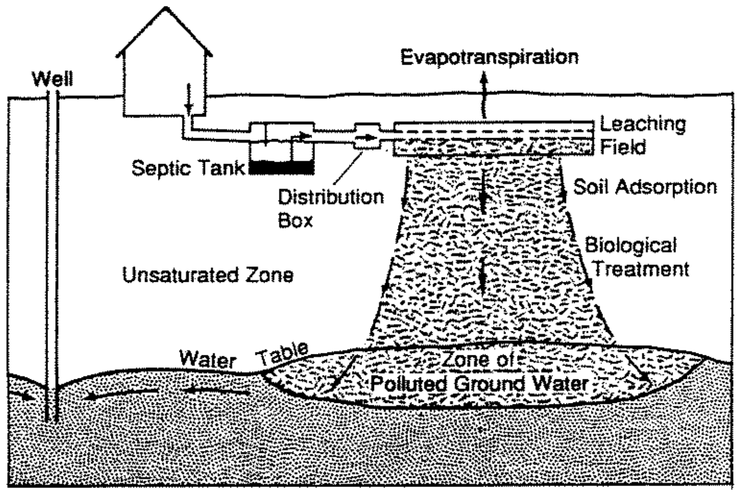
From a ground water quality point of view, these sewage facilities present very little threat to the resource since they discharge to surface bodies of water at the coasts rather than on land. Discharged water is not available for recharge to the surficial aquifer or to the deeper confined aquifers. However, these sources clearly present potential threats to estuarine water quality.

On-Site Septic Systems

Septic systems are the leading contributor to the total volume of waste discharged directly into the ground (more than a trillion gallons annually from residents in the U.S.), and according to the US EPA (1986), septic systems are the major source of ground water contamination. Contaminants introduced from septic systems include nitrate-nitrogen, coliform bacteria, viruses, and a variety of organic and inorganic chemicals from household products. In addition, sixty percent (60%) of the 23 million residential septic tanks in the United States are believed to be operating improperly (Weigmann and Kroehler, 1988).

Septic systems are comprised of a septic tank, distribution box, and a leaching facility. The septic tank provides for the separation of solids and liquids, during which time some waste is treated. The distribution box funnels waste to the leaching facility, where the liquid water is deposited into the soil. If septic tanks are not properly maintained by pumping every few years, solids may pass to the leaching facility causing plugging, backups into the dwelling, or breakouts of effluent on the land surface. Once this has occurred, corrective actions are expensive and may result in ground water contamination if septic cleaners containing solvents are utilized.

Figure 3-2: Septic System and Ground Water Contamination



Conventional septic systems provide only minimal treatment of wastewater, and release effluent contains approximately 40-60 mg/l nitrogen. As the effluent mixes with ground water and moves downgradient, the nitrogen becomes more dilute. Given local geologic conditions, a flow distance of several hundred feet is required to reduce concentrations to meet the drinking water standard of 10 mg/l for nitrate-nitrogen (see Section 9). The cumulative effects of numerous small septic systems may result in excessive nutrient concentrations in ground water and downgradient surface waters. These impacts are dependent upon locations of septic systems relative to wells and the overall septic system density.

As noted above, the public sewer systems on the Eastern Shore of Virginia serve just over 3,000 people out of a total of 44,000, and the majority of residents use private septic systems to dispose of human waste. In a 1986 study, the Virginia Water Project estimated that there were 12,105 year-round housing units in Accomack County and 5,008 in Northampton County which had septic tanks, cesspools, or other sewage disposal means (not public). It was also estimated that in both counties there was a total of 1,359 homes with failing or inadequate disposal systems. The results are summarized in the following table.

Table 3-2: Residential Disposal of Septic Wastes

	Year-round Housing Units	Estimated GPD
ACCOMACK COUNTY		
Served by public sewer	1,044	156,600
With septic tank or cesspool	10,077	1,511,550
With other sewage disposal means	2,028	304,200
NORTHAMPTON COUNTY		
Served by public sewer	934	140,100
With septic tank or cesspool	3,948	592,200
With other sewage disposal means	1,160	174,000
TOTAL	19,191	2,878,650

Source: *Water For Tomorrow*, Virginia Water Project, Inc., 1988

Based on calculations from the nitrogen loading section (Section 8), approximately 381,000 pounds of nitrogen are discharged to the ground water of the Eastern Shore from on-site septic systems per year.

Proper maintenance of septic systems includes periodic pumping of solids (septage) from the tank. On the Eastern Shore, the contents are brought to one of three privately-owned septage lagoons. These are described later in this section.

Virginia Pollution Discharge Elimination System (VPDES) Permits and Mass Drainfields

There are numerous industries that are required to obtain a discharge permit in order to dispose of wastewater. According to State Water Control Board Regulations, those applying for land application of sewage, sludge, or industrial waste must obtain a Virginia Pollution Abatement Permit (VPA). Discharging of pollutants from a point source to surface waters requires a Virginia Pollution Discharge Elimination System (VPDES) Permit. The major VPDES dischargers on the Eastern Shore of Virginia are Holly Farms, Perdue, and the Wallops Island Flight Facility. The remaining establishments have small design flows. Table 3-3 lists those industrial and public VPDES permit holders.

There are 76 facilities that dispose of waste water in mass drainfields. Mass drainfields are simply larger septic systems that are shared by more than one building, residence, or industry. Such facilities typically include restaurants, schools, and campgrounds, however they can also be associated with several single family residences. The discharge rates of these facilities are not high; in fact, combining all these facilities would not equal the discharge rate in gallons per day of Holly Farms alone. Table 3-4 identifies these facilities.

AGRICULTURE

Agricultural practices introduce two types of contaminants, pesticides and nitrate-nitrogen from fertilizers and livestock. These chemicals can pose serious threats to human health in excessive concentrations. Nitrates are particularly dangerous to infants. Ingesting too much nitrate-nitrogen can result in methemoglobinemia, or "blue baby syndrome". Asphyxiation can occur when the nitrate-nitrogen that is ingested is reduced to nitrite and is absorbed into the circulation system. Nitrite reacts with hemoglobin to produce a compound that does not carry oxygen, thus depriving an infant of oxygen. The EPA recommends that nitrate-nitrogen levels in drinking water be less than 10 mg/l.

The serious toxicity of pesticides has been widely reported in the cases of Agent Orange and DDT. On the Eastern Shore where private wells are commonly less than 300 feet deep, one pesticide, Aldicarb or Temik, has been detected in drinking water (Weigmann and Kroehler, 1988). Aldicarb is highly soluble and mobile in water. Agent Orange and DDT were banned decades ago. Aldicarb is no longer used.

Fertilizers

High application rates of commercial fertilizers over large areas of land have been shown to contribute nitrogen to the ground water in an agriculturally intensive region like the Eastern Shore. Publications and studies supporting this hypothesis are numerous. For reference, a selection of examples include: USGS, 1989, p. 38; EPA, 1990, pp. 125-128; Association of Ground Water Scientists and Engineers, 1989, p. 262; Miller, David A., 1980, pp. 430-431; *Ground Water Quality*

Protection, State and Local Strategies, 1986, p. 84, p. 145; *Ground Water Pollution News*, 1989,pp. 1-2. However, as stated on page 1-4 of this document, the average nitrogen concentration in the ground water was calculated to be 2.0 milligrams per liter. The national drinking water standard for nitrogen is 10 milligrams per liter. On the average, the shallow ground water quality is considered very good, however users down gradient from high nitrogen use may experience problems.

Farmers generally follow recommended fertilizer application amounts. This makes it possible to estimate the quantities of nitrogen fertilizers applied to each crop type. Using 1990 crop acreage figures, agricultural practices required approximately 5.8 million pounds of nitrogen in fertilizers. Table 3-5 presents a breakdown of nitrogen requirements by crop type. Approximately 6.7% of the land is fertilized with manure; the remainder is supplied by commercial fertilizer (Accomack County Extension Agent, J. Belote, personal communication, 1991). Out of a total of 165,000 acres of farmland, 94,000 are used for soybeans, a crop which requires no nitrogen fertilization because the plant is a nitrogen-fixer.

Current methods for the Eastern Shore recommend that fertilizer be applied in two stages: a small amount at planting, the rest after growth occurs. In the case of corn, this second application occurs when the plant has reached ankle height. The fertilizer is *side-dressed*, which means that it is dribbled on each row at each plant, so that a small amount is wasted in the soil. With the implementation of side-dressing and the new phased technique, the intention is to hold leaching of nitrogen to a minimal amount. However, USGS sampling that is representative of current and/or recent fertilization practices shows a concentration of 20-25 milligrams per liter (mg/l) nitrate-nitrogen in ground water beneath farm fields in the shallow flow system (G. Speiran, USGS, personal communication, 1991).

Historically, the number of farmers and the acres farmed have been declining since 1930. The type of crops grown has also changed. Whereas crops grown in the earlier half of this century were of the garden vegetable kind and required fertilizers, today's crops are mainly soybeans and are not fertilized. Still, significant amounts of fertilizers are presently used, as shown in Table 3-5. Also, both the Accomack and Northampton County Comprehensive Plans see agriculture as continuing to be the main land use in the future. Thus, although nitrogen fertilizer use has been decreasing, it remains relevant to look towards agriculture as a potential source of contamination to ground water, both from former and current practices. For this study, 89 and 79 lbs/acre were used as average nitrogen application rates in Accomack and Northampton counties respectively.

On a smaller scale, home owners in general use fertilizers as a part of lawn maintenance. Nitrogen loading from lawn fertilizers was studied by Nelson et al. in 1988. They determined that, on average, the homeowner applies 3 lbs. of nitrogen for every 1,000 square feet of lawn per year. With a leaching rate of 30%, 0.9 lbs. of nitrogen are leached into the ground water system for every 1000 square feet of lawn. On the Eastern Shore, lawn maintenance is not a high priority.

Pesticides

Pesticides include a wide variety of chemicals utilized for the control of animal pests, insects, fungi, and weeds. Factors which affect the level of risk for contamination include the specific chemical formulation, rates of application, timing of application, soil conditions, and hydrologic conditions. Those that have a low solubility, are degraded by sunlight, or react with water to produce new compounds are not likely to contaminate ground water.

Table 3-3: Facilities With Discharge Permits, Eastern Shore, Virginia

Accomack County

Facility Name	Ind/Mun	VPDES#	City	Receiving Stream	Plant Outfall Latitude	Plant Outfall Longitude	Flow (MGD) Design
Accomack Co. Nursing Home	M	VA0063606	Parksley	N. FORK PARKER CREEK TO METOMPKIN BAY	374537	753719	0.02
Bonawell Brothers Seafood	I	VA0004201	Saxis	POCOMOKE SOUND	375515	754350	*.001(4)
Chincoteague Fish Co.	I	VA0051462	Chincoteague	CHINCOTEAGUE CHANNEL	375600	752254	
Chincoteague WTP	I	VA0051756	Chincoteague	CHINCOTEAGUE CHANNEL	375605	752239	*-
Drewer & Son, Inc.	I	VA0081361	Saxis	STARLING CREEK	375512	754351	*.035,.018(4)
Edgerton, D. L. Fish Co.	I	VA0055239	Chincoteague	CHINCOTEAGUE CHANNEL	375612	752227	*(6)
Edgewood Mobile Home Park	M	VA0065196	New Church	TRIB TO TUNNEL'S MILL BR TO BULLBEGGER CRK	375709	753216	0.006
External Assist. Sys. Pension Trust	M	VA0078204	Route 13	TRIB TO TUNNEL'S MILL BR TO BULLBEGGER CRK	375655	753238	0.035
F&G Laundromat	I	VA0050920	Chincoteague	CHINCOTEAGUE CHANNEL	375600	752200	*0.005
Fisher, Lance G. Seafood Co., Inc.	I	VA0079448	Sanford	POCOMOKE SOUND	375500	754130	*.02(4)
Hills Oyster Farms	I	VA0058874	Chincoteague	DEEP HOLE CREEK TO LITTLE OYSTER BAY	375612	752057	*-
Holly Farms	I	VA0004049	Temperanceville	SANDY BOTTOM BRANCH TO HOLDENS CREEK	375325	753339	0.98
Kuzzens, Inc.	I	VA0081809	Painter	DITCH TO TAYLOR BRANCH TO OCCOHANNOCK CRK	373352	754803	
Lewis Oyster Co.	I	VA0057673	Saxis	STARLING CREEK TO POKOMOKE BAY	375511	754353	*no discharge
Marshall, William H. & Co.	I	VA0058360	Greenbackville	CHINCOTEAGUE BAY	380022	752326	
McCready Seafood	I	VA0095690	Chincoteague	EEK CREEK TO CHINCOTEAGUE BAY	375546	752232	*no discharge
Messick & Wessells - Nelsonia	I	VA0051403	Nelsonia	MUDDY CREEK	374916	753515	*0.005
Messick & Wessells - Onley	I	VA0053899	Onley	JOYNES BRANCH TO ONANCOCK CREEK	374134	754244	*0.005
Nandua Seafood Co., Inc.	I	VA0051161	Hacksneck	BACK CREEK TO NANDUA CREEK	373802	755252	
New Curch Energy Associates	I	VA0058521	New Church	UNNAMED TRIB TO PITTS CRK & POCOMOKE SOUND	375858	753254	
North Accomack Elem. School	M	VA0027162	Mappsville	UNN. TRIB TO MESSONGO CREEK TO POCOMOKE BAY	375128	753357	0.009
Onancock WTP	M	VA0021253	Onancock	N. BRANCH OF ONANCOCK CREEK	374258	754452	0.25
Perdue, Inc.	I	VA0003808	Accomac	PARKER CREEK TO METOMPKIN BAY	374410	753920	*1.7,.01(4)
Reed, Thomas E. - Seafood, In.	I	VA0005738	Chincoteague	DEEP HOLE CREEK	375621	752045	*(6)
Russell Fish Co.	I	VA0054003	Chincoteague	CHINCOTEAGUE CHANNEL	375559	752255	*(6)
South Accomack Elem. School	M	VA0027171	Melfa	UNNAMED TRIB TO WAREHOUSE POND	373920	754738	0.009
Stubbs, Reginald - Seafood Co, Inc.	I	VA0056421	Chincoteague	ASSATEAGUE CHANNEL	375501	752224	*.002(4)
Tangier WTP, Town of	M	VA0067423	Tangier	CHESAPEAKE BAY	374940	760035	0.1
Taylor, J.W. - Packing	I	VA0002992	Hallwood	MESSONGO CREEK TO POKOMOKE SOUND	375224	753529	0.1
Taylor & Fulton, Inc.	I	VA0082538	Mappsville	UNNAMED TRIB OF ASSOWOMAN CRK TO ASSOWOMA	375216	753319	
US - NASA Wallops Flight Facility	M	VA0024457	Wallops Island	HOG CREEK AND MOSQUITO CREEK	375550	752859	0.8 & 0.03
Vasiliou, Tom - STP	M	VA0082287	Oak Hall	TRIB TO TUNNEL'S MILL BR TO BULBEGGER CRK	375649	753233	0.001
VDOT - Rt. 13 Information Center	M	VA0023078	New Church	TRIB TO PITTS CREEK	375927	753213	0.02
VDH - Septage Lagoon - Boggs 01		VDHSLBO-01	Wachapreague	eventually to Nickawampus Crk. to Finney Creek	373738	754222	
VDH - Septage Lagoon - Bundick 01		VDHSLBU-01	Atlantic	" to Little Mosquito Creek	375538	753158	
VDH - Septage Lagoon - Bundick 02		VDHSLBU-02	Mappsburg	" to Machipomgo River	373405	754611	
Virginia Carolina Seafood Co., Inc.	I	VA0050997	Chincoteague	WATTS BAY	375432	752831	*-
Watkinson, Paul - Seafood	I	VA0050491	Saxis	POCOMOKE SOUND	375511	754354	
Whispering Pines Motel	M	VA0063371	Ticktown	UNNAMED TRIB TO DEEP CREEK	374320	754141	0.019

Table 3-3: Facilities With Discharge Permits, Eastern Shore, Virginia

Northampton County

Facility Name	Ind/Mun	VPDES#	City	Receiving Stream	Latitude	Longitude	Design
America House Motor Inn	M	VA0064921	Cape Charles	CHESAPEAKE BAY	370813	755807	0.02
American Original Corp.	I	VA0028797	Willis Wharf	PARTING CREEK TO MACHIPONGO RIVER	373045	754824	*.151(4)
Ballard Fish & Oyster Co.	I	VA0073679	Cheriton	KINGS CREEK	371658	760039	
Bayshore Concrete Prod. - Cape Charl.	I	VA0085677	Cape Charles	CAPE CHARLES HARBOR	371541	760131	
Bell, B.L. & Son	I	VA0004219	Oyster	OYSTER HARBOR	371709	755532	*.001(4)
Broad Street Laundry	I	VA0056502	Exmore	UNNAMED TRIB TO NASSAWADOX CREEK	373138	754930	
Broadwater Bay Seafood	I	VA0086126	Marionville	REDBANK CREEK TO HOG ISLAND BAY	372644	755033	
C&D Seafood	I	VA0002917	Oyster	OYSTER HARBOR	371715	755520	stopped dis.
Cape Charles Fish & Scallop, Inc.	I	VA0083283	Cape Charles	CAPE CHARLES HARBOR	371548	760100	
Cape Charles STP	M	VA0021288	Cape Charles	CAPE CHARLES HARBOR	371550	760100	0.25
Cheriton Laundry, Inc.	I	VA0051136	Cheriton	TRIB TO KINGS CREEK	371510	755735	
Eastville Laundromat	I	VA0054437	Eastville	OLD CASTLE CREEK	372038	755716	
Hamblin, J.E. - Seafood	I	VA0085693	Willis Wharf	PARTING CREEK TO MACHIPONGO RIVER	373130	754815	no discharge
KMC Foods, Inc.	I	VA0054119	Cheriton	HANBY BRANCH	371744	755733	*.
Machipongo Elem. School	M	VA0023817	Machipongo	UNNAMED TRIB TO JACOBUS CREEK	372429	755458	0.0208
Northampton-Accomack Memorial Hosp.	M	VA0027537	Nassawadox	WAREHOUSE CREEK TO NASSAWADOX CREEK	372839	755144	0.1
R&C Seafood Co.	I	VA0052264	Oyster	OYSTER SLIP	371715	755515	
Terry, H.M. - Co., Inc.	I	VA0003956	Willis Wharf	PARTING CREEK TO MACHIPONGO RIVER	373037	754821	*.0004(4)
West, John H.	I	VA0083437	Oyster	OYSTER HARBOR	371714	755522	

Source: * - figure comes from the Water Quality Mgt. Plan, SWCB, 1980. The remaining numbers are up to date (1991) from the SWCB. They do not have flows for industrial facilities except Holly Farms and Taylor Packing.

NOTE: (2) NPDES permit limits (1980)
(4) Estimated
(6) No limits - has an NPDES permit, but is not required to monitor (things like crab shedding)

Table 3-4: Facilities Using Mass Drainfields, Eastern Shore, Virginia

FACILITY NAME	TOWN	gallons per day
ACCOMACK COUNTY		
Virginia Landing	Quinby	90000
Tom's Cove	Accomack County	N/A
Trail's End Chincoteague Bay	Horntown	20000
Inlet View/Bunker Hill	N/A	N/A
Maddox Family Campground	Chincoteague	N/A
Pine Grove Campground	Chincoteague	N/A
Island Motor Inn	Chincoteague	6400
Refuge Motor Inn	Chincoteague	8800
Driftwood Motor Lodge	Chincoteague	6700
Chincoteague Motor Lodge	Chincoteague	9360
Waterside Motor Inn	Chincoteague	5700
Conner & McGee	Chincoteague	3300
Eastwind Townhouse	Chincoteague	9600
Assateague Inn	Chincoteague	4040
Don's Seafood Market & Restaurant	Chincoteague	4000
Seatag Lodge	Chincoteague	3000
Birchwood Motel, Inc.	Chincoteague	5400
Mulberry Street Townhouse	Chincoteague	9600
David P. Burgess Townhouse	Chincoteague	2700
R&S Dry Cleaning & Laundry	Chincoteague	N/A
McDonald's	Chincoteague	4000
ETTAS Restaurant	Chincoteague	4300
Landmark Crab House	Chincoteague	12500
R&S Laundromat	Chincoteague	5500
Mr. Chocolate Island Creamery	Chincoteague	4500
Oak Ridge Townhouse	Chincoteague	9000
Reed Triplexes	Chincoteague	2700
Chincoteague High School	Chincoteague	4000
Chincoteague Elementary	Chincoteague	2000
Parks Mobile Park	Oak Hall	7200
Pizza Hut	Oak Hall	2500
Arcadia High School	Accomac	6912
Wright's Seafood Restaurant	Atlantic	5000
Eastern Shore Seafood Production	Mappsville	1500
Byrd Foods	Mappsville	2000
Parksley Middle School	Parksley	2000
Red & White Stores	Parksley	1500
St. Paul's Lutheran School	Hallwood	3000
Bi County N.H. Nursing Center	Gargatha	6400
Accomac Office Complex	Accomac	9600
Mary N. Smith Middle School	Accomac	6000
Nandua High School	Onley	13826
Redwood Gables Restaurant	Onley	1800
Chesapeake Square Shopping Center	Onley	12000
Four Corners Plaza	Onley	12000
Eastern Shore Comm. College	Melfa	12000
Ches-Atlantic	Painter	1500

Table 3-4: **Facilities Using Mass Drainfields, Eastern Shore, Virginia**

FACILITY NAME	TOWN	gallons per day
Exmore Moose Lodge	Belle Haven	5000
Kuzzen's Ames Farm/ MLC	Painter	10500
Peerless Sterling Bull Camp	Modest Town	1200
Peerless Sterling Gargatha	Temperanceville	4500
Peerless Sterling Somers Farm	Bloxom	4500
Peerless Sterling Lakeview	Accomac	2600
Taylor & Fulton Inc.	Hallwood	9000
Taylor & Fulton Poulson House	Hallwood	1500
Virginia Farms/ Farm Exchange	Tasley	1500
Raymond A. Last-VPDES	Chincoteague	7650
Willett's Laundromat-VPDES	Lee Mont	3200

Accomack TOTAL **394988**

NORTHAMPTON COUNTY		
Cherrystone Holiday KOA	Northampton Co.	
Paul's Restaurant	Cheriton	3500
Capeville Campground	Northampon Co.	7500
Cheriton Day Care	Cheriton	2000
Trawler Seafood Restaurant	Exmore	700
Hardees	Exmore	2500
Silver Beach Camping	Silver Beach	2700
Broadway Academy	Exmore	3000
McDonald's	Nassawadox	4500
Anchor Motel Restaurant	Nassawadox	7640
Candlelight Restaurant	Birdsnest	5760
Holiday Motel	Townsend	18000
Burger Unlimited	Eastville	1500
Curtis Jones & Son Packing Sh	Eastville	2240
Kuzzens - Newman	Eastville	1800
Northampton High School	Eastville	16000
Cape Center Inc.	Capeville	2500
Holiday Acres Mobile Home Park	Weirwood	4800
Curtis Jones, Jr.	Bayford	1550
P.C. Kellam Potato Shed	Bridgetown	2000

Northampton TOTAL **90190**

GRAND TOTAL **485178**

Source: Virginia Tech (N/A indicates information not available)

The primary crops grown on the Eastern Shore of Virginia are soybeans, small grains (wheat and barley), potatoes, a variety of garden vegetables, and some ornamental plants. Several different types of pesticides are used depending on the pest, crop type, and application requirement. These factors significantly vary from farm to farm. Since there is no formal reporting of pesticide use, other than that of restricted-use pesticides, it is impossible to surmise the quantities and brands that are applied each year. As such, it need be stressed that the leaching of pesticides into the ground water is a threat to water quality and should be monitored.

Animal Wastes and Animal Carcasses

Animal wastes can contaminate ground water with nitrate-nitrogen and bacteria. In 1990, 21 million chickens were raised for poultry on the Eastern Shore of Virginia. Commercial poultry is the only significant livestock industry in the area, and is contained entirely within Accomack County. Commonly, contamination results from feedlots and improperly constructed or leaking manure storage piles or pits. Eastern Shore chicken growers apparently do not store wastes in such piles, but instead clean the chicken houses out once or twice yearly whereupon the manure is spread onto the farm land.

The Virginia State Extension Service reports that for every thousand chickens, one ton of poultry manure is produced (W. Weaver, Virginia Tech, personal communication, 1991). Tests done by Perdue and Tyson of 57 poultry litter samples indicate that nitrogen constitutes 44.73 pounds per ton of manure (Virginia Tech, 1991). Therefore, in 1990, 21,000 tons of poultry manure was produced, contributing a total of 940,000 pounds (470 tons) of nitrogen. During the year or so that manure remains in the chicken houses, some of the nitrogen volatizes. However, on a weight basis, chicken manure has the highest nutrient availability rate, compared to that of horse, cattle, and hog manure. While this makes it a good fertilizer, it is also most easily leached into ground water.

In large quantities, chicken carcasses can also pose a threat to ground water quality. A natural mortality rate of about 5% creates a need to dispose of dead chickens. Assuming that the majority of chickens die within the first two weeks after hatching, mortality of dead birds can be split between those that die at 0.5 lbs. and those that die weighing 3 lbs (C. Larsen, Virginia Tech Veterinary Medicine, personal communication, 1991). A 5% mortality rate accounts for 1.05 million dead birds in a year with a population of 21 million chickens. Multiplying half of those by 0.5 lbs. and half by 3 lbs. gives a yearly rate of 1.84 million lbs. of dead birds. Dead chickens are disposed of in one of four ways: burial, incineration, composting, or rendering for use as chicken or hog feed. In Accomack County, the Tyson rendering plant is available for growers. The facility is used by growers primarily during times of abnormally high mortality. An estimated 400,000 lbs. are brought to the rendering plant per year, but there is no data to support this. The one facility that had been incinerating has decided to compost, since it is more economical (J.R. Lewis, SCS, personal communication, 1991).The majority of dead birds are thus either buried or composted. Burial (or dumping in the woods, in some cases) poses a threat to ground water quality. Section 9 briefly discusses composting.

Table 3-5: Nitrogen Fertilizer Requirements, Eastern Shore of Virginia

ACCOMACK COUNTY

Crop Type	1990 Acreage	Recommended N in lbs/acre	lbs. N Used
Soybeans	62,000	0	0
Corn	5,500	75-175	687,500
Small grains	25,000	50-80	1,625,000
Irish potatoes	5,500	150	825,000
Sweet potatoes	1,600	50-75	100,000
Stalked tomatoes	2,200	80-90	187,000
Snap beans (Spring)	1,000	40-80	60,000
Snap beans (Fall)	2,300	40-80	138,000
Cucumbers (Spring)	1,000	100-125	112,500
Cucumbers (Fall)	2,000	100-125	225,000
Others	2,500	50-150	250,000
Ornamentals	700		
Grapes and Orchards	120		

Accomack Total N applied acres	47,420		4,210,000
Average N Application (lbs/acre)*		89	

NORTHAMPTON COUNTY

Crop Type	1990 Acreage	Recommended N in lbs/acre	lbs. N Used
Soybeans	32,000	0	0
Corn	500	75-175	62,500
Small grains	12,000	50-80	780,000
Cotton	1,300	60	78,000
Potatoes	2,500	50-150	250,000
Snap beans (Spring)	600	40-80	36,000
Snap beans (Fall)	600	40-80	36,000
Cucumbers (Spring)	800	100-125	90,000
Cucumbers (Fall)	800	100-125	90,000
Tomatoes	650	80-90	55,250
Peppers	100	100-130	11,500
Spinach	280	100-125	31,500
Nursery	840		
Others	1,000	50-150	100,000

Northampton Total N applied acres	20,570		1,620,750
Average N loading (lbs/acre)*		79	
TOTAL FERTILIZED	**67,990**		**5,830,750**
***Total Average Nitrogen Loading:** (Calculated by subtracting out Spring Acres Double Cropped)		**84**	

Sources: Fact Sheet - Accomack County, 1989 National Survey of Conservation Tillage Practices, personal conversation with Northampton Extension Agent Fred Diem, 2/26/91

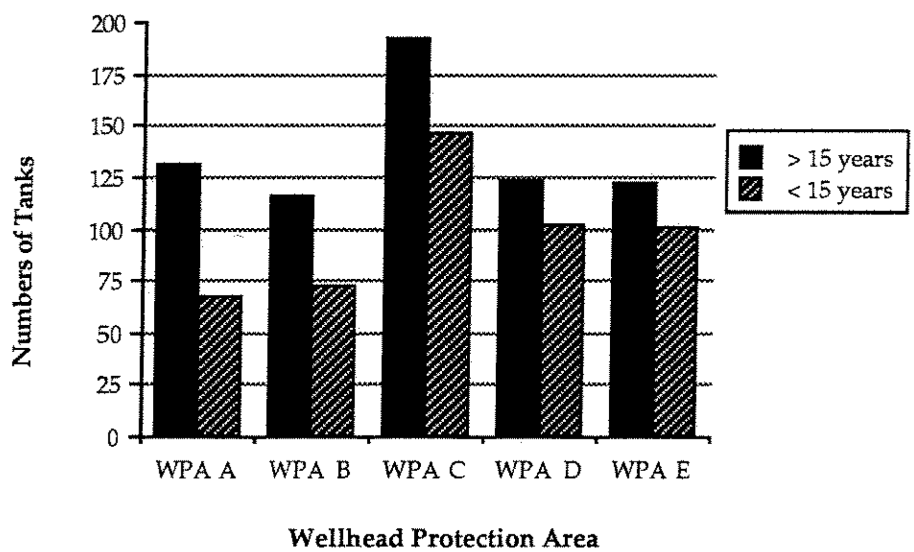
INDUSTRIAL/COMMERCIAL LAND USES

Underground Storage Tanks

Petroleum stored in underground storage systems is one of the greatest national threats to ground water quality. The EPA estimates that approximately one-third of all existing systems nationwide are currently "non-tight", or potentially leaking. The average expected life span of unprotected steel tanks in acidic soils is approximately 15 years, although new steel underground storage tanks are warranted for 30 years. After time, corrosion may begin, resulting in pin-hole sized leaks which may discharge hundreds of gallons of fuel over a several-month period. These leakage rates are small enough to go unnoticed to the tank owner for several months, but are large enough to cause significant ground water contamination problems. Gasoline contains a variety of components including benzene, toluene, and xylene, all which are known to have negative health affects. Newer tanks are being constructed with materials resistant to corrosion and with cathodic protection, which is aimed at decreasing the likelihood of leakage.

A total of 1,154 underground storage tanks are located in Accomack and Northampton Counties. Of these, 684 or (59%) are over 15 years old. The majority of all storage tanks store gasoline and are made of steel. Together, they have a storage capacity of 4,462,347 gallons.

Figure 3-4: Underground Storage Tanks Broken Down By Age and Wellhead Protection Area, Eastern Shore of Virginia



Source: Virginia State Water Control Board

Underground storage tanks were grouped by Wellhead Protection Area (WPA) in Table 3-6. WPA's are introduced and described in Section 5. WPA C, which covers the largest land area, also has the greatest number of underground storage tanks, with a total of 329. The remaining wellhead protection areas all contain close to 200 tanks. The town of Chincoteague, located in WPA A, contains 129 tanks which is the most located in any one town. WPA A also has the highest percentage of storage tanks older than fifteen years.

State Water Control Board records indicate that there have been leakage problems in several tanks in the two counties. Of the total, 3.6% of the tanks in Accomack and Northampton Counties have been reported as leaking. As of July 3, 1991, there are twenty-nine contaminated sites in Accomack County, and twelve contaminated sites in Northampton County. A column in Table 3-6 on the next page identifies the leaking tanks by town and wellhead protection area. WPA A has the highest percentage of leaking underground storage tanks, with 9 out of 199 tanks leaking (4.5%). According to the SWCB, seven tanks in Accomack County and one in Northampton County have been closed and are no longer leaking. Only two tanks in Accomack County have a monitoring program underway. It may be of interest to determine which of the leaking and non-leaking tanks lie on the spine recharge area, and install monitoring programs for those tanks.

TOXIC CHEMICALS

A wide variety of commercial and industrial land uses represent contamination threats to ground water. Small scale businesses such as auto body shops or dry-cleaning establishments, which may not be regulated by federal or state laws, utilize significant quantities of toxic chemicals such as solvents. Accidental or inappropriate disposal of hazardous wastes, even in small quantities, may result in ground water contamination exceeding state and federal drinking water standards. For example, many of the drinking water standards for volatile organic compounds (VOC's) are in the low parts-per-billion range.

Industries are required to report use and manufacturing of chemicals under several federal and state laws. EPA's Toxic Substances Control Act (TSCA, P.L. 94-469) requires that all manufacturers or importers of chemical substances be identified. Under the Superfund Amendments and Reauthorization Act (SARA, 1986), specific chemicals and amounts used must be reported. In Virginia, the Toxic Substances Information Act of 1976 requires that all businesses must report all chemicals that are manufactured or used in the manufacturing process. Reports must be updated annually.

On the Eastern Shore of Virginia, there are no Superfund or toxic dump sites. Several industries do use toxic materials, however. Tables 3-7 and 3-8 identify these industries as reported separately to the State and to EPA.

Table 3-6: Underground Storage Tanks by Wellhead Protection Area

WPA	TOWN	NUMBERS COUNT	NUMBERS LEAKING	TANK TYPE STEEL	TANK TYPE F.GLASS	TANK TYPE UNKN.	PRODUCT DIESEL	PRODUCT GAS	PRODUCT KERO	PRODUCT F.OIL	PRODUCT U.OIL	1000'S GAL CAPACITY	AGE >15yrs	AGE <15yrs
ACCOMACK COUNTY														
A	CHINCOTEAGUE	129	2	126	2	1	9	54	11	52	1	152.955	87	42
	GREENBACKVILLE	15	0	15	0	0	5	10	0	0	0	10.25	12	3
	HORNTOWN	12	0	12	0	0	0	4	0	8	0	10.85	10	2
	NEW CHURCH	20	3	20	0	0	3	13	1	1	0	90.9	9	11
	WALLOPS STATION	3	4	3	0	0	2	0	0	0	1	12.55	3	0
	WATTSVILLE	20	0	20	0	0	2	15	1	2	0	80.8	10	10
	total	199	9	196	2	1	21	96	13	63	2	358.305	131	68
B	ATLANTIC	18	0	18	0	0	1	8	4	5	0	17.35	11	7
	HALLWOOD	11	1	8	0	3	0	5	1	2	0	7.65	9	2
	HORSEY	1	0	1	0	0	0	1	0	0	0	1	0	1
	MAPPSVILLE	7	1	7	0	0	0	6	1	0	0	15.5	6	1
	MEARS	3	0	3	0	0	1	2	0	0	0	1.38	0	3
	NELSONIA	21	1	19	0	2	1	16	0	1	0	79.55	11	10
	OAK HALL	33	0	32	0	1	3	24	4	1	1	90.55	11	22
	TEMPERANCEVILLE	36	2	34	0	2	8	16	1	5	3	166.05	25	11
	WALLOPS ISLAND	56	0	47	9	0	24	21	1	5	0	2137.132	40	16
	WITHAMS	3	1	3	0	0	0	2	0	1	0	1.65	3	0
	total	189	6	172	9	8	38	101	12	20	4	2517.812	116	73
C	ACCOMAC	81	1	78	1	2	11	40	11	8	3	173.64	56	25
	BLOXOM	14	1	13	0	1	4	8	1	1	0	19.93	7	7
	CENTERVILLE	5	0	5	0	0	0	5	0	0	0	16	5	0
	GREENBUSH	7	0	6	0	1	0	6	0	0	0	4.6	6	1
	LEEMONT	4	0	4	0	0	0	2	1	1	0	2.4	4	0
	LOCUSTVILLE	3	0	3	0	0	0	2	1	0	0	1.22	3	0
	MELFA	31	1	30	0	1	6	23	1	0	0	60.2	16	24
	ONANCOCK	59	1	58	0	1	9	37	5	6	0	95.9	22	37
	ONLEY	41	2	40	0	1	4	26	4	3	2	106.8	26	15
	PARKSLEY	62	3	60	2	0	6	40	7	4	0	113.005	31	31
	TASLEY	22	1	21	0	1	8	8	2	0	2	37.925	16	6
	total	329	10	318	3	8	48	197	33	23	7	631.62	192	146
D	BELLE HAVEN	23	1	23	0	0	6	15	2	0	0	84.08	12	11
	CRADDOCKVILLE	10	0	10	0	0	3	6	1	0	0	7.05	9	1
	DAVIS WHARF	4	0	4	0	0	1	3	0	0	0	2.6	0	4
	KELLER	15	0	13	0	2	2	9	2	0	1	24.63	8	7
	MIDDLESEX	3	0	3	0	0	2	0	1	0	0	20.5	0	3
	PAINTER	26	1	26	0	0	5	15	4	1	0	36.7	12	14
	PUNGOTEAGUE	5	0	5	0	0	0	5	0	0	0	2.75	5	0
	QUINBY	4	0	4	0	0	1	3	0	0	0	2.65	0	4
	WACHAPREAGUE	8	0	6	0	2	1	5	0	0	0	11.55	5	3
	HARBORTON	5	1	5	0	0	1	2	1	0	0	3.65	2	3
	total	100.5	3	96.5	0	4	21.5	62	10.5	1	1	194.335	52	48.5
OUT of WPA	SANFORD	3	0	3	0	0	0	2	1	0	0	1.83	3	0
OUT of WPA	SAXIS	13	1	13	0	0	4	8	1	0	0	9.6	7	6
COUNTY TOTAL		836	29	801	14	21	133	467	71	107	14	3715.327	502	343
NORTHAMPTON COUNTY														
D	BAYFORD	4	0	4	0	0	1	2	0	0	0	2.2	2	2
	BIRDS NEST	3	0	3	0	0	0	2	0	1	0	1.1	2	1
	BRIDGETOWN	1	0	1	0	0	0	1	0	0	0	1	0	1
	EXMORE	77	4	71	3	3	10	53	7	2	2	142.04	45	32
	JAMESVILLE	4	0	4	0	0	0	1	0	1	0	2.2	4	0
	NASSAWADOX	27	0	25	0	2	2	14	3	1	0	62.03	14	13
	SILVER BEACH	1	0	1	0	0	1	0	0	0	0	0.275	1	0
	WEIRWOOD	7	1	7	0	0	1	6	0	0	0	17.1	2	5
	WILLIS WHARF	1	0	1	0	0	1	0	0	0	0	2	1	0
	CHURCHNECK	1	0	1	0	0	0	0	0	1	0	1	1	0
	total	126	5	118	3	5	16	79	10	6	2	230.945	72	54
E	CAPE CHARLES	84	2	80	1	3	16	47	9	3	0	226.255	49	36
	CAPEVILLE	16	0	16	0	0	5	10	1	0	0	51.55	9	7
	CHERITON	30	2	30	0	0	2	24	3	1	0	67.63	11	19
	CHESAPEAKE	8	0	8	0	0	0	3	0	0	0	10	8	0
	DALBYS	3	0	3	0	0	0	2	1	0	0	8.55	1	2
	EASTVILLE	30	1	29	0	1	3	22	4	0	0	86.94	14	16
	MACHIPONGO	12	1	12	0	0	1	10	1	0	0	30.05	7	5
	SEAVIEW	5	0	5	0	0	0	4	0	1	0	16.55	5	0
	TOWNSEND	4	0	4	0	0	0	3	0	0	1	18.55	4	0
	total	192	6	187	1	4	27	125	19	5	1	516.075	108	85
COUNTY TOTAL		318	12	305	4	9	43	204	29	11	3	747.02	180	139
GRAND TOTAL		1154	41	1106	18	30	176	671	100	118	17	4462.347	682	482

Source: Virginia State Water Control Board

SOLID WASTE DISPOSAL

The predominant form of solid waste disposal on the Eastern Shore is through landfilling. There are currently two public landfills in Accomack County and one public and one private landfill in Northampton County. Two additional landfills have been filled and are now closed. They are located in Chincoteague and northern Accomack County. Incorporated towns in the Accomack-Northampton Planning District utilize their respective county landfills for solid waste needs. Locations of landfills in both counties are included in Figure 3-5.

The Northampton County landfill was opened in 1985 and is expected to be in service for 20 years. It is located less than a mile north of the village of Oyster. The entire site is approximately 174 acres, with the landfill portion containing 78 acres. The landfill is to be used in phases and is divided into four cells, each of which is expected accept waste for five years. This landfill is lined and has a leachate collection system. Sampling is conducted quarterly from six shallow monitoring wells and the leachate pond. Without conducting a detailed analysis, a review of the sampling data revealed that the wells located downgradient from the landfill are displaying poorer water quality than the background well. Monitoring of the ground water quality should continue at this landfill with the consideration of the installation of wells screened deeper in the aquifer than the current wells. The inclusion of these wells will help to determine if any leachate is migrating in a vertical direction and recharging the Yorktown-Eastover aquifer.

The southern landfill in Accomack County is located at Bobtown. Opened in 1973, 86 acres of its 113-acre property are filled. Virginia Department of Waste Management, Solid Waste Management Regulations require that any solid waste management facility for which a permit was issued prior to the effective date of the new regulations comply with all of the provisions of the regulations by July 1, 1994. The regulations now require all landfills to be lined. The southern landfill was constructed without a liner and old landfills must either be brought up to standard or be closed by 1992.

The northern landfill in Accomack County is located approximately one mile north of Temperanceville. It was permitted for use in 1985 and comprises 150 acres. The landfill has been divided into three adjacent, independent, fill areas and is estimated to handle approximately 22 tons of waste per day. At the time of construction, the projected life span of the landfill was between 20 and 30 years. At this time, approximately 9 acres have been used. Should an accident occur, this landfill poses a significant threat to the quality of ground water on the Eastern Shore since it is located directly on the spine recharge area. Any leakage of leachate from the landfill into the ground water could potentially reach the lower Yorktown-Eastover aquifer. The Northern Landfill is lined, and has two components which help reduce the chance of contamination to the ground water. First, there is a stormwater management system in place to catch water contributed by rain. The landfill is also equipped with a leachate system which collects liquids originating in the waste, all of which are stored in 10,000 gallon tanks. When the tanks fill, they are brought to a wastewater treatment plant in Onancock. This landfill has fourteen monitoring wells installed to collect ground water quality samples. These wells are sampled quarterly for a range of chemical parameters. Currently, the samples are not showing any signs of significant contamination of the ground water. According to the Director of Public Works for Accomack County,Joe DeMarino, there have been "no problems" with any sample results from the monitoring wells (personal conversation, 7/24/91). Sampling should continue for both the northern landfill which is currently in operation and the southern landfill which is planned to be closed. Monitoring wells with screens located deeper in the aquifer should be installed to assess any vertical migration of leachate to the Yorktown-Eastover aquifer. The sample results are available for review in the Department of Public Works office in Accomac.

Table 3-7: EPA List of Active Generators and Transfer Storage Disposal Facilities, Accomack and Northampton Counties

ID#	Facility Name	Location	Date reported	Generation of Non-Acutely hazardous waste (kg/mo.)			Other
				< 100	100-999	> 1000	
ACCOMACK COUNTY							
VA9143609148	Chincoteague National Wildlife Refuge	Chincoteague	2/4/87		X		
VAD023812878	Davis Auto Center, Inc.	New Church	10/28/86		X		
VA7800020888	GSFC/NASA Wallops Flight Facility	Wallops Island	4/7/89		X		
VAD044983658	Holly Farms Poultry Ind. Inc.	Temperanceville	10/28/86		X		
VA8800010763	NASA Wallops Flight Center	Wallops Island	8/15/80			X	Land Disposal
VAD023864127	Parks Motor Co. Inc.	Parksley	10/28/86		X		
VAD980715312	Perdue Inc.	Accomac	12/29/86		X		
VAD982578155	VA Dept. of Transportation	Accomac	1/12/89		X		
VAD982677874	Vaarng-Armory-Onancock	Onancock	5/14/90		X		
VAD988172151	Whittaker Bioproducts	Chincoteague	7/5/90			X	
NORTHAMPTON COUNTY							
VAD982709784	Alban Engine Power	Cape Charles	12/22/89		X		
VAD982565830	Bayshore Concrete Products	Cape Charles	1/15/88		X		
VA2572124483	Cape Charles Air Force Station*	Cape Charles	8/18/80			X	
VAD000650531	Municipal Corp. of Cape Charles	Cape Charles	8/18/80			X	
VAD023725572	Center Chevorlet, Inc.	Exmore	11/24/86			X	
VAD009091620	Chesapeake Bay Bridge-Tunnel	Wise Point	3/13/90			X	
VAD988186144	Chesapeake Hardware Products	Chesapeake	10/2/90		X		
VAD051365120	Eastern Shore Railroad, Inc.	Cape Charles	7/7/86			X	
VAD988194429	Exxon Co. USA #26457	Exmore	3/28/91	X			

* - Currently the Eastern Shore National Wildlife Refuge.
Source: US EPA, Region III Office, Philadelphia

Table 3-8: Virginia Toxic Substances Chemical Inventory, Accomack and Northampton Counties

			SUBSTANCE				Amount Used - (kg/yr)				
Facility Name	Latitude	Longitude	Acid	Base	Organic	Nutrient	10-100	101-1000	1,001-10,000	10,001-100,000	>100,000
ACCOMACK COUNTY											
Harry Drummond, Inc.	373325	754920			X		X				
Eastern Shore Printers	374247	754435	X	X	X		X				
A J Gray & Son, Inc.	375528	753331	X		X	X	X	X		X	
Helena Chemical Co.	374238	754216	X			X	X	X		X	X
New Church Energy Associates	375900	753200			X						X
Stony Point Decoys	375647	753218			X			X			
NORTHAMPTON COUNTY											
Bayshore Concrete Products Corp	371545	760130			X			X	X		
Lebanon Chemical Corp.	371606	755424	X						X	X	X

Source: Virginia Department of Health, Bureau of Toxic Substances

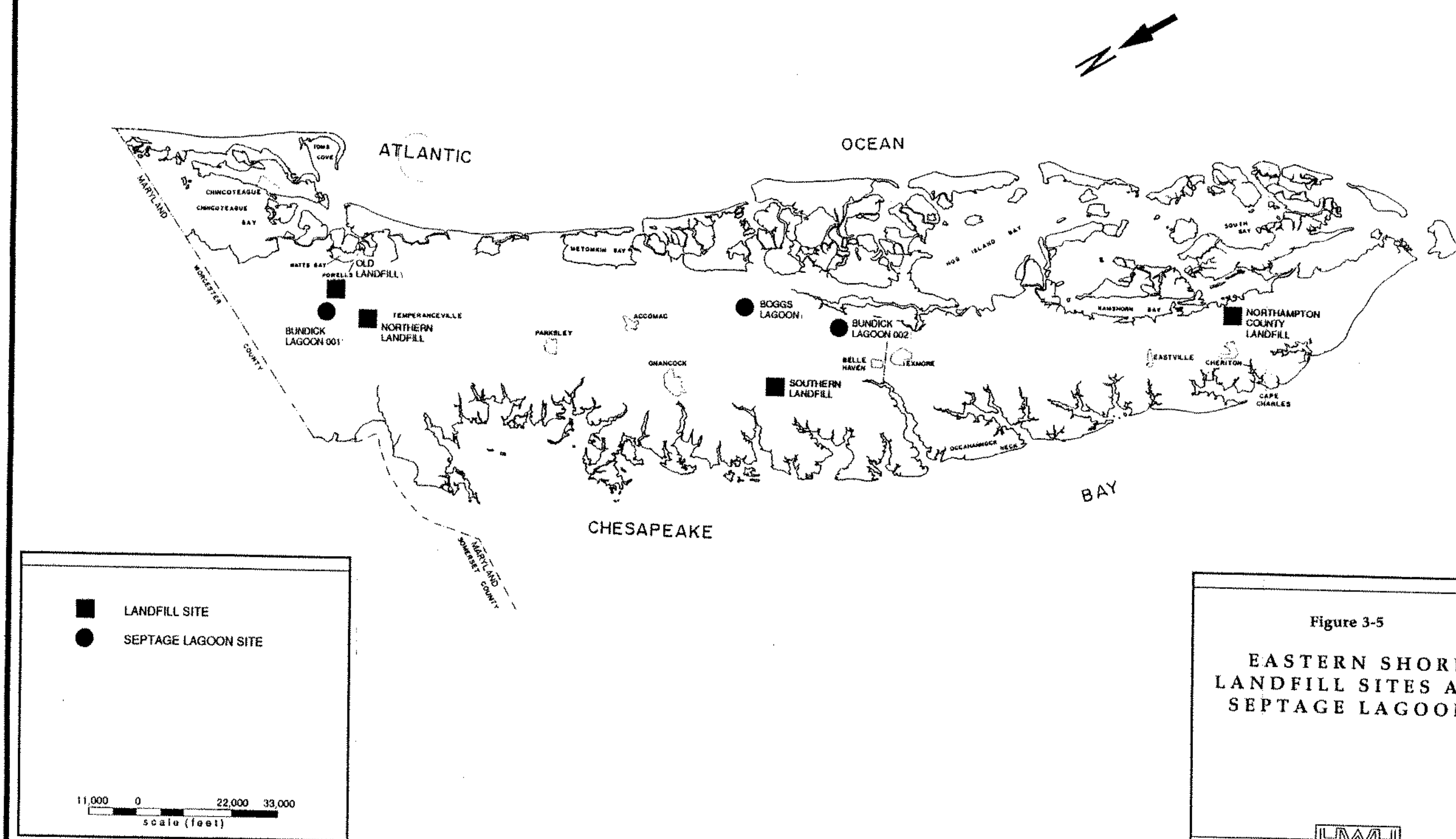


Figure 3-5

EASTERN SHORE LANDFILL SITES AND SEPTAGE LAGOONS

HWH

SEPTAGE DISPOSAL

There are three anaerobic septage lagoons located in the two counties which are owned by two well-drilling companies (Figure 3-5). The lagoons are in wooded areas which are set aside as receptacles for septage. When septic tanks are periodically emptied, the waste gets dumped into these lagoons. Lagoons are usually earth-diked ponds, varying in shape and size, and are relatively maintenance-free. The entire lagoon stabilizes biodegradable organics under anaerobic conditions where the rate of reaction or stabilization is slow. Bad odors are a characteristic of these areas, and lagoons can threaten the ground water quality because they contain concentrations of organisms close to that of primary waste water sludge.

One of the companies which owns the lagoon estimates that their lagoon receives waste from 1,000 septic tanks a year. The other reports that its two lagoons combined receive an average of 75,000 gallons of septage per month. According to the Northampton County Ordinance, septic tanks must be emptied every five years. This follows the recommendation of the Chesapeake Bay Preservation Act. As yet, Accomack has not adopted this as policy and has no set standard for emptying-intervals of septic tanks. Undoubtedly with the enforcement of the Preservation Act, these lagoons will be used more heavily.

In Virginia, septage was essentially unregulated prior to 1982. Now septage is subject to on-site sewage handling and disposal regulations requiring pumpers to take septage to approved facilities. Such facilities are municipal treatment plants or state-approved lagoons, which are aerobically digested by bacteria. In counties with population densities of less than 100 persons per square mile, septage can be directly applied to the land with the approval of several boards (Weigmann and Kroehler, 1988). The Eastern Shore lagoons are not required to follow the 1982 legislation because of a grandfather clause. The lagoons are not lined, and thus pose a threat to the ground water supply. In particular, one of the lagoons in Accomack County lies within the spine recharge area. As with the landfill, the location of this lagoon in this special area poses a serious threat to ground water quality as deep as the lower confined aquifer. No contamination has been documented to date, and it is speculated that sediments have lined the bottom of the lagoon (J. Green, personal communication, 1991).

Review of ground water samples taken in 1985 from two monitoring wells located at the private lagoons in Accomack County revealed that as of that time there was no impact on ground water quality from these lagoons. In order to be assured that water quality beneath the site is not impacted, ground water quality monitoring should continue, and the sampling should include analysis for organic compounds. In addition, the ground water flow direction should be determined to ensure that the wells are indeed capturing recharge from the lagoons.

EXISTING LAND USE

4

SECTION 4 - EXISTING LAND USE

PURPOSE

The purpose of this section of the report is to appraise the existing land use conditions on the Eastern Shore of Virginia and to analyze the ways which land use distribution, controls, and other factors may have an overall effect on ground water. The use and good condition of the ground water supply is critical for the continued viability of human habitation in the region since ground water is the only source of potable water. In the buildout and nitrogen loading portion of this study, scenarios for assessing the impacts of land use development on ground water are explored. In conjunction, land use instruments which govern the development within the spine recharge area and wellhead protection areas must also be analyzed.

OVERALL STATUS OF LAND USE CONTROLS

Currently, both Accomack and Northampton Counties have recently revised their comprehensive land use plans (Accomack in 1989, Northampton in 1990). Each county also has a zoning ordinance, both of which are under revision. In this report, the comprehensive plans are the primary sources for general information on existing land use. Separate from the county bylaws, there are town plans and zoning ordinances for 12 incorporated towns in the region--8 in Accomack and 4 in Northampton. Two other towns, one in each county, have zoning ordinances, but no plan. Eight of these towns also have subdivision ordinances. Since the percent of overall land area of the region they affect is relatively small, they are not examined separately here.

Each county's comprehensive plan is designed to set development policy only, as they do not have legally enforceable land use maps. The Accomack Plan states that, "adoption of the Comprehensive Plan is only the beginning of the planning process. To derive any benefit from the plan, steps must be taken toward its implementation. The principal instruments of plan implementation are the zoning and subdivision ordinances, and sufficient staffing of the Accomack County Department of Environmental Affairs to effectively administer these ordinances" (Accomack County Comprehensive Plan, 1989, p. i-4).

The Northampton plan states that the "phase of the Comprehensive Plan that addresses private sector issues is the land use plan, together with the regulatory ordinances and policies adopted by local government. The Land Use Plan is the umbrella document that sets the pattern and provides overall guidance" (Northampton County Comprehensive Plan, 1990, p. II-9). The Northampton Plan further states that it "presents a Land Use Plan for Northampton County. The Plan has been prepared in coordination with updated land development regulations to address issues with which the county is faced in the late 1980's and which will likely continue during the 1990's. Northampton County is currently considering significant changes to its existing zoning ordinance.

The advisory nature of both county plans presents a conservative approach to the interpretation of Virginia Law in defining the purpose of the Comprehensive Plan and Land Use Plan. In comparison, the counties of Fairfax and Loudoun, which are facing substantial issues of growth including traffic and transportation problems and a severe strain on county public facilities, have developed comprehensive plans (particularly the land use plan and map) that are enforceable legal documents which can supersede zoning and other development regulations in many cases. In these Northern Virginia cases, the long-range impacts of future county development have been assessed according to plan projections of population, employment, land-use density and other factors to assess future county service and facility needs, funding requirements, and needed changes in other county regulatory instruments.

Because Eastern Shore of Virginia Plans are primarily to be carried out through the zoning and related ordinances, such as subdivision, these ordinances will be the primary focus of this section.

There are other factors that affect existing land use development on the Eastern Shore. These include regulations for wells, septic systems, forestry, agriculture, mining, and stream and shore bank protection. While such regulations have been in effect for varying periods of time and have been enforced to varying degrees, many regulations are fairly recent and their effects thus far on the long-term development of existing land use is thought to be relatively slight. Therefore it is only necessary to assess these regulations in terms of their effects in the future. In addition, the recently enacted Chesapeake Bay Preservation Act is a comprehensive and potentially far-reaching instrument that can have substantial effects on future land use. Both counties have guidelines in place to comply with the Act. Potential effects of the Act on ground water are examined at the end of this chapter.

EXISTING PATTERNS OF LAND USE

Agricultural land under irrigation, residential land in subdivisions, and industrial land occupied by industries that are intensive water users are the most significant factors of existing land use patterns that influence ground water withdrawal on the Eastern Shore. All of these factors will be examined in the context of existing land use in the region.

Table 4-1 summarizes the existing distribution of land in broad categories within the region. The categories of land use as defined in the Accomack and Northampton Plans do not completely coincide, but they are close enough that a broad land use profile of the region can be assembled. The table illuminates several contrasts between the two counties:

1) nearly 57% of all land in the region lies in Accomack County;
2) nearly 70% of all land in agriculture and forestry uses is located in Accomack;
3) nearly 66% of all land in marshes, wetlands and tidal areas is located in Northampton;
4) nearly 78% of all residential land lies in Accomack;
5) over 96% of all industrial land lies in Accomack.

Thus, the overall picture of land use in the region is one of more intense development in Accomack County, even in the land use categories often viewed as land extensive such as agriculture and woodlands. Agricultural, residential, and industrial uses could have potentially significant affects for ground water consumption in Accomack County. Within Northampton County, agricultural and residential uses are worth a closer look.

Table 4-1: Existing Land Use - Accomack and Northampton

Category	Northampton (Acres)	%	Accomack (Acres)	%	Total (Acres)	%
Agriculture & Woodlands	87,025	37.8	198,879	65.3	285,904	53.2
Residential	3,800	1.6	13,361	4.4	17,161	3.2
Commercial	123	0.1	407	0.1	530	0.1
Industrial	102	0.1	2,454	0.8	2,556	0.5
Institutional	715	0.3	840	0.3	4,111	0.8
Recreation	177	0.1	8,332	2.7	8,509	1.6
Marsh/Tidal	135,500	58.9	70,371	23.1	205,871	38.3
Other*	2,505	1.1	9,996	3.3	12,501	2.3
TOTAL	**229,947**	**100.0**	**304,640**	**100.0**	**537,143**	**100.0**

*In Northampton, roads and utilities are included; in Accomack, figure includes land identified as vacant, but not roads and utilities. Vacant land is not identified in Northampton.

Source: Northampton and Accomack Comprehensive Plans (1990, 1989)

LAND USE AND OPEN SPACE REQUIREMENTS FOR WATER AND SEWER

There are three general conditions under which drinking water and waste water can be provided on a building lot. In some cases there are central or "public" systems for water and sewer, including a central or common septic field for sewage disposal. In others, a central water system is available, but individual sewerage, usually a septic system, must be located on each lot. The third case is the most common on the Eastern Shore of Virginia, where both individual water from a well and individual sewerage are provided on each lot.

An individual septic system, including a holding tank and drain field, can occupy about 5,000 square feet when sized for a three or four bedroom, two bath house. Setback distances are required for wells from building foundations and from the septic system, and this adds another several thousand square feet. Current subdivision regulations in Northampton require, and the Accomack Comprehensive Plan recommends, that space be available on each lot for a reserve drainfield. This adds another requirement for unobstructed open space, perhaps another 4,000 square feet.

Land above septic systems cannot be used for other purposes such as plantings (excluding grass), walkways, driveways, parking areas, or any other use that would possibly result in the blockage of, or damage to, the system. Additionally, "protection areas" around wellheads are now being set up to help assure that contaminants will not penetrate the well and seep into the ground water below.

When the requirements for wellhead protection, primary septic system and backup drainfield are taken together, there may be a need for upwards of 11,000 square feet on each lot devoted to these systems. A septic system and backup drainfield, when used in conjunction with a central water system, may still require 8 to 9,000 square feet or more. These figures should be kept in mind when developable land in the two counties are examined in the following pages.

EXISTING LAND USE IN ACCOMACK COUNTY

Tables 4-2 and 4-3 summarize existing zoning controls in both Eastern Shore counties.

Agriculture and Agricultural Districts

Agriculture in Accomack County accounts for over 65% of all land use. Potential problems exist for ground water conditions in such areas from the improper application of pesticides and fertilizers, inadequate handling of animal wastes, poor methods of retaining soils, and other land-based conditions that can affect ground water through runoff of, or percolation from, surface water to ground water recharge areas.

There are several conditions in the Accomack agricultural areas (A-districts) that are noteworthy. First, large amounts of such land under active crop production are irrigated. Improper irrigation accelerates the removal of soils, pesticides, fertilizers, and other matter from irrigated land. Some of the chemicals may remain dissolved in water and percolate through to the ground water.

Second, the minimum lot requirement under Accomack zoning and subdivision regulations is 30,000 square feet per lot (Table 4-3). While only single family residences are permitted as a matter of right in the A-districts, there are no discernable restrictions on subdivisions. Thus, subdivision of land in agricultural districts into 30,000 square foot lots, is possible. Under current zoning regulations, up to 46 percent or 13,800 square feet of each lot can be covered by a primary structure. There are no limitations on coverage of secondary or auxiliary structures except those established by setback requirements. Such structures could easily add another 3-4,000 square feet of impervious surface. The remaining 11-12,000 square feet of open area may be adequate for a well and septic system, but the relatively small lot size and possibility of substantial numbers of such lots close together raises the possibility of deleterious effects on the ground water.

A third land condition in agricultural districts is the frequent juxtaposition of agricultural and forestry uses with areas which often have direct relationships with ground water sources. These areas can include bogs or marshy areas; exposed, sloping banks; streams or other water bodies; wellhead areas; natural springs; pits used for dry waste or garbage disposal; and septage lagoons.

Housing and Residential Districts

Residential uses account for slightly less than 4.5% of land uses in Accomack County, but they account for over 13,000 acres of land area. Currently, conditions in residential areas (R-districts) that could adversely affect ground water include potentially high subdivision densities, lack of sufficient space on each lot for proper wastewater disposal, and high densities of multi-family buildings on relatively small lots.

There are at least three densities of single family usage permitted in the R-District. As seen in Table 4-3 if a lot has central water and either public or private sewer, the lot area requirement is 10,000 square feet. If the lot has either central water or central sewer, but not both, the lot size must be increased to at least 15,000 square feet. If the lot must accommodate both its own water and sewer systems, then it cannot be less than 20,000 square feet in size. Setback requirements mean that about 60 to 70 percent of these lots that are 10,000-12,000 square feet may not be occupied by the primary structure. However, ancillary structures, driveways and other features often found in residential areas, such as walks, trees, and other landscaping, can cut down the amount of open space available for well and septic areas. Thus, as lot size increases substantially to accommodate individual water and sewer systems, the amount of space usable to such systems may only increase marginally, if at all, and the percentage of such space relative to lot size actually decreases.

Table 4-2: Land Use Category by Zoning District, Eastern Shore of Virginia

Use Category	Districts: Accomack A	R	B	I	BI	Northampton AR	R20	R11	RM	MHP	CN	CG	CW	PI	IL
Ag./Forestry	x	a	a		e	xe	xe							x	
Preserve	x	a	a		x	x	x							x	
Lodge/Club	x	a	x			x	x		e				x		
Rec./Private	x	e	a			x		e	e	xe		x	x		
Rec./Public	e	x	a			x		e		xe		x	x		
Dock, Private	x	a	a			x							x		
Dock, Public	a	e	a			x							x		
Single Family	x	x	e			x	x	x	x						
Multi-Family	e	e	a			x	x	x	x	x	x	x	xe		
Mobile Home	e	e	e			xe	xe	xe		x					
Mobile Home Park	e	e	e							x					
Camp/Trailer	e	e	a			e							x		
Seas. Housing	a	a	a		x	x									
Home Office	x	x	a			x	x	x	x						
School Library	x	x	x			e	e	x	e		x	x		x	
Religious	x	x	x			x	x	x	x	x					
Cemetery	x	a	a			e									
Post Office	x	x	x				e	x		e			x		
Other Public	a	a	a			e	e	x	e	e			x	x	
Utility	x	x	a	x		x	xe	xe	xe	xe	xe	x	xe	x	x
Retail Gen.	e	e	x								x	x	x		
Public Assem.	a	a	x								x	x			
Restaurant	e	a	x			e					x	x	x		
Hotel/Motel/Transient	e	e	x			e	e					x	x		
Industry General	e	a	e	x								e	e	x	x
Ag. Processing	a	a	e	x											
Seafood Plant	e	e	e	x		e							e		
Sawmill	a	a	e	x		e								x	
Quarrying /Conc.	a	a	a	x		e								x	
Marine Comm.	e	e	x	x		x							x	x	
Serv. Sta./Gar.	a	a	x	x							e	x			
Dry Cleaning/Laundry	e	e	x	x							x	x			
Build. Supply	a	a	x	x											x
Indoor Stor.	a	a	a	x											
Printing/Mach.	e	e	x					e			x	x		x	
Office, General	e	e	x						e		x	x		x	
Hospital	e	e	x						e				xe		
Other Health	e	e	x						e			xe			x
Funeral Home	a	a	x				e	e			e	x			
Junkyard	a	a	a									e			
Other Outdoor Stor.	a	a	a	x											x
Airport	a	a	a			e									x
Outdoor Adv.	a	a	a			x	x	x	x	x	x	x		x	x
Other Trans.	a	a	a	e							x	xe		x	x
Landfill	a	a	a			e									

a = any other use, review needed, e = exception, review needed, x = permitted, xe = permitted in some areas, review needed in others.

Table 4-3: Zoning Lot Sizes and Open Space, Accomack and Northampton Counties

Zone District By County	Minimum Lot Size Sq. Ft.	Dimensions Min. Lot Size in Feet	Gross Open Space* Sq. Ft.	Percent Open Space
ACCOMACK				
A - Agriculture	30,000	150 x 200	16,200	54.00
R - Residential				
Central Water/Sewer	10,000	100 x 100	8,950	89.5
Cent. Water/Indiv. Sewer	15,000	100 x 150	10,450	69.7
Indiv. Water/Sewer	20,000	100 x 200	11,950	59.7
Multi-Family				
Central Water/Sewer				
Number of Units				
2	12,000	100 x 120	9,550	79.6
3	14,000	100 x 140	10,150	72.5
4	15,000	100 x 150	10,450	69.7
5	16,000	100 x 160	15,750	67.2
20	31,000	100 x 310	15,750	50.8
B - Business	NA	NA	NA	NA
I - Industrial	NA	NA	NA	NA
BI - Barrier Island	174,240	200 x 871	84,460	48.5
NORTHAMPTON				
AR - Ag. Residential	43,560	125 x 348	26,400	60.6
Residential				
R-20 Single Family	20,000	80 x 250	12,250	61.3
R-11 Single Family				
Public Water/Sewer	11,000	60 x 183	5,860	53.3
Public Water or Sewer	20,000	60 x 333	8,860	44.3
RM - Multi-Family				
Duplex: Public Water/Sewer	40,000	110 x 363	10,498	52.5
Indiv. Water & Sewer	50,000	110 x 227	11,568	46.3
Patio/Atrium	100,000	880 x 113	26,400	26.4
Townhouse	40,000	346 x 101	19,800	49.5
Multi-family, Other	25,000	140 x 179	15,250	61
MHP - Mobile Home Park	5,000	40 x 125	4,000	80
CN - Commercial Neighborhood	15,000	100 x 150	6,840	45.6
CG - Commercial General	15,000	100 x 150	6,840	45.6
CW - Commercial Waterfront	15,000	100 x 150	4,500	30
PI - Planned Industrial	50 acres	1000 x 2178	1,506,800	69.2
IL - Industrial Limited	43560	200 x 218	27,960	64.2
IG - Industrial General	30000	150 x 200	21,070	70.2
HD - Historic District	NA	NA	NA	NA
AP - Airport Protection	NA	NA	NA	NA
PUD - Planned Unit Develop.	NA	NA	NA	NA
FH - Flood Hazard	NA	NA	NA	NA

*This figure represents the minimum open space per lot or development possible under existing yard requirements. Driveways, walks, accessory uses and other site features could further reduce this area. Conversely, not all buildings are built to these setback lines.

Potentially inadequate space for water and sewer systems is also found in R-Districts where multi-family structures are allowed. Table 4-3 indicates that while two-family structures require at least 6,000 square feet each per lot, the construction of a five-family structure would effectively double the unit density. If a twenty-unit structure were constructed, the density would be doubled again, and the potential effects on ground water more pronounced. A two-unit structure would have a possible 9,550 square feet of open space for water and sewer systems. Three or more units would increase this acreage only marginally. The amount of open space per unit would actually decrease as would the percentage of such space relative to the size of lot. As with the single-family examples, other features could further reduce the space available.

One anomaly present in the Accomack Subdivision Regulations is found in Section 5., Paragraphs 5.2.4-1 through 5.2.4-3. These paragraphs repeat the requirements of varying lot sizes found in the R-District. (Table 4-3). However, uniformly larger lots (15,000 square feet) are required if the area has either public water or public sewer. This seems to make sense in the case of central water and individual sewer (septic or septage) because of increased land requirements for the sewage system. However, the reverse situation would not seem to require additional lot size. Individual wells may require somewhat more area due to well location requirements, but not as much as individual sewerage.

Industry, Business and Industrial/Commercial Districts

Industry and commercial uses occupy less than one percent of the land in Accomack County. However, estimates of water consumption by some of the major water users in Accomack suggest that industry uses in excess of 30 percent of the ground water on a daily basis (Comprehensive Plan, 1989, p. II-68). There is no minimum lot size in either industrial or commercial districts. While facilities with individual sewage disposal systems must have their lot sizes approved by the state health official for the county, the criteria for such approval are not clear in the Zoning Regulations. Thus, uses on one site could substantially affect uses on an adjacent site.

EXISTING LAND USE IN NORTHAMPTON COUNTY

Table 4-3 also summarizes existing open space due to zoning controls in Northampton County.

Agriculture and Agricultural Districts

Agriculture and woodlands in Northampton account for almost 38 percent of all land use. Similar potential problems are associated with agriculture in Northampton County as with Accomack County. Ground water contamination may result from the activities of pesticide and fertilizer applications, problems with soil erosion from improper tillage or forestry harvesting, and leaking septic or cesspool facilities. As in Accomack County, large portions of agricultural land in Northampton are irrigated, and it is estimated that 19-23 percent of all agricultural land in Northampton is currently under irrigation.

Residential zones in Northampton agricultural areas offer larger minimum open space potentials than those in Accomack. The minimum lot size for residential development in Northampton agricultural districts (AR) is one acre (Table 4-3). Using minimum frontage and setback requirements, it may be ascertained that 26,400 square feet of each one acre lot not fronting on water or Route 13 would be available for open space. This compares to a figure of 16,200 square feet in the A Districts of Accomack. As in Accomack, this open space may be covered by outbuildings, walks, driveways, or other features that further restrict the space used for wells or septic systems. Again, the result of these relatively small areas introduces the potential for forcing wells and sewerage to co-exist in somewhat restricted areas.

The land use categories that cover the largest portion of Northampton are marsh/tidal areas; these occupy almost 59 percent of the county, over 135,000 acres. Agriculture and woodlands take up about 38 percent. Inevitably these two uses are intertwined in many parts of the county, in that water from wetland areas associated with dammed creeks may be used for irrigation purposes, and crops may have been planted within drained marsh areas. Where this happens there is the potential for direct contamination of ground water by agricultural or forestry practices.

Housing and Residential Districts

Residential land use in Northampton occupies a much smaller land area in Northampton than in Accomack--3,800 acres versus 13,361 acres respectively. Residential zoning in Northampton, however, is somewhat more diverse than in Accomack. While the single residential district used in Accomack can accommodate single family and multifamily housing in several configurations, the Northampton R Districts are more detailed in the number and type of housing units permitted and the conditions under which such units are permitted given types of water and sewer systems.

More importantly for ground water protection, Northampton single family districts often require larger lots for single family houses for either central, combined or individual water/sewer systems. For example, central water and individual sewer in Northampton require a lot size of 20,000 square feet. In Accomack, the corresponding lot size would be 15,000 square feet. However, in Northampton County the primary building coverage can occupy nearly 66 percent of the lot, leaving only 8,860 square feet or less for a well and sewer system. In Accomack, the building coverage is restricted to about 30 percent, leaving over 10,400 square feet for landscaping, well, and sewer space.

Current zoning in Northampton County provides for a Residential Multi-family or "RM" District. Duplex, patio/atrium, townhouse and apartment structures are permitted in this district. Of these, the patio/atrium option can occupy at least 73 percent of the lot area, based on a configuration incorporating a minimum of 10 dwelling units. The remaining 2,640 square feet per unit would be very crowded should individual septic systems be installed. Additional landscape features such as driveways, parking areas and plantings would further reduce the space for septic systems. It is typical that this type of unit is built to the lot line on at least two sides, and thus the close proximity of individual septic systems is almost guaranteed.

Given the current zoning, townhouse units have the potential to be even more crowded than the multi-family residential units. Individual units could have just slightly over 1,500 square feet for septic systems, and multifamily apartment units can have about 3,200 square feet of open space per unit. These units can also be in tight configurations raising some of the same concerns expressed about the atrium units. At least 10 parking spaces must be provided for the minimum 5 units, which would occupy about 560 feet per unit. Thus the space available for septic systems would be reduced to about 2,600 square feet per unit. Additional landscape features could reduce this figure even further.

Industry, Business and Industrial/Commercial Districts

Industrial and commercial uses occupy about 225 acres or less than one-fifth of one percent of all land in the county. While such minimal areas are not likely to have major impacts on ground water supplies, several features of the zoning requirements for such areas are worth noting. For example, in any commercial district, CN, CG, or CW, the building and parking spaces can occupy over 50 percent of any development parcel. The amount of open space left for the well and septic system--

6,800 square feet in the configuration adopted for the assumption used here--may be minimal given other features, such as trash disposal, landscaping and parking and circulation, that can occupy the site. In the CW or Commercial Waterfront District, there are no open areas required, thus allowing for a particularly crowded water and sewage system for those sites adjacent to water bodies.

Other Uses

Northampton has a Planned Unit Development District in which 75 percent of the land area may be occupied by lots, buildings, streets and off-street parking. If such lots were developed as townhouse or atrium developments, then on-lot space for septic systems would be extremely limited. The 150 units or lots that would be permitted under the minimum development size of 15 acres and the maximum density of 10 dwelling units per acre for RM zoning could result in a substantial demand for a central, land based sewage disposal system. Of the 25 percent of the development left in open space, about 3.75 acres, much or most could be occupied by such a system.

By far the largest land use in Northampton County is that occupied by marsh or tidal areas. However, there is no specific zone district to treat such land. The Northampton Comprehensive Plan addresses the need for special treatment of tidal wetlands, barrier islands, and wetlands bordering on Bay side creeks and their branches. Additionally, in the Zoning Regulations, the use of wetlands in calculating developable areas on development parcels is excluded. However, there appears to be no specific protection plan for non-tidal wetlands, which are important for the recharge of ground water supplies.

Table 4-2 sets out detailed use categories and establishes their status in each zoning district for the two counties. In general, Accomack County appears to have a less restrictive, more inclusive ordinance. As evident in the table, nearly every land use is either permitted or excepted in agricultural, residential, and business districts. Comparatively, industrial zoning is highly restrictive, allowing only industrial and utility uses, with no exceptions allowed for other non-residential or residential uses.

Northampton's approach to zoning is quite the opposite. The county has an agricultural district, four residential districts, three business or commercial districts, and three industrial districts. Northampton also has four "overlay zones": historic, airport protection, planned unit development, and flood hazard, which can be used with the plan review to modify the underlying zones for the purposes of each overlay. In addition, Northampton has further front yard setbacks required in its Zoning Regulations along U.S. Route 13 that would increase the area space per lot. This is designated as "Highway Protection" in the Comprehensive Plan.

Northampton's zoning is substantially restrictive. For example, some agricultural uses are permitted only with special exceptions in the Agricultural/Residential District. Few industrial uses, even sawmills and agricultural processing plants, are permitted in the Agriculture/Residential District. In residential districts, many public facilities are either prohibited or only permitted with a special exception. Some anomalies do exist. For example, in the Residential Multi-family District, usually the least restrictive of any residential zone, only religious uses are permitted as a matter of right. Schools, libraries and some other public facilities are permitted only with special exceptions. Post offices are prohibited, as they are in AR Districts.

LAND USE CONTROLS AND EFFECTS ON GROUND WATER

The following chart summarizes land uses, the categories that may have particularly substantial effects on ground water, the general nature of those effects, and the status of those land use categories under present zoning or other review.

Table 4-4: Analysis of Land Use Effects on Ground Water Supplies

LAND USE/ USE CATEGORY	NATURE OF GROUND-WATER EFFECT	REVIEW STATUS
<u>Agriculture</u>		
Cropping	Pesticides, fertilizers may penetrate to water table and ground water	Matter of right (MOR) in both counties.* (see last page of table)
	Irrigation draws substantial amounts of water in dry periods.	Most withdrawals are not metered.
Grazing	Animal wastes may contaminate water table and ground water.	Review under Northampton Zoning only*.
Forestry	Pesticides may penetrate to ground water; cutting may enhance erosion.	Matter of right (MOR) in both counties.
<u>Residential</u>		
Single Family	Some lots may be too small to comfortably accommodate wells and/or septic systems, and drainfield reserve areas.	Matter of right, but VA health review is required.
Mobile Homes	Mobile Home Parks must have enough land per unit to accommodate well and/or septic system.	Special exception or health depart review; both counties.
Multi-Family	As for single family.	Matter of right, but VA health review is required.
<u>Utility</u>	This category can include public and private water and sewage operators that can withdraw large amounts of water and dispose of large amounts of waste water. The methods, condition of equipment, and conservation practices of the operator can affect ground water supplies.	Matter of right in Accomack A, R and I zones. Review in B zone. MOR in Northampton AR, CG, PI and IL zones. Possible review in others. VA Water Control Board requires permit for large withdrawals, discharges.

Table 4-4: Analysis of Land Use Effects on Ground Water Supplies (Continued)

Retail		
Restaurant	Restaurants can be large water users and often, discharge substantial amounts of waste water.	Accomack - reviewed in A,R zones. MOR in B. Northampton - MOR in C zones. Reviewed by VA Board of Health for minimum water flow.
Hotel, Motel, Other Transient Facilities	Can be large water user and waste water discharger. Especially in combination with a restaurant.	Accomack - reviewed in A, R zones. MOR in B. Northampton - reviewed in AR, R20 zones. MOR in CG, CW.
Industry		
General Industry	A variety of industries including research labs, production facilities, and service industries--especially food and bottling industries--can be major water users and can discharge toxic wastes, depending on their processes.	Accomack - MOR in I zone; Reviewed in A, R and B zones. Northampton - MOR in PI, IL and IG zones. Exception in CG and CW zones. Major water withdrawals subject to VA State Water Control Board approval.
Ag. Processing, Seafood Plant	These industries usually use large amounts of water for cleaning the product and usually discharge waste water filled with food wastes.	Accomack - See above. Northampton - Exception in IG for Ag. : in CW, IG for seafood.
Sawmill, Quarrying, Concrete Mix	Sawmills may use water for cooling and discharge waste pulp; quarries sometimes act as "drain holes" for surrounding area contaminants; concrete plants use substantial water and discharge waste filled with lime and toxics.	Accomack - MOR in I. Exception in A, R, B. Northampton - Sawmill MOR in IG; Quarry, Conc. MOR in PI. Exception in IG.
Marine Commer., Service Station, Airport, Junk yard	These uses often discharge or leak petroleum products to the ground. Additionally, battery acid and other by-products may leak from junk yards.	Accomack - Marine Serv. Stn. MOR in B,I. Airport , junk yard exception in A,R, B Northampton. Marine MOR in AR, CW, PI and IG. Serv. Stn. MOR in CG, Junk yard MOR in IG exception in CG; Airport MOR in IG, exception in AR.

Table 4-4: Analysis of Land Use Effects on Ground Water Supplies (Continued)

Dry Cleaning, Building Sup. Other Storage	These uses can discharge distillates and and other toxics to land areas.	Accomack - Dry Clean Bldg. Supply Exception in A, R; Other Stor. MOR in I, Exception in A, R, B. Northampton - Dry Clean MOR in CN, CG; Bldg. Supply MOR in IL. Indoor Stor. MOR in IG; Outdoor Stor. MOR in IL, IG.
Landfill	Landfills have been shown to be potentially major polluters of ground water sources. Substantial amounts of toxic materials have been--and are--dumped in these locations and, depending on ground soil and geology, may leach these toxics to aquifer.	Accomack - Exception only in A, R and B zones. Northampton Evidently prohibited in all zones.

*Farm Use Only

Generally, where the above uses are a matter of right, that is, where they can proceed to construction without review by government authorities and other advisers qualified to assess their effects on soil and ground water conditions, they may pose a distinct threat to ground water supplies. Degradation can occur either from overuse or contamination of ground water aquifers, in areas where soil and geological conditions indicate a high susceptibility. In cases where potentially harmful uses are reviewed, the review process may need strengthening to assure that such reviews are accomplished beyond that of the normal site plan or other process. After the review and possibly the remediation, the uses which could have highly adverse long and short-term effects should be monitored on a periodic basis to be sure that the remediation remains in place. A field survey and engineering/planning studies should be conducted to determine what existing land uses are potentially threatening to ground water and soil conditions so that remedial measures may be carried out.

SUBDIVISION OF LAND

Both counties have subdivision ordinances in place. In Accomack, final plats must be approved by the county and State Highway Department for public streets and drainage, and by the State Health Department for water and sewer facilities. Health and public road improvements must be secured by cash or a bond. In addition, trailer parks must also be approved by the State Bureau of Tourism. Accomack's subdivision ordinances also states that the State Health Department can order lot sizes larger than the minimum sizes established in the Zoning and Subdivision Ordinances if "factors of drainage, soil condition, population density or other conditions can cause potential health problems." Additional open space requirements are set out in the ordinance for buffering trailer parks from surrounding property. Lots larger than 3 acres in size are excluded from subdivision requirements under the Subdivision Ordinance in Accomack County. All final subdivision plats must be prepared by a state-registered engineer or surveyor. There is currently no requirement for drainfields reserved for septic systems in Accomack, although that is suggested in the County Comprehensive plan.

In Northampton, divisions of land are apparently excluded from subdivision review if the resultant lots are 5 acres or greater in size and if a single subdivision of a lot or parcel is made for the purpose of sale or gift to a member of the immediate family of the property owner. If the subdivision has 26 or more lots created, it is considered a major subdivision. A major subdivision must be reviewed by the State Highway Department, the State Health Officer, each incorporated town within 2 miles of the project, each utility company providing service to the project, and all abutting property owners and other agencies the Planning Director deems appropriate. The State Highway and Health Department comments must be received prior to review and action by the County Planning Commission. Plans must be prepared by a state-licensed surveyor or engineer. All major subdivisions must have a central water system in Northampton. All proposed improvements are bonded for implementation by the owner or his/her agent.

The procedure for approval of minor subdivisions, those with 25 lots or less and with lot areas of less than five acres, is the same as that of major subdivisions except that final approval can be granted by the Planning Director rather than the Planning Commission.

Lots in Northampton that use private, individual wells and septic systems must provide an additional, non-overlapping replacement drainfield site. No such site is required if a well is not located on the lot. Additionally, wetlands cannot be separated from a lot. All wetlands must be incorporated into an adjoining lot where they are counted against the lot size for purposes of establishing minimum lot area and for calculating buildable portions of the lot. This can have the effect of allowing building and development adjacent to wetlands on the subject lot. It also removes the wetland as a special area separated from development and subject to special protection.

Subdivisions in Accomack County

There have been over 160 subdivisions in Accomack County (Table 4-5) approved between 1972 and 1990. Of these 15 are campgrounds or other seasonal developments. These 15 subdivisions have 4,193 lots of which nearly 66 percent, or 2,765, currently have structures or trailers on them. Another 44 subdivisions are trailer parks containing 2,813 lots. Nearly 56 percent, or 1,563, of these are occupied by units. The remaining 113 subdivisions are primarily occupied by single-family houses ranging in size from 2 to 5 bedrooms. There are a few duplexes, but these units are primarily 3-bedroom, 2-bath dwellings. Of the approximately 8,500 lots in these subdivisions, only 19 percent or 1,627 are currently improved with structures.

Table 4-5: Subdivision Development in Accomack County, 1972-1990

Type of Subdivision	Number in County	Number of Lots	Number Improved	% Improved
Campground or Seasonal/Vacation	15	4,193	2,765	65.9
Trailer Parks	44	2,813	1,563	55.6
Single or Multi-Family	104	8,449	1,627	19.3
Total Subdivisions	163	15,455	5,955	38.5

Source: Accomack County Department of Environmental Affairs, Zoning Administrator's Office, April 1991.

Of the 163 subdivisions referenced above, at least 60 have central water systems. The remainder have individual wells on each lot. Over 100 subdivisions have both individual water and septic on each lot. Eleven subdivisions have central holding tanks for sewage that are pumped out periodically. The septage is then disposed of in lagoons. One subdivision has both central water and a central drainfield for wastewater disposal.

Subdivisions in Northampton County

There were about 150 subdivisions approved in Northampton between 1974 and early 1991. Between 1970 and 1980 approximately 320 trailers and 602 other year-round housing units were added to the existing housing stock. If one assumes a similar proportion of development in the subdivisions recorded, the results would be as those set out in Table 4-6. The number of lots recorded in these subdivisions total 2,016. Of these, it is surmised that about 1,154 have been improved. It is further surmised that 542 of the lots are improved with trailers, while 322 are improved with single family houses. Accordingly, an additional 290 camping and seasonal lots would be currently active.

Table 4-6: Subdivision Development in Northampton County

Type of Subdivision	Number in County	Number of Lots	Number Improved	% Improved
Campground or Seasonal/Vacation	49*	431*	290*	67.3
Trailer Parks	34*	673*	542*	80.3
Single or Multi-Family	68*	912*	322*	35.3
Total Subdivisions	151	2,016	1,154	57.2

Source: *Derived figures Director, Planning and Zoning, Northampton County; Northampton County Comprehensive Plan and Plan Background, July 1989.
It is thought by county planners that all of these subdivisions are served by individual water and sewer.

THE CHESAPEAKE BAY PROGRAM ON THE EASTERN SHORE OF VIRGINIA

Introduction

The Virginia State Chesapeake Bay Preservation Act (CBPA) of 1988 - Chapter 21 of the Virginia State Code, Sections 10.1-2100 through 10.1-2115 - sets out requirements for all local governments in Tidewater Virginia to develop land use regulations based on the state code in order to protect water quality in the Chesapeake Bay and its tributaries. Each locality will incorporate the new regulations into their comprehensive plan, zoning bylaws, subdivision plans, and other land development ordinances. Both counties on the Eastern Shore and the self-governing towns are required to prepare such regulations. Under the CBPA where a town does not have planning, zoning, or other such regulations, or chooses not to prepare regulations on its own, it may act to be subject to the county program.

Basic Approach

The state program is overseen by the Chesapeake Bay Local Assistance Board. The Board is comprised of nine members appointed by the Governor. The Board is staffed by the Local Assistance Department, a state agency that provides technical support to the Board and technical advice and assistance to the local governments. The Board has developed regulations for the designation of Chesapeake Bay Preservation Areas and for land use management to accomplish the aims of the legislation in those areas. It also provides financial and technical assistance to local governments where required. The Board must approve all locally prepared plans and assure compliance of each local government with the Act, but is not responsible for specific decisions about particular sites in the Preservation Areas. Those decisions will continue to be made by the local government based on the locally prepared regulations.

The Chesapeake Bay Preservation Area (CBPA) contains three general land categories: the Resource Protection Area (RPA); the Resource Management Area (RMA); and the Intensely Developed Area (IDA). Very generally, an RPA is land at or near the shore of the Bay or tributary which can protect water quality but, if damaged by development or other disturbance, can degrade water quality. These areas include tidal wetlands, nearby non-tidal wetlands, tidal shores and other lands whose disturbance would harm the area. An RPA must contain a buffer area along the landward side measured from the landward face of the above features. Only redevelopment and new, water-dependent uses can be developed in an RPA.

An RMA is land which protects the RPA. Development and other land disturbance in these areas can have adverse effects on the RPA and ultimately degrade water quality. Floodplains, steep slopes, soils susceptible to erosion, soils with a high degree of permeability, non-contiguous non-tidal wetlands and lands required to protect water quality are to be included as RMA's. In some cases the entire drainage basin of a water body may be designated as an RMA boundary. RMA's must be designated landward of RPA's. Any use permitted by local zoning can be developed in an RMA, subject to certain performance criteria.

An IDA is an area that, due to previous development, may be located in an RPA or RMA. Redevelopment and infill development can take place in these areas where little natural land area remains. An IDA must be so designated if an area has more than 50 percent of its surfaces in impervious materials, or is served by public water and sewer, or has a housing density of 4 or more dwellings per acre.

State regulations were adopted in September, 1989 and became effective October 1 of that year. Lots recorded after the effective date are subject to the regulations. However, local governments may allow modification of the buffer up to 50 feet, and may not require a reserve drainfield (one of the regulatory requirements) depending on the local program developed. All local governments are to have their adopted local regulatory programs in place by November 19, 1991. Northampton's program was incorporated into its Draft Comprehensive Plan in late 1990 and was drafted as an overlay district for the zoning ordinance. Accomack's program was also drafted as a zoning overlay district and is currently being assessed by the County Board of Supervisors.

Implications for Ground Water Protection

All locally prepared programs for Chesapeake Bay Preservation Areas (CBPA's) must meet general performance criteria. These criteria are designed primarily to reduce nonpoint source pollution of surface water and to protect sensitive lands from disturbance. The criteria include:

1) preservation of natural vegetation;
2) restricting disturbance of land;
3) restricting impervious cover;
4) controlling soil erosion--especially in areas of susceptible soils and during land clearing construction and other land-disturbing activities, such as tillage;
5) controlling the volume and quality of stormwater runoff;

6) controlling the overflow and leaching of septage from tanks and drainfields by regular, mandatory pumping;
7) providing for reserve drainfield capacity for septic systems that equals the treatment capacity of the primary drainfield;
8) requiring site plan review and the preparation of various studies such as a water quality impact assessment and a site plan review document;
9) control of stormwater quality in agricultural and forestal areas within or adjacent to the RPA.

Of the above performance criteria, all relate to the ultimate use and condition of ground water. However, several have the potential for more directly affecting ground water withdrawals and quality.

Overflow and leaching of septic drainfields and tanks, especially when they are in close proximity to wells, can cause both immediate and long term effects on drinking water. The inclusion of provisions for pumping out systems every five years is a start to controlling this overflow and leaching. The requirement of provisions for back-up drainfields in areas that do not overlap the original facility provides a longer-term solution to the problem.

Control of storm water quality in agricultural and forestal areas is also important to ground water quality. This performance criteria is primarily directed toward the protection of surface water from pollution by soil erosion, pesticides and fertilizers. These problems also can affect ground water, but not simply through storm water runoff. The large amount of water used for irrigating crops in the area can carry these pollutants into the soil as well. Where surface soils have a high degree of porosity, especially where the subsurface soils are not clay or clay loam, chemical compounds used in agriculture and silviculture can be transmitted to ground water fairly quickly. Where wells and watering ponds draw from this contaminated ground water, especially in the upper aquifer, deleterious effects on humans and animals from consumption can be expected to be noticed relatively quickly.

Another area where there may be beneficial effects on ground water quality is in the attention of the Act and local programs to protect wetlands. Depending on substrata conditions, wetlands can act as large filtration systems for broad areas that drain surface waters to the wetland. This water may then penetrate to ground water aquifers at a faster rate than is possible when water seeps into surrounding upland soils. The process of filtering out harmful substances is enhanced where wetlands and marshy areas are protected by buffers of natural vegetation. Such a buffer zone is called for in the Act and its attendant regulations. The capacity of the buffer to adsorb pollutants is further increased where these substances are further controlled through agricultural best management practices and erosion control plans.

In addition to the performance criteria set out in the Act, state agencies have called for further performance standards. Briefly, these are as follows:

1) prevent any increase in pollution from new development;
2) achieve a 10% reduction in pollution from redevelopment;
3) achieve a 40% reduction in pollution from agriculture;
4) limit any land disturbance to 60% of a site;
5) preserve vegetation and limit impervious coverage;
6) require a soil erosion and sediment control permit;
7) stormwater from new development must be limited to pre-development levels;
8) federal and state wetlands permits are needed before grading and clearing;

9) agriculture requires a Conservative Plan of Best Management Practices approved by the Soil & Water Conservation District and put in place by 1995.

There are several points worth noting. The limitation of development of a site to 60 percent of the total area is commendable. However, as can be seen in the studies done for existing land use (Table 4-3), some zone districts already limit building area to substantially less than this figure. There may be substantial problems of pervious areas sufficient for individual well and septic systems, as well as for any requirements for reserve drainfields, given such figures and the size of lots.

There are some differences in the CBPA regulations drafted by the two Eastern Shore counties. For example, Northampton will require a Minor Water Quality Assessment of a proposed action if the action disturbs less than 10,000 square feet of land. For Accomack, the same figure is 5,000 square feet. In each draft there is considerable attention paid to requirements for RPA's, but less definition to the requirements for RMA's. Requirements for IDA's are not included in either county's draft.

Some selected modifications of the current regulations shall be made to increase the potential for ground water protection. Attention would have to be paid to space requirements for drainfields, impervious surfaces, and developments adjacent to the buffer areas. Protection of wellhead areas is one open space requirement that could be added, especially if the type of relationship between underground aquifers and surface water bodies can be identified.

SUMMARY OF LAND USE ON THE EASTERN SHORE

Both Accomack and Northampton Counties are currently revising their zoning based upon recently completed comprehensive plans, and the need to comply with the Chesapeake Bay Act. The pattern of land use on the Eastern Shore has been very stable over the past. In summary, nearly 70% of all land in agriculture and forestry uses is located in Accomack; nearly 66% of all land in marshes, wetlands, and tidal areas is located in Northampton; nearly 78% of all residential land lies in Accomack; over 96% of all industrial land lies in Accomack. Thus, the overall picture of land use in the region is one of more intense development in Accomack County, even in the land use categories often viewed as land extensive such as agriculture and woodlands. Agricultural, residential, and industrial uses could have potentially significant affects for ground water consumption and water quality in Accomack County. Northampton County has the majority of its land in marsh and wetlands, however, development densities could be quite high along the center of the county, where the ground water is recharged.

Many of the land uses are allowed by right, meaning that permits and reviews by each county are not required to determine if the development will have an impact on ground water use or quality. In cases where potentially harmful uses are reviewed, the review process may need strengthening to assure that such reviews are accomplished beyond that of the normal site plan or other process. After the review, the uses which could have highly adverse long and short-term effects should be monitored on a periodic basis to be sure that the ground water quality is not affected.

Both counties have a significant number of approved subdivisions with a high percentage of undeveloped lots. Of the 15,455 approved lots between 1972 and 1990 in Accomack County, only 39% have structures. In Northampton County 2,016 lots were approved during the same time period and 57% are improved with structures. This indicates that there is a significant potential to increase the number of housing units, population, water needs, and wastewater disposal needs without additional approvals required.

The Chesapeake Bay Act once implemented in both counties, will help to control negative ground water quality impacts from existing and future development with the requirements for periodic pumping of septic systems, leach field reserve area requirements, site plan review, restrictions on amounts of impervious areas on building lots, stormwater quality management considerations, and the protection of valuable wetlands.

DELINEATION OF GROUND WATER SUPPLY MANAGEMENT AREAS

5

SECTION 5: DELINEATION OF GROUND WATER SUPPLY MANAGEMENT AREAS

INTRODUCTION

HWH approached the issue of protection of the ground water of the Eastern Shore by first examining the geologic and hydrologic conditions of the region, drawing upon existing technical literature. Appropriate criteria for aquifer and wellhead protection were explored, utilizing accepted EPA-approved criteria coupled with the hydrogeologic realities of the area. After appropriate criteria were selected, a methodology was determined and implemented to map the protection zones.

SELECTION OF GROUND WATER PROTECTION CRITERIA

The three-dimensional character of the ground water flow system to the confined aquifer governed the choice of the aquifer and wellhead protection area criteria. Initially, a criterion of time of travel (TOT) was evaluated. With TOT, a distance is calculated from the well or wellfield that corresponds to the amount of time it would take a particle of water (or contaminant) to move to the supply source within a designated threshold (10-year TOT, 25-year TOT, etc.). TOT is an extremely effective criteria in some hydrogeologic environments, particularly in unconfined aquifers in which the time it takes precipitation to recharge the saturated zone is quite short. In that situation, recharge of water is assumed to follow a piston-like pattern of flow downward through the unsaturated zones in a relatively short time frame. TOT distance thresholds are then based on the time of travel of a particle of water within the saturated zone, moving horizontally with the average velocity of the ground water under pumping conditions.

On the Eastern Shore the character of ground water flow assumes more of a three-dimensional rather than a two-dimensional nature. To obtain an accurate TOT calculation for a given well in a confined system would have to account for the time taken for recharge water to pass through the unsaturated zone, the time it takes to move both vertically and horizontally within the overlying unconfined aquifer to the uppermost confining layer, the time it takes to move through that confining layer and the time it takes to move horizontally to a well screened in the confined aquifer. When a three layer system such as the Yorktown-Eastover aquifer is considered, the problems of determining TOT become extremely difficult to solve with any degree of certainty. The data requirements and qualifying assumptions to determine the length of time it would take to move through such a complex pathway is extensive; TOT is not an appropriate protection criterion in this hydrogeologic environment.

Criteria were selected for aquifer and wellhead protection based upon the unique hydrogeologic conditions found on the Eastern Shore. The conceptual model indicates that the recharge area to the most important aquifer (the Yorktown-Eastover aquifer) lies along the center of the peninsula. Accordingly, protection criteria were determined to address this particular situation. Radial distance was used for Zone 1, while hydrogeologic flow boundaries were used for Zones 2 and 3. Each ground water supply management area is explained below along with the method used to map the protection zones.

Zone 1

<u>Criteria</u>: 200-foot radial distance around a well.

<u>Rationale</u>: The need for a protective zone immediately around a well has more to do with human error than to hydrogeologic conditions. This zone is employed to maintain an area

around the well to prevent potential contaminants from moving into the aquifer via a poorly constructed or faulty annular seal at the well. Wells that are poorly built or are old may lack the concrete or bentonite clay seal designed to prevent leakage from the surface down along the well casing into the aquifer. In addition, properly constructed seals may also break down over time and create a pathway for water an contaminants to flow into the well. A 200-foot radius around each well where virtually all activity is banned offers a measure of protection against accidental spills.

Method: The radial distance is established by drawing a scaled circle around the well on a map.

Zone 2 - Spine Recharge Area

Criteria: Hydrogeologic boundaries based on recharge areas.

Rationale: The conceptual model of the hydrogeology of the Eastern Shore indicates that the primary recharge area for the Yorktown-Eastover aquifer is located along the center of the peninsula. Assuming that precipitation falling on the surface of the Eastern Shore follows the flowpaths displayed in Figures 2-6 and 2-7, water falling along the center will penetrate vertically through the confining layer and recharge the confined aquifer. Recharge to the unconfined aquifer (the Columbia) has been estimated at between 12 and 26 inches per year (see below and Appendix E). Recharge through the uppermost confining layer to the Yorktown-Eastover is much slower, governed by the low permeability of the confining clays and silts. That recharge rate is estimated at only about 0.10 feet per year (see below and Appendix E).

Using the principle of conservation of mass, the amount of water that seeps through the uppermost confining layer to a pumping well at a low recharge rate over a large area must be balanced by an equal volume of water that recharges the unconfined aquifer at a higher rate. The volumes of water will be the same, but the recharge rates and the area required will differ. The land surface from which recharge flows into the unconfined aquifer is much smaller that the area through which recharge flows into the confined aquifer. Optimally, a full three-dimensional ground water flow model that accounts for the various differing permeabilities and thicknesses would be used to determine the recharge areas in the unconfined and confined aquifer and use particle tracking to back-track the starting points for water particles that are discharged by the pumping wells. That modelled contributing area would then be a logical choice for a protection zone.

Without such a sophisticated model, a simpler solution was derived. Using a moderately conservative recharge rate of 9 inches per year for the Columbia aquifer, the amount of area within each of five areas (described below) to produce the permitted volume discharged was determined. That area was then divided equally on either side of the peninsula to form Zone 2. For this study, average values were used for recharge across the entire study area. Once the USGS model is available (see page 6-4), aquifer properties can be varied, and the model rerun.

Method: The largest users of ground water on the Eastern Shore were located and mapped. This group of twenty-six wells or wellfields (Appendix E) accounts for most of the total ground water discharge permitted on the Eastern Shore. The drawdown of the pumping wells was modelled analytically using a standard ground water solution to the flow equation, the Cooper-Jacob method. The individual drawdowns were then added to model the interference effects from neighboring wells throughout the Eastern Shore. The area of the peninsula was divided into five regions based on the grouping of wells, the amount of permitted pumpage and the contributing areas defined by contour mapping of the modelled drawdowns (Figure 5-1).

The protection zone for each of the five areas was determined on the basis of recharge. The total amount of permitted pumping was determined for each area. The amount of land area required to balance that volume of pumping with a 9 in/yr recharge rate was calculated. The 9 inches was chosen as a conservative value to account for drought years. Since the recharge area was determined to be located along the center of the peninsula, the length of the spine was measured in each zone of contribution, and the width of the protection zone determined by dividing the recharge area necessary by the length of the spine available. This width ranges from 1,530 feet to 4,660 feet but, to remain conservative, a larger 5,000-foot strip (2,500 feet on each side) was plotted along the spine throughout the entire peninsula (Figure 5-2).

The 5,000-foot strip represents the size of surface area that contributes water to the wells in the Yorktown-Eastover aquifer. As the recharge flows downward in the Columbia aquifer it also moves horizontally towards the coasts (see Figure 2-7). The contributing area at the base of the Columbia has therefore grown wider. The transfer rate from the Columbia to the Yorktown-Eastover aquifers is then lower in order to maintain the same volume of water passing through the confining unit.

Zone 3 - Wellhead Protection Areas

Criteria: Hydrogeologic boundaries using contributing areas of flow.

Rationale: The moderate to low transmissivities found within the Yorktown-Eastover aquifer coupled with high levels of permitted discharge on the part of a number of major users creates substantial drawdowns in individual wells. These drawdowns interfere with one another, and since individual cones of depression are additive, the interference patterns serve to exacerbate the problems of excessive water level drop. Pumping from the confined Yorktown-Eastover aquifer produces a gradient on the overlying confining unit and the unconfined Columbia aquifer. In those areas, patterns of recharge and downward vertical flow occurring primarily along the central spine will be modified to some extent by the increased gradients, particularly where the confining unit possesses relatively high hydraulic conductivity or where the clays and silts are missing altogether. Those conditions could apply especially where the documented paleochannels cross the Eastern Shore peninsula. In such locales, recharge will occur from areas other than the central spine under conditions of substantially higher gradients created by pumping.

To address this issue on a peninsula-wide basis, Zone 3 is proposed. Zone 3, based on ground water divides created by the superpositions of pumping patterns upon the ambient potentiometric surface, covers virtually the entire peninsula. The

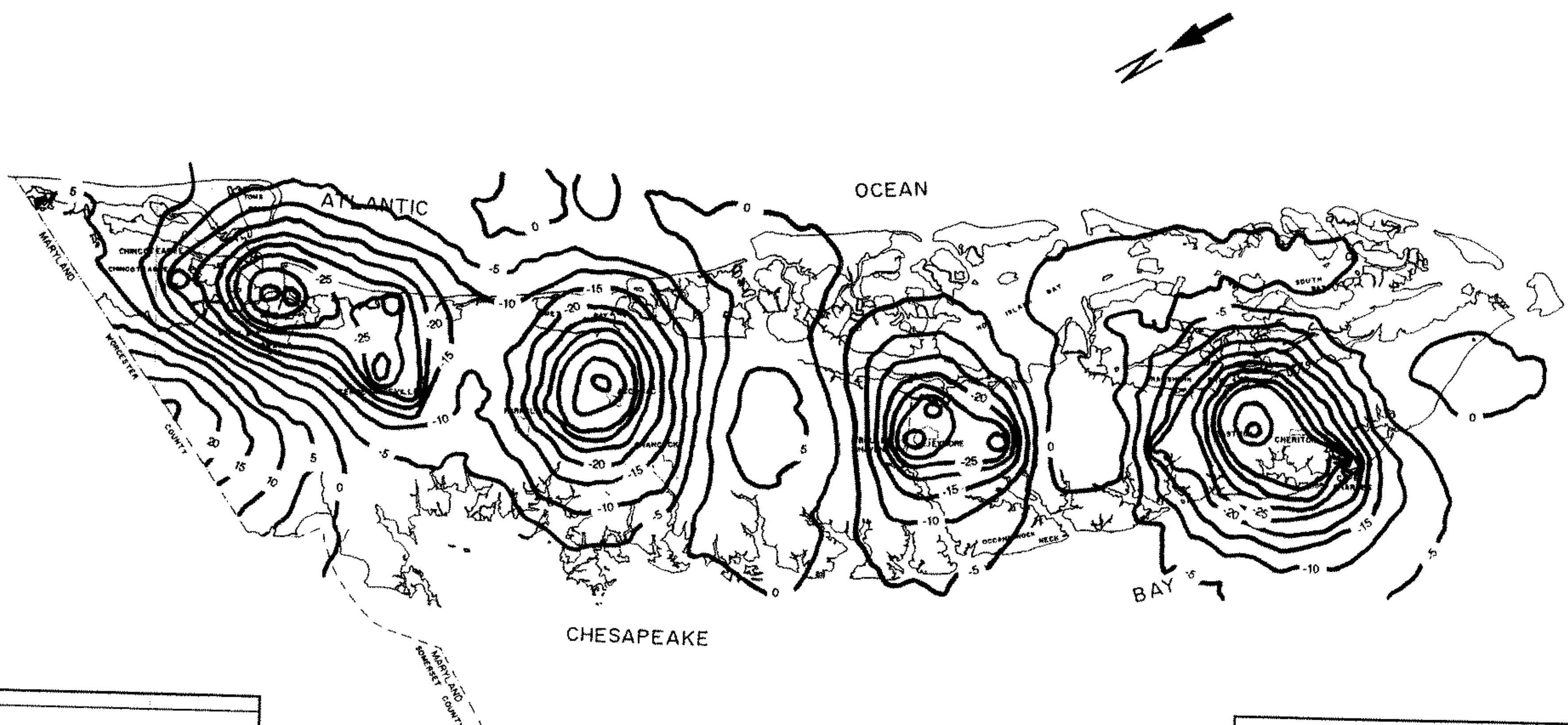


FIGURE 5-1

EASTERN SHORE POTENTIOMETRIC MAP:

Pemitted Pumping

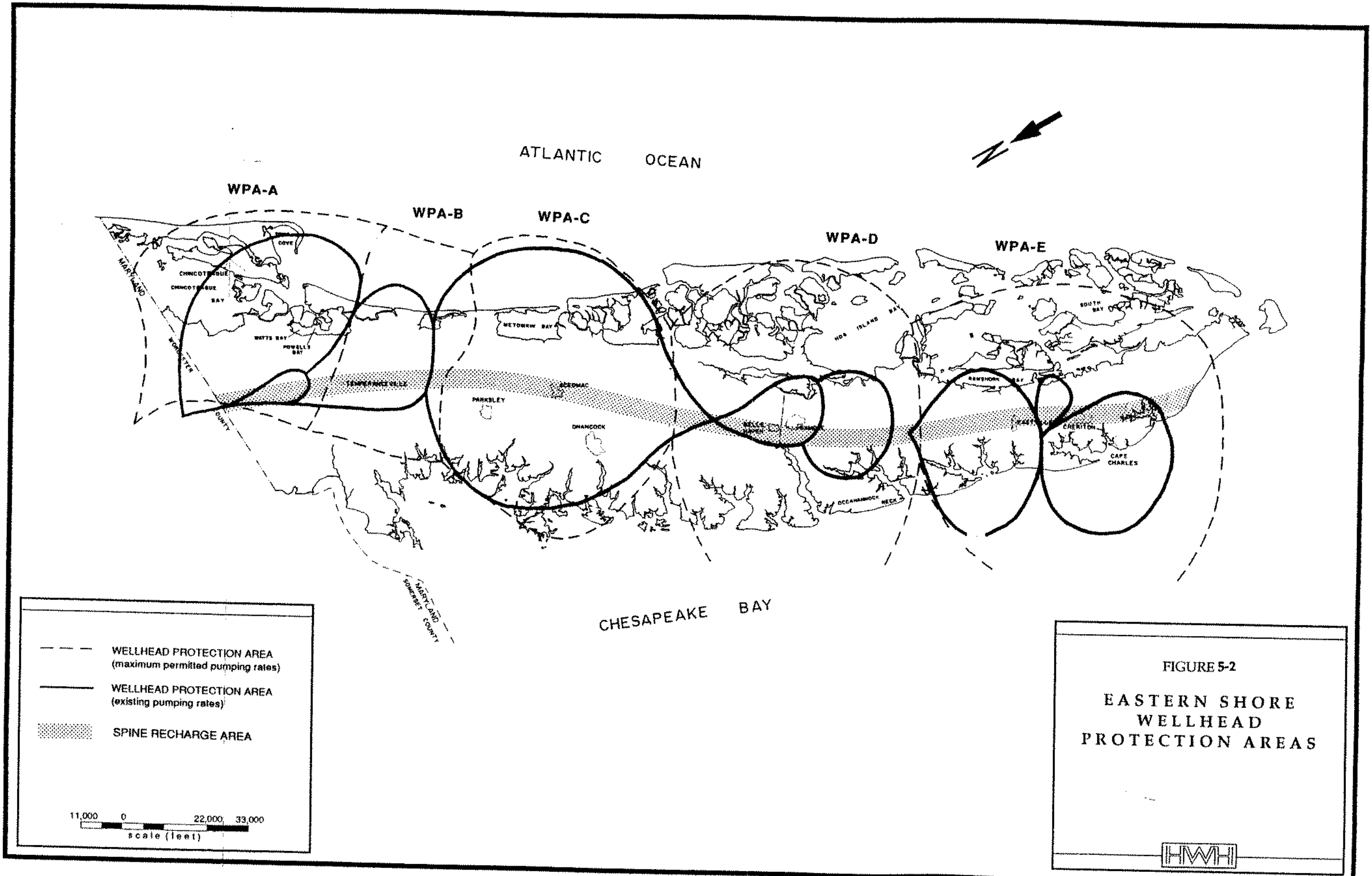


FIGURE 5-2

EASTERN SHORE WELLHEAD PROTECTION AREAS

employment of such a zone serves to establish formally how widespread the impact of ground water withdrawals has been on the hydrogeologic system of the Eastern Shore. Creating a zone of protection at the scale of Zone 3 re-emphasizes the dependence of the area on its ground water supply and how activities throughout the region, not simply along the central corridor, affect the quality and quantity of ground water.

Method: The results of the analytical modelling to determine the amount of drawdown caused by pumping the major producing wells on the Eastern Shore were combined with a map of the pre-pumping conditions taken from the numerical flow modelling conducted by Bal, 1977. The resultant water level surface was then analyzed to ascertain ground water divides that form the boundaries to the zones of contribution to the Eastern Shore. See Figure 5-1 for the potentiometric map for permitted pumping rates. The zones of contribution constitute Zone 3 (Figure 5-2).

PHYSICAL DESCRIPTION OF EACH WELLHEAD PROTECTION AREA

The Wellhead Protection Areas (WPA's, Zone 3 ground water supply management areas), reflect the contributing areas to existing wells under permitted pumping rates. Below is a breakdown of certain activities within each WPA, along with a general geographical description. Please refer to Figure 5-2 for the location of each WPA.

Wellhead Protection Area A - Chincoteague Area

Area: 27,000 acres
Number of Wells: 13
Number of VPDES dischargers: 17
Landfills: 2 closed
Lagoons: none

Of the WPA's, this wellhead protection area covers the least extent of upland. It includes Chincoteague Island to the east, Captain's Cove to the north, Oak Hall to the south, and includes the town of New Church and the NASA Wallops Station. The old northern landfill in Accomack County (now closed) is located within this area, and apparently there is a closed landfill on Chincoteague. Large wells serve Captain's Cove, the Town of Chincoteague, NASA Wallops Main Station, and New Church Energy Association. These facilities also have discharge permits to dispose of liquid wastes in the area. Water taken from the tap at Stoney Point Decoys, NASA Wallops Flight Center, and NASA Wallops Island have all tested above 5 mg/l for nitrate-nitrogen, with readings ranging from 7.11 to 11.5 mg/l.

Wellhead Protection Area B - Holly Farms (Tyson Foods) Area

Area: 43,000 acres
Number of Wells: 9
Number of VPDES dischargers: 6
Landfills: 1
Lagoons: 1

The towns of Withams, Hallwood, Nelsonia, and most of Wallops Island are located in this wellhead protection area. To the east, it extends into the Atlantic Ocean, and to the west it reaches as far as Route 698 near the Saxis area. This wellhead protection area contains the greatest visible contamination threat. Directly on the spine recharge area is the Northern Landfill for Accomack County and one of the two Bundick septage lagoons, which is unlined. Any contamination which reaches the ground water within this recharge area could eventually contaminate the Yorktown-Eastover aquifers. Water withdrawers and septage dischargers located in this area are Holly Farms, which is second to Perdue in its permitted water withdrawal rate, Taylor Packing Company, and the NASA Wallops Island facility. The Atlantic Fire House is the only known facility in WPA B to have nitrate-nitrogen levels above a negligible amount; a sample taken in 1981 measured 5 mg/l.

Wellhead Protection Area C - Perdue Area

Area: 76,000 acres
Number of Wells: 15
Number of VPDES dischargers: 7
Landfills: none
Lagoons: 1

This is the contributing area created by pumping from Perdue, Byrd Foods, the towns of Onancock and Parksley, and the Accomack County Nursing Home. Because of large amounts of industrial water withdrawals, this wellhead protection area is the largest one on the peninsula. The current pumping rates, dominated by Perdue Inc., show a drawdown area almost as large as the drawdown expected for the maximum, permitted pumping rates. The WPA extends into both the Bay and the Atlantic, and includes Bloxom to the north and Melfa to the south, and Accomac, Parksley, Onley, and Onancock in the central portions. WPA C contains the Boggs septage lagoon. Two public water supply wells for the Town of Parksley have had nitrate nitrogen levels ranging from 5.65 to 8.5 mg/l during testing intervals between 1974 and 1989. An observation well sampled in 1980 measured 10 mg/l for nitrate-nitrogen.

Wellhead Protection Area D - Exmore Area

Area: 65,000 acres
Number of Wells: 9 and 1 proposed
Number of VPDES dischargers: 9
Landfills: 1
Lagoons: 1

WPA D covers the border of Accomack and Northampton Counties. The southern landfill for Accomack County and a Bundick Lagoon is located within its boundaries. To the east, the boundaries cover most of Paramore Island and Hog Island, and it extends far out into the Chesapeake Bay on the west side. The villages of Keller and Johnsontown are the north and south extents of wellhead protection area B, respectively. Also included are Pungoteague, Wachapreague, Exmore, and Nassawadox. Wells are in use for the town of Exmore, Virginia Landing Campground, the Accomack-Northampton Hospital, and American Original Foods. Peaceful Beach Campground plans to install a well in this wellhead protection area. An observation well on Churchneck has measured very high nitrate nitrogen levels, ranging from 13.0 to 24.0 mg/l.

Wellhead Protection Area E - Cape Charles Area

Area: 52,000 acres
Number of Wells: 17 plus 7 proposed
Number of VPDES dischargers: 13
Landfills: 1
Lagoons: none

This wellhead protection area is the most southern on the peninsula, not quite reaching Fisherman's Island. Similar to WPA D, its boundaries include most of the marshland on the east, and extend out to a large distance into the Bay. Machipongo is the northernmost town, and Eastville, Cheriton, Cape Charles, and Townsend are all included in the protection area. Major wells in the area are presently proposed but permitted, and include wells for the DiCanio and Brown & Root communities near Cape Charles. Current water withdrawers are the towns of Eastville and Cape Charles, America House Motor Inn, Sea Watch International, KMC Foods, and Bayshore Concrete Products. The Northampton County Landfill is also located within this area. A Brown and Root well sampled in 1977 had a nitrate-nitrogen level of 17.0 mg/l, and an observation well near Oyster exhibited nitrate-nitrogen levels ranging from 6.9 to 9.0 mg/l.

WATER BUDGET/BALANCE

6

SECTION 6: WATER BALANCE

Because aquifer and wellhead protection is so intimately tied to the issues of water quality and quantity, some quantification of the amount of recharge both to the unconfined and confined aquifer systems was needed. The estimate of the available water could then be compared to the amount extracted in terms of current, permitted and future yields.

RECHARGE TO THE COLUMBIA AQUIFER

An estimate of the amount of water recharging the unconfined Columbia aquifer as made using a standard water budget calculation (Appendix E) following the approach detailed in Dunne and Leopold, 1978. A water budget is calculated by creating a "balance sheet" of hydrologic inputs and outputs to the system. The input to the system is precipitation. Average values for monthly precipitation from the weather station at Painter, Virginia were used, representing six years of record (1985-1990). Outputs from the system include the amount of water evaporated directly or transpired indirectly to the atmosphere, estimated using an approach from Thornthwaite and Mather (1955) (Appendix E). The Thornthwaite and Mather approach is designed for use in temperate and humid environments and is an appropriate choice to estimate potential evapotranspiration (ET) on the Eastern Shore. Where ET is greater than precipitation, a potential water loss develops and accumulates during the dry months (June, July and August). The amount of moisture held in the soil (a function of soil type and plant rooting depth) will be reduced because of this accumulated water loss. Calculations are then made to estimate the actual ET and to determine the amount of water available for runoff and recharge. The water budget approach resulted in an estimate of 17 inches per year of recharge to the unconfined Columbia aquifer on the Eastern Shore, assuming 50 % runoff, 12 inches per year with 60% runoff and 26 inches per year with 40% runoff.

The water budget modelling is fairly robust with regard to most of its components. Temperature and precipitation records show only moderate scatter, characteristic of a temperature climate. The fact that relatively little soil moisture deficit develops is typical with the climatic regime of the Eastern Shore. Where the model does show sensitivity is in the estimate of the amount of runoff that takes place. The Soil Conservation Service (SCS) models of runoff calculations are only applicable to small catchments, and empirical estimates for runoff percentages are difficult to obtain at the scale of the entire peninsula. Given the permeable nature of soils on the Eastern Shore, a 50% estimate is reasonable (Dunne and Leopold, 1978). If 40% is estimated to run off, the recharge estimate jumps to approximately 26 inches per year. If 60 percent runoff is estimated, about 12 inches per year recharges the aquifer.

The volumetric amount of recharge is determined by multiplying the recharge rate by the area of the peninsula. Using an area of 400 square miles and 17 inches of recharge per year, the volumetric recharge to the unconfined aquifer is approximately 324 million gallons per day. Most of the withdrawals from the surficial aquifer consist of agricultural extractions, and many are undocumented. However, it can be fairly safely maintained that the withdrawals do not approach even within an order of magnitude of the amount being recharged. The quantity of water within the Columbia aquifer appears to be of little concern.

RECHARGE TO THE YORKTOWN-EASTOVER AQUIFER

The clays and silts separating the unconfined Columbia and the confined Yorktown-Eastover aquifers range in thickness from 20 to 100 feet. The permeability of this confining layer is low, but precisely how low is difficult to determine empirically. To calculate the flux across the confining layer for transient (time-dependent) conditions using Darcy's Law, some value for hydraulic conductivity (permeability) has to be used. To avoid this problem, and to obtain a conservative estimate of recharge to the Yorktown-Eastover aquifer, HWH used as steady state approach to calculate recharge. Recharge was determined via a cross-sectional model for the confined ground water system. The governing differential equation for one-dimensional flow at steady state was integrated and boundary conditions appropriate to the Eastern Shore used to determine the constants of integration. The result was an equation that could be solved for a recharge rate (see Appendix E). The recharge rate was multiplied by the area of the confining layer receiving recharge to determine the volumetric quantity of water reaching the confined system.

The coefficients necessary to solve the derived equation are aquifer transmissivity, hydraulic head (water level), and the width of the peninsula. To examine the sensitivity of the analytical model, a range of values were used to determine an estimate for recharge. The average width of the peninsula is about 8 miles in Accomack County and about 6 miles in Northampton County, although sections exist that are considerably narrower. Calculations were made for widths of 4, 6, and 8 miles. Transmissivity values found in geologic reports of the Eastern Shore varied considerably, ranging from less than 1000 ft^2 per day to over 5000 ft^2 per day. The modelling incorporated a range of transmissivity from 500 to 5000 ft^2 per day. Values from the potentiometric surface map of Bal, 1977 were used for hydraulic head at the ground water divide, varying from 15 to 26 feet above mean sea level.

The results show that recharge to the confined Yorktown-Eastover aquifer is very slow. Calculated rates ranged from 0.01 ft/yr under the worst case conditions to 0.85 ft/yr for a somewhat optimistic scenario of narrow peninsula width coupled with high transmissivity and high hydraulic head. The average recharge rates for the 6 and 8 mile wide peninsula scenarios was 0.13 and 0.07 ft/yr, respectively. These average recharge rates take into account the average widths of the two counties at the selected average transmissivity values, but do not account for the large variability (more than a factor of two) in each of these numbers as discussed in Appendix E (Page E-6). These average rates also coincide with the conceptual model of a fairly restrictive confining layer separating the Columbia and the Yorktown-Eastover aquifer.

Recharge in the model changes directly in proportion to transmissivity increases and hydraulic head increases, but reacts oppositely to changes in the width of the peninsula. The model is quite sensitive to differences in peninsula width. With a decrease of 2 miles (8 to 6 miles, or 6 to 4 miles) recharge more than doubles. The model is also sensitive to values of transmissivity. Over the anticipated range of 500 to 5000 ft^2/day, recharge values approximately double with each 1000 ft^2/day increase. The model is least sensitive to hydraulic head, primarily because of the restricted range of heads that are used. Each 2 foot increase in head translates to about 0.01 ft/yr increase in recharge.

While the rate of recharge is quite low, the volumetric total of water that enters the confined system is fairly large. However, the conceptual model demonstrates that recharge does not occur across the entire area of the confining layer. Rather, it occurs predominantly over the central portions (Figures 2-6 and 2-7). Therefore, multiplying the calculated recharge rate by the entire area of the peninsula on the assumption that all of the confining layer surface permits recharge would incorrectly inflate the volumetric total entering the confined system. A range of areas smaller than the entire Eastern Shore was used to estimate the volumetric recharge to the confined Yorktown-Eastover aquifer (Appendix E).

Using an area of 200 mi^2 and a recharge rate of 0.10 ft/yr (averaging 0.13 and 0.07 ft/yr), there is some cause for concern in terms of water quantity in the Yorktown-Eastover aquifer. At a 0.10 ft/yr recharge rate, pumping at the permitted amount of 15.6 MGD would create a deficit situation, in effect, mining the ground water of the confined system. Even when considering a recharge area of 300 mi^2, the volumetric total at 0.10 ft/yr is within 3 MGD of currently permitted use.

If the Yorktown-Eastover aquifer is receiving recharge at a rate of 11 MGD, and the maximum withdrawal volumes could reach 15.6 MGD according to VAWCB issued permits, then significant problems could develop in the future. Continuous drops in hydraulic head and increases in chloride levels have been observed in VAWCB test wells in the vacinity of the largest industrial withdrawal wells. If maximum withdrawals reach 15.6 MGD, then salt water intrusion (lateral and upconing), well interference and water quality degradation of the Yorktown-Eastover aquifer, already observed near major industrial users, will be aggravated.

In view of these results, serious consideration should be given to (a) better quantification of the amount and distribution of recharge that enters the confined system, (b) careful examination of additional permits for large volume water users that would increase the amount of pumpage significantly beyond current levels, and (c) reevaluation of existing permits relative to actual use and need.

SALT WATER INTRUSION

Serious questions exist relating to the issue of sheer water quantity that can be extracted from the Eastern Shore's confined system. Of equal importance to the amount of water being extracted is the issue of where the water is being taken from. In particular, consideration for the problem of salt water intrusion has to be considered.

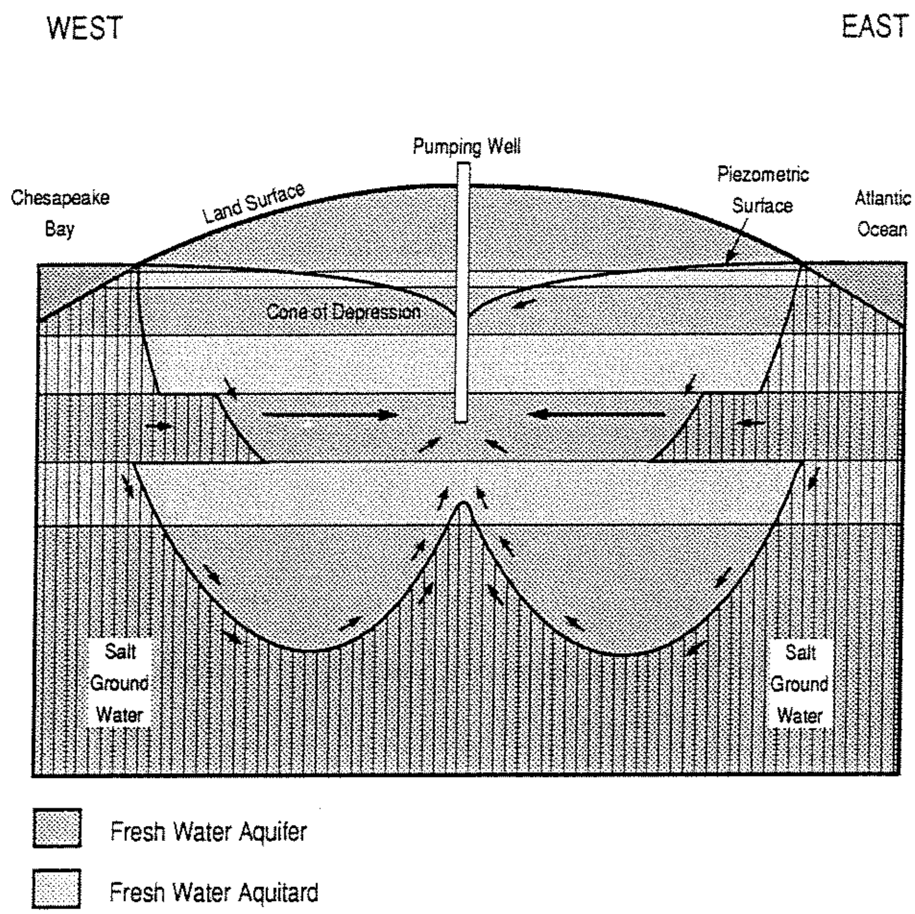
Salt water intrusion to a fresh water aquifer can occur in several ways. Intrusion can occur from lateral inflow of salt water into the fresh water zone. In this scenario, salt water is viewed as a wedge that pushes in to the fresh water lens as fresh ground water head declines because of a drop in areal recharge or from pumping of wells in the fresh water zone (Figure 6-1). Several analytical models have been developed for the analysis and description of flow in a fresh water zone overlying a static body of salt water including the standard Ghyben-Herzberg equation and an approach by Glover, 1959.

With confined aquifers, salt water can also intrude vertically through confining layers in response to reversals of gradient. As pumping proceeds or as areal recharge to the fresh water aquifer declines, the hydraulic head in the fresh water zone becomes less than that in the salt water zone. Flow that originally moved upward from the fresh water zone through the confining layer and discharging to the salt water zone reverses. As a result, salt water leaks through the confining layer into the fresh water zone. This problem particularly afflicts wells located along coastal areas.

The wedge-like movement of salt water into fresh water zones and the leakage through confining layers from gradient reversals was the subject of the recent U.S. Geological Survey study on the Eastern Shore, using the SHARP interface model (Richardson, in press). That report remains in the U.S.G.S review process and is not yet published. When the results do become available, they should be closely examined to assess the impact of lateral intrusion and intrusion through confining layers, particularly on high volume wells located near the coasts.

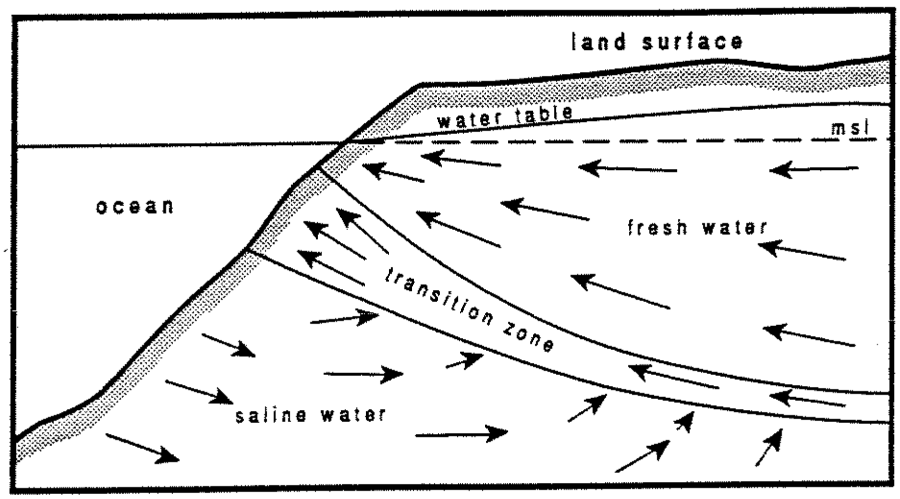
Figure 6-1

SALT WATER UPCONING FROM WELL



regardless of pumping rate, and a number of analytical equations have been developed to describe this movement of salt water (McWhorter and Sunada, 1977). If a well pumps at too high a rate, the salt water upcone will reach the well and contaminate the supply source. Therefore, pumping fresh water from an aquifer underlain by a salt water zone must be done using very small drawdowns to prevent upconing from reaching the well. It is possible to obtain an upconing of the salt/fresh interface that is stable for a given pumping rate, the thickness of fresh water zone and particular well construction. In practical terms, the salt/fresh interface is usually stable if the upcone rises less than one third of the distance between the bottom of the well and the original, non-pumping interface elevation.

Figure 6-2 Upward Vertical Migration of Salt Water



Several analytical solutions have has been developed to predict the maximum discharge a well can produce given a particular thickness of fresh water, hydraulic conductivity, and distance to a well screen. Three were examined for use on the Eastern Shore (Appendix E). The models are designed to predict the recommended maximum rate a well should pump to avoid the problem of moving the salt water upcone beyond the critical level of stability. Two of the models selected (McWhorter, 1972 and McWhorter and Sunada, 1977) are designed for cases of partial penetration of a well, in circumstances where the screened portion of the well is small in relation to the total depth, a common factor to virtually all wells on the Eastern Shore. The third approach (Bennett, 1968 in Reilly and others, 1987) incorporates a recharge factor into the calculations.

The upconing models were applied for conceptual purposes to obtain an idea of the magnitude of the problem of upconing. The aquifer was modelled as a single confined unit, ignoring intermediate confining and semi-confining layers to simplify the analysis. Parameters needed for the modelling (e.g.,thickness of the undisturbed fresh water zone, position of well screen, hydraulic conductivity, etc.) were determined for a high volume producing well, Perdue #2, taken from the literature. In particular, the elevation of the pre-pumping salt/fresh interface was designated at the elevation of the the 250 mg/l chloride level, calculated by subtracting the mapped 250 mg/l chloride surface elevation (Fennema and Newton, 1982) from the pre-pumping water level surface elevation (Bal, 1977). Water with more than 250 mg/l tastes salty and is generally unacceptable for most domestic and industrial uses. While the 250 mg/l chloride level does represent a limit of potable water, it is not a true salt/fresh water interface. The allowable discharges produced by all the upconing models are directly proportional to the difference in density between the salt (usually sea water) and fresh water, generally estimated at 0.025 mg/l. The density differences between fresh water and water with 250 mg/l chloride is negligible, resulting in trivially small allowable discharge rates. To make use of these analytical tools even for conceptual purposes, the density difference had to be maintained as that between sea and fresh water.

The results (Table 6-1) show the models predict considerably lower levels of pumping discharge rates than either permitted or existing rates in order to maintain a stable upcone. The predicted rates for this well range from a low of 20 gpm from an extremely conservative model to 80 gpm, using the Bennett and other, 1968 model that incorporates recharge. However, if a true salt water interface existed at the 320 foot level (with a chloride concentration of approximately 30,000 mg/l), this well and most all high volume wells on the Eastern Shore would have been contaminated at either their permitted or actual rates.

Table 6-1: Salt Water Upconing Modelling Results

Well:	Perdue #2			
Model Input Parameters			*Discharge Data*	
Screen bottom elevation	253	ft msl	Permitted discharge (gpm)	503
Salt/fresh interface	320	ft msl	Actual discharge (gpm)	278
Thickness of fresh water	340	ft		
Areal Recharge	0.10	ft/yr		
Hydraulic conductivity	37.5	ft/day		
Modelled allowable discharge to prevent upconing				
Model from McWhorter, 1972			**20**	**gpm**
Model from McWhorter and Sunada, 1977			**46**	**gpm**
Model from Bennett and others, 1968			**80**	**gpm**

The reasons why sea water does not flow from the wells of the Eastern Shore is a combination of several factors. The models assume a sharp interface between the salt and fresh water, a phenomenon that rarely occurs in field conditions, especially if pumping is intermittent. Instead, the salt/fresh interface usually forms a gradational zone from highly saline or brackish water to fresh water. Also, as indicated above, the interface position used in the modelling was not assumed to be a pre-pumping true interface (approximately 30,000 mg/l). The model instead used a post-pumping 250 mg/l chloride level, which is not a true salt water/fresh water interface. The actual position of salt water lies somewhat below the level used in the modelling, below the confining layer that separates the lower Yorktown-Eastover modelling was not assumed to be a pre-pumping true interface (approximately 30,000 mg/l). The model instead used a post-pumping 250 mg/l chloride level, which is not a true salt water/fresh water interface. The actual position of salt water lies somewhat below the level used in the modelling, below the confining layer that separates the lower Yorktown-Eastover aquifer from the underlying unit, the St. Mary's Formation. None of the models used incorporates a low permeability unit into the calculations, and salt water intrusion from upconing would be slowed by the presence of a lower boundary of silts and clays.

The results of this modelling should serve not as any sort of regulatory tool but as a warning that large discharges will promote salt water contamination from upconing unless pumping rates and intensities are regulated. Also, the primary issue at hand is not whether sea water with a chloride concentration of 30,000 mg/l is actively intruding into the fresh water aquifer. The more important question is whether water that possesses chloride concentrations of 250 mg/l and is essentially useless for direct consumption, either as drinking water or as industrial use water, will be drawn into the wells. In all likelihood, that is probably happening now in a number of wells on the Eastern Shore despite the fact that samples from most wells show lower overall concentrations. Most wells completed in the Yorktown-Eastover aquifer have screens in all three layers and draw water from all three. The lower Yorktown-Eastover is often the least transmissive of the three and contributes the least water. The overall result is that a mixing of water occurs, and samples taken from a given well represent the bulk chemical signature of all three layers. Water in the upper two layers is not likely to have been affected by high chlorides yet, and dilution masks the elevated concentrations of chloride from the lower section. Salt water upconing will occur with pumping, and careful management of the resource is required to avoid irreparable damage to the fresh water aquifers.

BUILDOUT/DEVELOPABLE LOT ANALYSIS

7

SECTION 7: BUILDOUT

DEVELOPABLE LOT/LAND USE ANALYSIS

Of the total land area on the Eastern Shore (about 537,000 acres), approximately 38 percent or 206,000 acres are wetlands and coastal islands, not suitable for residential, agricultural or industrial use. Approximately 53% of the land area on the Eastern Shore is under agricultural use or forestry. The remaining 9% of the land is under residential use (3.2%), commercial/industrial use (0.6%), in the public domain (2.4%), or other uses (2.3%) (Table 4-1, p. 4-3.).

With the exception of sewage treatment plants servicing the towns of Cape Charles and Onancock, existing development on the Eastern Shore relies on individual subsurface disposal systems for sewage treatment. No large-scale sewering is anticipated in the future. Residential development is scattered, with a low density pattern of development overall. Commercial and industrial development is concentrated along the center strip of both counties, following Route 13. Drinking water is supplied by a combination of public water supply and private wells.

Zoning requirements (dimensional and use) vary widely, both within the counties, and within the towns. Land use in Virginia is regulated at the county level, with the exception of the areas within incorporated towns. Land use in these areas is regulated by the towns themselves.

The authority for local governments to zone land in Virginia is granted by the Virginia General Assembly and can be found as Article 8 of the Code of Virginia. The Virginia Zoning Code cites ten general purposes for zoning including *"to protect surface water and groundwater"* (VA Code Ann. sec. 15.1-489). The Zoning Code also authorizes conditional zoning, site plan ordinances, and the provision for variances.

In addition, local governments are required to develop a comprehensive plan for *"the physical development of the territory within its jurisdiction"* (VA Code Ann., sec. 15.1-446.1). The comprehensive plan becomes the general plan for development and the basis for the formulation of zoning ordinances in the local jurisdiction. Specifically, the code requires local governments to include in their plans *"the designation of areas for the implementation of reasonable groundwater protection measures"* (VA Code Ann,. sec. 15.1-446.1).

Local control over development can also be found in the State's law controlling land subdivision (VA Code Ann. sec. 15.1-465). This authority can be particularly important in an area such as the Eastern Shore where very little land is currently subdivided into smaller residential lots.

A land use control measure that recently became available for use in Virginia is found in the Chesapeake Bay Preservation Act (VA Code Ann. sec. 10.1 -2100). This new law passed in 1988 requires that counties, cities, and towns of Tidewater Virginia incorporate general water quality protection measures into their comprehensive plans, zoning ordinances, and subdivision ordinances. This authority provides very general and broad powers to local governments in Virginia to control land uses that may impact on water quality.

Methods

The primary purpose of buildout, or developable lot, analysis was to evaluate the impacts of existing and potential land uses on ground water quality. The analysis therefore focused on the Zone 2 spine recharge area, as delineated in this study.

The buildout analysis followed a three step process. First, Zones 2 and 3, as delineated in this study, were transferred onto US Geological Survey 1:25,000 scale topographic quadrangles for Northampton County and Accomack County land use district maps, also at 1:25,000 scale.

Secondly, existing land uses within the spine were documented. The potential for further development was determined from future land use maps prepared for both counties, and the information was transferred onto the set of 1:25,000 scale maps. An example of future land use within the spine is shown on Figure 7-1.

The Soil Conservation Service (SCS) identified the Nimmo-Arapahoe soil association as the only upland soil type in the two counties that is considered undevelopable (R. Lewis, personal communication, 1991). Areas with these soils were identified on the land use maps, and analyses were conducted with and without inclusion of these areas. Small regions of hydric soils were not factored into analyses.

Finally, areal extent was measured for each future land use class, subdivided by county, ground water protection zone, and soil class. Fifteen percent (15%) of developable land was taken out for roads within each land use category.

All data used in the analysis was entered into a computerized spreadsheet program (Microsoft Excel), to aid sorting and analysis. The spreadsheet was programmed to perform the necessary calculations for the various buildout scenarios. The total future number of units was calculated by taking the total land area within each land use category in each protection zone, subtracting out 15% for roads and poorly drained soils. The remainder was divided by the permitted number of lots per acre under current zoning (Northampton) or recommended zoning (Accomack Comprehensive Plan, 1989). Table 7-1 lists parameters used.

Table 7-1: Minimum Lot Sizes Used in Buildout Analysis

Accomack County		Northampton County	
RR: Rural Residential	1 unit/acre	Residential	20,000 ft^2
R-1: Residential	3 units/acre	Agriculture	43,560 ft^2
R-2: Residential	2 units/acre		
Agriculture:	1 unit/5 acres		
Source: Accomack County Comp. Plan, 1989		Northampton County Zoning Ordinance, 1990	

The analysis results have important implications for the assessment of nitrogen contamination of ground water and for the development of appropriate regulatory approaches in protecting ground water quality on the Eastern Shore.

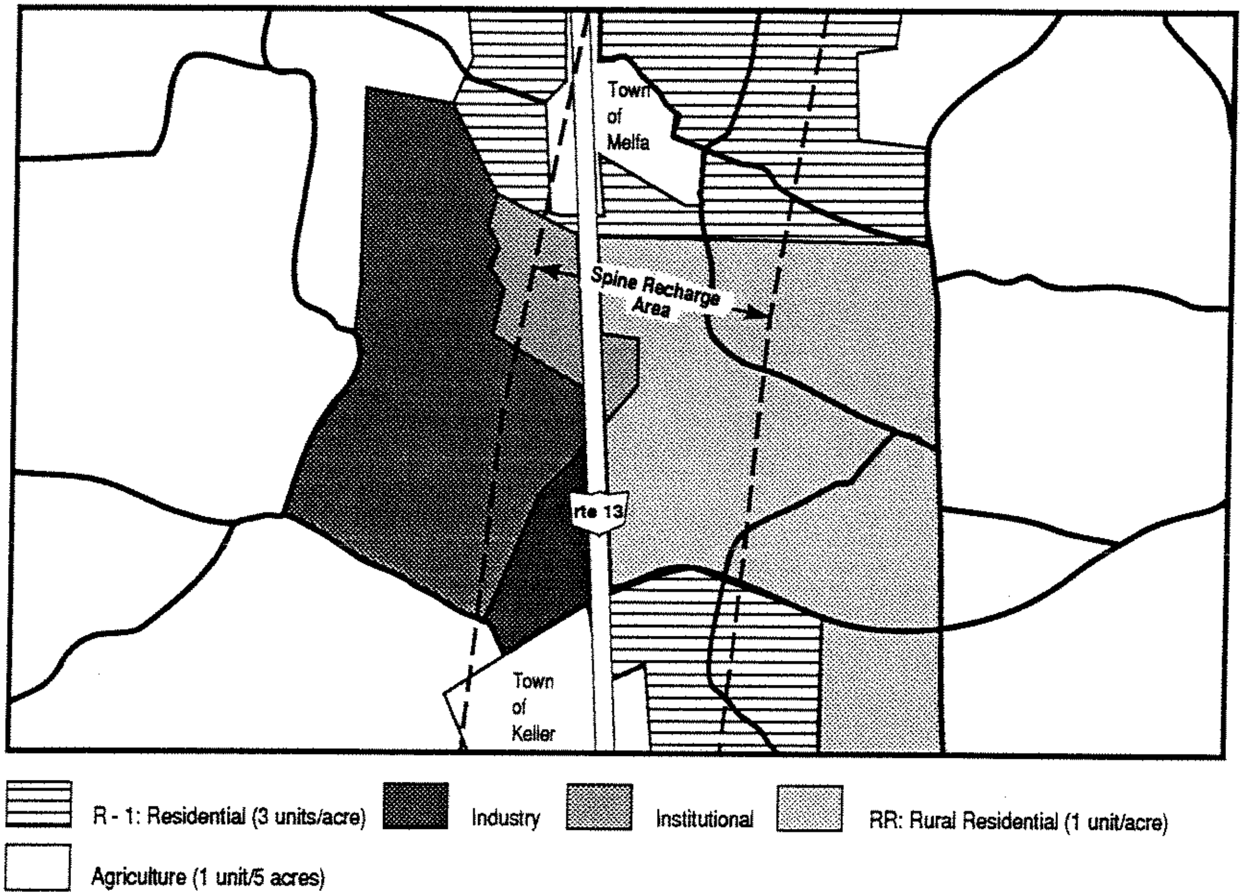
Buildout Assumptions

For incorporated towns in Accomack County certain assumptions were made in order to complete the buildout analysis. Each town has its own zoning which is not included in the Future Land Use Plan for the County. The following assumptions were made:

1) The percentage of the town which lies within the spine was determined by taking the ratio of acres of town within the spine to total acres of incorporated town.
2) The breakdown of land use types was assumed to be equivalent to that of the entire county, leaving out agriculture, parks, and marshland. In Accomack County, it was estimated that 75% is residential, 1.8% is trade, 17.5% is industrial, and 5.3% of is institutional. These percentages were

Figure 7-1:

Example of Future Land Use Within Spine Recharge Area



multiplied by the acres of each town which fall on the spine. An estimate of acreage by land use within the town was thus achieved.

3) Using the estimated potential residential acreage in each town from (2), the number of potential dwelling units was calculated. An average of 2 units per acre was used.

For Northampton County, there are two types of residential land delineated on the future land use map, Rural Residential (and village area) and Urban Development Area. In the Comprehensive Plan, each urban development area is broken down into residential, commercial, industrial, roads/railroads and public land areas. The maps showing the locations of these types are inadequate for transferral to the USGS quadrangle maps. Therefore, land use within the urban development areas was estimated. Proportions of each land use type within the spine were assumed to be equivalent to that of the area as a whole; and residential land was separated from other types within each urban development area.

Calculations within incorporated towns and Urban Development Areas are included in Tables 7-3 and 7-4.

BUILDOUT ANALYSIS RESULTS

Buildout results are summarized in Table 7-2; complete results are shown in Table 7-5.

Table 7-2: Buildout Summary

	Existing Units County-wide	Total Acres within spine	Res./Ag. Acres within spine	**Potential Units within spine**
Accomack County				
developable soils		17,140	16,561	15,893
all soils	15,840	22,147	19,901	16,470
Northampton County				
all soils	6,183	16,921	15,535	21,207

In both counties, the potential number of single-family dwelling units within the spine recharge area, according to current plans, is greater than the number of units that currently exist within the *entire* two counties. While the number of potential housing units may be striking, development is currently slow on the Eastern Shore of Virginia. Indeed, the population has actually decreased in the past decade. Consequently, there is opportunity to enact management tools to control future development and thereby protect ground water quality and quantity.

BUILDOUT ANALYSIS SUMMARY

The buildout analysis used a computerized spreadsheet approach to determine the maximum number of future residential units in both counties. The buildout focused on land areas within the delineated spine recharge zone (Zone 2) to the Yorktown-Eastover aquifer, since this area would most likely affect public water supply quality. Using minimum lot size requirements according to each county's comprehensive plan, the maximum number of units or houses that could be possibly built was calculated. In Accomack County this resulted in 16,470 potential units in the spine recharge area. For Northampton County, the maximum potential number of units was calculated to be 21,207 (Table 7-2). As discussed previously, this results in more potential units than that which currently exist within each county.

Table 7-3: Calculations for Buildout Within Incorporated Towns, Accomack County

CALCULATIONS OF CURRENT DWELLING UNITS WITHIN SPINE

Incorporated Town	Acres within spine	Total acres of town	% of town within spine	1990 census # dwelling units	Estimated dwelling units in spine
Accomac	173	262	66	205	136
Onley	83	486	17	276	47
Melfa	154	177	87	191	166
Keller	211	214	98	107	105
Painter	184	415	44	113	50
Belle Haven	408	820	50	245	122

CALCULATIONS OF LAND USE WITHIN TOWNS

Land Use	Acreage in county (%)	Estimated acreage within towns (%)	Estimated Acres					
			Accomac	Onley	Melfa	Keller	Painter	Belle Haven
Residential	4.3	75	131	63	116	159	138	308
Trade	0.1	2	3	2	3	4	3	7
Industrial	1.0	18	30	15	27	37	32	71
Institutional	0.3	5	9	4	8	11	10	22
Total	5.7	100	173	84	154	211	184	408

MAXIMUM POTENTIAL DWELLING UNITS WITHIN SPINE

Town	Estimated residential acres within spine	Residential acres subtracting 15% for roadways	Average units/acre	Potential dwellings in spine	Existing dwellings in spine	Maximum Additional Units Possible
Accomac	131	111	2	222	136	86
Onley	63	54	2	107	47	60
Melfa	116	99	2	197	166	31
Keller	159	135	2	270	105	165
Painter	138	118	2	235	50	185
Belle Haven	308	261	2	523	122	401

Table 7-4: Calculations for Buildout Within Urban Development Areas, Northampton County

CALCULATIONS OF CURRENT DWELLING UNITS WITHIN SPINE

Urban Development Area	Acres within spine	Total acres of area	% of area within spine	Current Population (Comp. Plan)	Estimated Pop. in spine	# persons/ dwelling (1990 census)	Est. number of dwelling units in spine
Exmore/Willis Wharf	1,164	4,225	28	2,684	740	2.1	350
Nassawadox	1,230	1,860	66	1,775	1,174	2.1	556
Eastville	1,423	2,277	63	800	500	2.1	237
Cheriton/Cape Charles	1,448	5,428	27	4,274	1,140	2.1	540

LAND USE WITHIN URBAN DEVELOPMENT AREAS ACCORDING TO COMPREHENSIVE PLAN

Land Use	Exmore/ Willis Wharf	Nassawadox	Eastville	Cheriton/ Cape Charles
Residential	65	88	77	66
Commercial	5	7	3	4
Industrial	6	2	2	7
Roads/Railroads	17	1	15	19
Public	7	2	2	5

MAXIMUM POTENTIAL DWELLING UNITS WITHIN SPINE

Urban Development Area	Estimated residential acres within spine	Minimum lot size (acres)	Potential dwellings in spine	Estimated existing dwellings in spine	Maximum Additional Units Possible
Exmore/Willis Wharf	759	0.46	1,650	350	1,300
Nassawadox	1,076	0.46	2,340	556	1,784
Eastville	1,096	0.46	2,382	237	2,146
Cheriton/Cape Charles	948	0.46	2,061	540	1,522

This buildout has important implications for wastewater disposal impacts and future water supply needs. Obviously, not every possible unit will be developed in the near future, however the buildout assessment expresses the "blue print" that has been established for growth by both counties. If this development were to occur, then significant water demands and wastewater disposal needs would have to be addressed. For the combined total number of units of 37,677, a water demand of 5.65 MGD (37,677 units x 150 gallons per day) would be needed. As of 1990 only 1.2 MGD is supplied by public water sources. Public water withdrawals would have to increase by over 4.5 times. Regarding wastewater disposal, if all of these units were allowed to be built, then a total of 6.22 MGD of wastewater (37,677 units x 165 gallons per day) would have to be either treated and disposed to the ocean or Bay, or be discharged to the ground water through septic systems. Further analysis of wastewater impacts under buildout conditions is discussed in Section 8.

The numbers generated in the buildout were used in the nitrogen loading model to determine maximum nitrogen loading under the planned densities and land use types for both counties. The buildout numbers for maximum number of units, agricultural areas, etc. are used to predict nitrogen loading under the current land use plans, and to allow for scenario testing of different land use patterns.

This buildout analysis can be used as a predictive tool to help assess the impacts of future development on the many community services that would be needed to support this level of development and to help plan for changes in development densities and patterns of future development. In reality, the near future will only see a fraction of this buildout potential due to market conditions and other factors. Buildout analyses such as this one can be used to identify potential land use conflicts and to begin to plan for changes to address these conflicts.

Table 7-5: Developable Lot Analysis, Accomack and Northampton Counties

ACCOMACK COUNTY

Measurements in acres

Permitted WPA A

Land Use Type	Developable Acres	Undevel. Acres	Total Acres	Units/ Acre	Potential Units Dev. soils	Potential Units All soils
RR: Rural Residential		12	12	1	0	10
R-1: Residential						
R-2: Residential						
Trade		60	60			
Industry						
Institutional						
Parks & Recreation						
Agriculture	161	3,183	3,344	1/ 5 acres	27	569
Total	161	3,256	3,417		27	579

Permitted WPA B

Land Use Type	Developable Acres	Undevel. Acres	Total Acres	Units/ Acre	Potential Units Dev. soils	Potential Units All Soils
RR: Rural Residential	733		733	1	623	623
R-1: Residential				3		
R-2: Residential	29		29	2	50	50
Trade	626		626			
Industry	187		187			
Institutional	29		29			
Parks & Recreation						
Agriculture	3,164	145	3,309	1/5 acres	538	563
Total	4,769	145	4,915		1,211	1,236

Land Use Type	Permitted WPA C Developable Acres	units/ acre	Potential Units	Permitted WPA D Developable Acres	units/ acre	Potential Units
RR: Rural Residential	1,220	1	1,037	401	1	341
R-1: Residential	2,985	3	7,612	899	3	2,292
R-2: Residential	205	2	349	312	2	530
Trade	585					
Industry	197			71		
Institutional	181			10		
Parks&Recreation	0					
Agriculture	3,726	1/5 acres	633	1,811	1/5 acres	308
Incorporated Town	410			802		
residential	310	2	526	605	2	1,028
trade	7			14		
industrial	72			140		
institutional	22			43		
Totals by area	9,509		10,157	4,306		4,498

NORTHAMPTON COUNTY

Land Use Type	Permitted WPA D Developable Acres	units/ acre	Potential Units	Permitted WPA E Developable Acres	units/ acre	Potential Units
Rural Resid. & Village Area	628	2.178	1,163	2,218	2.178	4,105
Urban Development Area	2,394			2,871		
residential	1,836	2.178	3,998	2,044	2.178	4,452
commercial	151			111		
industry	96			128		
roads/railroads	206			490		
public	170			98		
Agricultural or Forestral Area	3,102	1	2,637	5,707	1	4,851
Total by Area	6,125		7,798	10,796		13,409

NITROGEN LOADING

8

SECTION 8: NITROGEN LOADING

INTRODUCTION

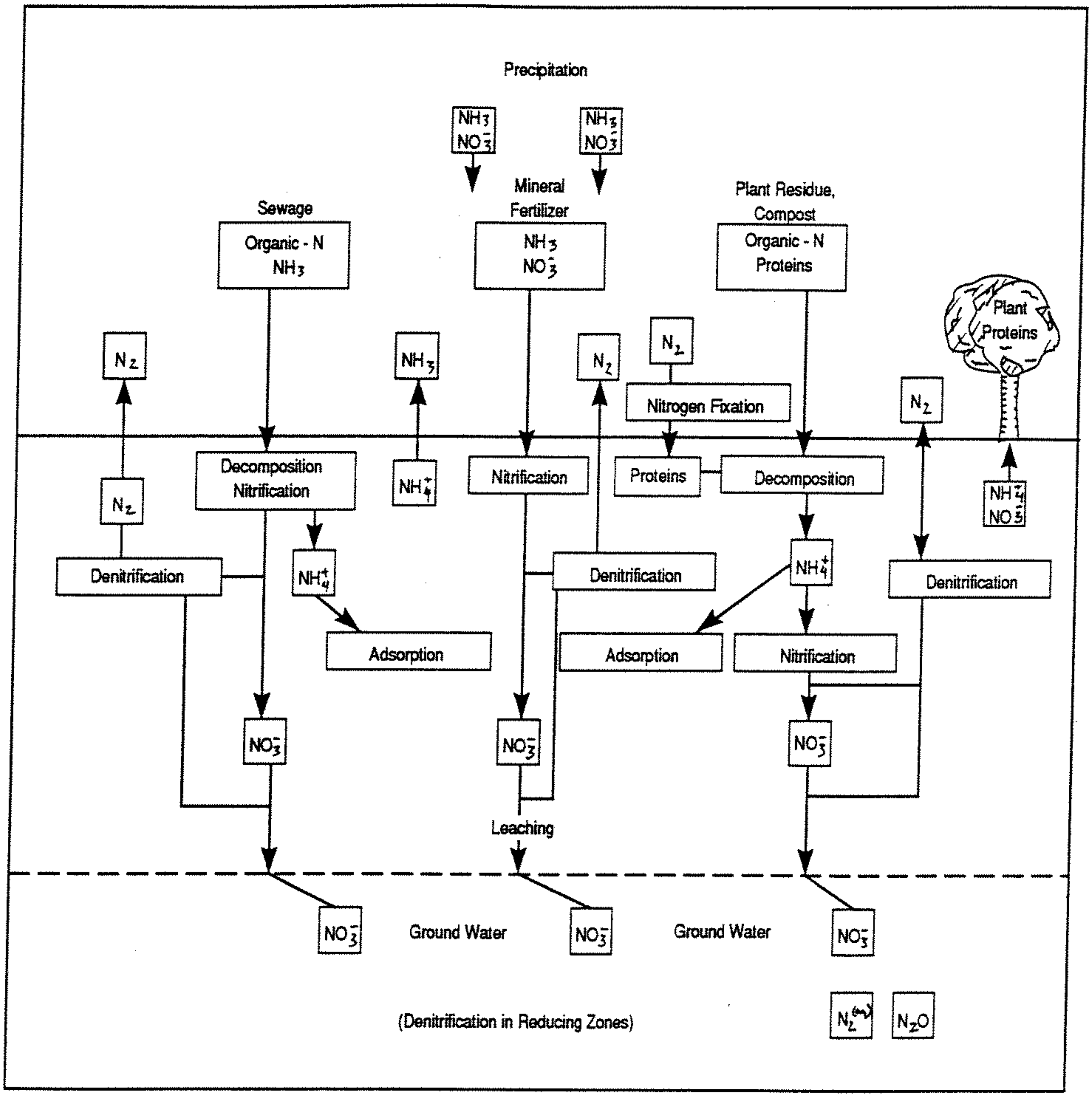
Nitrogen is present in surface and ground water environments in four primary forms. The forms are organic nitrogen, ammonium-nitrogen, nitrite-nitrogen and nitrate-nitrogen. Organic nitrogen consists of a variety of soluble, colloidal and particulate forms. Ammonium-nitrogen (NH_4^+) is characteristic of poorly oxygenated (anaerobic) conditions and is readily adsorbed by soil particles in the unsaturated, oxygenated zone above the water table where it is rapidly converted to nitrate-nitrogen. However, ammonium-nitrogen may travel long distances in areas where the saturated zone is anaerobic. Ammonium-nitrogen is the primary form of nitrogen in septic system effluent and in wetland soils. Nitrite-nitrogen (NO_2) is an unstable form which is rapidly transformed into nitrate-nitrogen, and so is usually present in very small quantities. Nitrate-nitrogen (NO_3) is characteristic of oxygenated (aerobic) conditions and is highly mobile in ground water. In this form, nitrogen may travel long distances with little attenuation. (Freeze and Cherry, 1979; Canter and Knox, 1986)

Nitrogen transformations are complex, bio-physio-chemical processes. Figure 8-1 illustrates some of the common nitrogen transformations, described below. The process by which organic nitrogen is transformed to ammonium-nitrogen is called *mineralization* or *ammonification*, and occurs under both aerobic and anaerobic conditions. The process whereby ammonium-nitrogen is transformed to nitrate-nitrogen is called *nitrification* and occurs under aerobic conditions. *Denitrification* is the process by which nitrate-nitrogen is converted to gaseous forms such as N_2 and released to the atmosphere. Denitrification occurs under anaerobic conditions, particularly within wetland soils. The opposite transformation, whereby atmospheric nitrogen is converted to ammonium nitrogen is called *nitrogen fixation*, and is performed by bacteria and blue-green algae (cyanobacteria). (Freeze and Cherry, 1979; Canter and Knox, 1986)

NITROGEN AS A CONTAMINANT

Although all forms of nitrogen are critical components of natural systems, nitrogen can cause water quality degradation if present in excessive quantities. In drinking water supplies, elevated nitrate-nitrogen levels can cause an illness known as infant cyanosis, methemoglobinemia, or "blue-baby syndrome" in infants, caused by the alteration of hemoglobin and subsequent problems with oxygen transport. In addition, high nitrate-nitrogen levels have been linked to the formation of carcinogenic nitrosamines (Porter, 1978). To reduce potential health risks, the U.S. EPA has established a drinking water standard of 10 milligrams per liter (mg/l) for nitrate-nitrogen. A statistical analysis of ground water samples collected on Long Island, New York, demonstrated that when median nitrate-nitrogen concentrations were 6 mg/l, 10 percent of the samples exceeded the 10 mg/l drinking water standard (Porter, 1978). To account for this variability, the Cape Cod Planning and Economic Development Commission (CCPEDC) and several towns across the state of Massachusetts have adopted a more conservative concentration of 5 mg/l, as a planning guideline. The Virginia State Water Control Board adopted a ground water standard of 5 mg/l for nitrate-nitrogen in the early 1970's. Since then, the anti-degradation policy supersedes these standards. In the case of Virginia, the numeric limits are meant as guidance and are for permitted discharge. The ground water standards are different and separate from drinking water standards, and are not levels that have to be reached should a clean-up be necessary. (T. Wagner, SWCB, personal communication, 1991).

Figure 8-1: Nitrogen Transformations



Adapted from Freeze and Cherry, 1979.

SOURCES OF NITROGEN

Nitrogen originates from a variety of natural and anthropogenic sources, including sewage, fertilizers (residential and agricultural), road runoff, precipitation, landfills, and wildlife. A discussion of published loading rates for these various sources is provided below.

Sewage

Sewage-derived nitrogen may be produced by a variety of sources, including sewage treatment plants, septage lagoons, on-site sewage disposal systems, exfiltration from leaking sewer mains and combined sewer overflows (CSO's). On the Eastern Shore, on-site sewage disposal systems are the primary source of nitrogen to the ground water.

The quantity of nitrogen produced by a given on-site sewage disposal system is a function of the volume and concentration of the effluent discharged, which, in turn, is dependent on the per capita water usage and the occupancy rate. Daily rates of water use may range from 36 to 150 gallons per person per day (EPA, 1980; Nelson et al., 1988) with average rates on the order of 50 to 75 gallons per day (gpd). In estimating sewage flow rates, however, it is important to differentiate between the amount of water actually used and the amount ultimately discharged to ground water as sewage flow. Typically, 20% of the water used may be lost through evaporation or transpiration during irrigation and other outside uses (Nelson et al., 1988). For the purpose of this study, a ground water discharge rate of 55 gpd per capita was used for sewage flow.

Quantification of household populations is very difficult, particularly in seasonal communities such as the Eastern Shore, where summer populations may be significantly higher than winter populations. For the purpose of this investigation, an average annual occupancy rate of three people per household was used, based on average occupancy rates as determined for Northampton County. However, a sensitivity analysis was conducted to evaluate household populations ranging from two to four people.

A review of the literature indicates that nitrogen concentrations in raw sewage may range from 20 to 100 mg/l. Once sewage enters a properly functioning septic system, however, some removal of this nitrogen occurs both within the septic tank and in the soils below the leaching area. Studies have indicated that between 30 to 60% of the nitrogen may be removed in this way (Porter, 1978; Andreoli et al., 1979). Thus, in estimating loading rates from on-site sewage disposal systems, it is important to use nitrogen concentrations in effluent discharging from the leaching area. Data on total nitrogen concentrations in effluent sampled either from the leaching area or from ground water immediately below the leaching area are summarized in Table 8-1.

Table 8-1: Total Nitrogen Concentrations in Septic System Effluent

Source	Concentration
Bouma et al., 1972	30 mg/l
Walker et al., 1973	40 mg/l
Dudley and Stevenson, 1973	14 mg/l
Magdoff, 1974	31 mg/l
Magdoff, 1974	41 mg/l
Reneau, 1977	23 mg/l
Brown and Assoc, 1980 (summary)	37 mg/l
Ellis, 1982	34 mg/l
Canter and Knox, 1986 (summary)	40 mg/l
Nelson et al., 1988 (summary)	34 mg/l

A critical review of these reports, particularly the more recent ones, suggests that an average effluent concentration of 40 mg/l is a conservative yet defensible value to use in evaluating water quality impacts of on-site sewage disposal. This value was used in our analyses. Using a flow rate of 55 gallons/capita/day and an average effluent concentration of 40 mg total nitrogen/l, the average loading rate per capita is 6.72 lbs N/year.

Fertilizers

Agricultural fertilizers are usually the primary nitrogen source to ground water in heavily farmed areas. Accomack and Northampton Counties are predominantly agricultural, with land in farms accounting for approximately 53% of the total land area. In Accomack County, poultry production is the main industry. The predominant crop grown in the two counties is soybeans, a plant which is a nitrogen-fixer and so does not require nitrogen fertilization. The remaining acreage of crop land requires a significant amount of fertilizer (see Table 3-5). For Accomack County this averages 89 lbs/acre and in Northampton County the average agricultural nitrogen application is 79 lbs/acre.

Fertilizer and manure applications and poultry production may contribute large quantities of nitrogen to the underlying aquifer depending upon the agricultural management practices in use. The application, production, and storage of fertilizers and animal wastes result in the most important nitrogen contributions.

From the Cooperative Extension Agents in both counties, information was gathered regarding crop type acreage and fertilizer application rates. This was used to calculate an average fertilizer application rate of 84 lbs N/acre/year, for all agricultural areas in both counties. An average leaching rate of 25% was assumed for farm fertilizers. Many researchers have documented nitrogen leaching rates that range from 1%-47%(Ritter, and Manger,1985; Bouk, 1984; Bacon, 1989; Bower, 1989; Owens, 1987; and Hubbard, 1986). Nitrogen leaching rates to ground water can be affected by many factors including: crop type, application rates, irrigation, soil types, application timing, fertilizer formulations, and climate. As such, the literature shows a wide range of nitrogen loading values. The value of 25% was chosen since it represents a value most often selected in modelling studies of nitrogen movement, and also because it represents a mid range of the values from the literature.

Animal Wastes

Given the high levels of organic and ammonium-nitrogen in manure, animal waste may function as both point and non-point sources of nitrogen contamination. Chicken manure, in particular, has a high nitrogen availability rate, making it easily leachable into ground water.

If wastes are produced or stored on open ground at poultry houses, rainwater can transport nitrogen by percolation through the wastes and into the soil and ground water. All poultry waste is assumed to be used as agricultural fertilizer for the purpose of this study. Prior to application as fertilizer, most manure remains in the poultry houses until it is cleaned out once or twice per year (J. Belote, personal communication, 1991). Storage of poultry wastes is usually thought to be a source of nutrients and pathogens that contaminate ground water. For this reason, on the Eastern Shore in Maryland, efforts are being made to construct storage sheds for poultry manure, rather than continue the current practice of letting manure pile up uncovered outside.

Natural mortality accounts for many tons of dead poultry birds. As explained in Section 3, the practice on the Eastern Shore of Virginia is to either bury or compost the chickens. The majority of chickens which die before being sent to the processing plant die within the first two weeks of life, and it is estimated that given the 1990 population, a total of 1.8 million pounds of dead birds had to be disposed. At 3.3% nitrogen (Keeton, 1980), dead chickens contributed 60,638 pounds of nitrogen to Accomack County in 1990.

Lawn Fertilizers

Fertilizers applied to residential lawns and golf courses contribute nitrogen to ground and surface waters. The pathway may be either direct, via surface runoff, or indirect, via gradual leaching to ground water. The amount of fertilizer that ultimately leaches into ground water is a function of the type of ground cover, soil characteristics, climate, type of fertilizer used, application rate, and the degree of irrigation/rainfall. A literature review of experiments conducted primarily on turf plots suggests that leaching rates may vary from less than 1% to 80%, depending on site specific conditions (see Table 8-2). Leaching rates rarely exceeded 30%, however, unless extremely high fertilization and irrigation rates were used (e.g. Nelson et al., 1980).

Table 8-2: Leaching Rates for Fertilizers Applied to Turf Areas

Reference	% Leached
Brown, 1977	2-27%
Brown, 1982	1-18%
Chichester, 1977	1-8%
Dowdell and Webster, 1980	2-5%
Hesketh, 1986	0-31%
Mancino, 1980	0-4%
Morton, 1988	2-14%
Nelson, 1980	5-81%
Petrovic, 1988	0-17%
Starr and DeRoo, 1981	<1%

Based on a review of this data, with particular emphasis on regional similarities, a leaching rate of 30% was selected as a conservative (worst case) average value for nitrogen applied as fertilizer to residential lawns within the study area.

The typical lawn size for a given lot will vary widely depending on overall lot size, residential character, and individual preferences. Few quantitative studies have been conducted of average lawn sizes. The Long Island, New York and the Barnstable County, Massachusetts 208 studies both used an average lawn area of 5,000 square feet. More recently, a survey conducted as part of the Yarmouth Water Resources Protection Plan documented an average lawn size of 4,350 square feet on half acre lots (Nelson et al., 1988). There have been no known studies on the Eastern Shore of Virginia regarding lawn sizes and application rates of fertilizers. For this study, an average lawn size of 5,000 square feet was used.

Fertilizer application rates are similarly difficult to quantify. The Cape Cod and Long Island 208 studies used an average annual application rate of three pounds per 1,000 square feet. The Yarmouth survey documented a similar annual application rate for homeowners (2.8 lbs/1,000 sq. ft.) and a higher annual application rate for professional lawn maintenance companies (4.7 lbs/1,000 sq. ft.). For this study, an average annual application rate of 3 lbs/1,000 sq. ft., equivalent to 39 lbs N/acre, and a leaching rate of 30% was used. Although lawn fertilization is not a widespread practice on the Eastern Shore of Virginia, these studies are the only means of taking into account any turf maintenance.

Landfills

Unlined landfills contribute large quantities of nitrogen to ground water through the decomposition of buried organic matter. Nitrogen loading from landfills was based on nitrogen concentrations in typical leachate, 218 mg/l (Patrick and Quarles, 1983). The area of the landfills was obtained from the Accomack-Northampton Planning District Commission, and an annual recharge rate of 24 inches per year was used (no vegetation/transpiration). This yielded a loading rate of 1184 lbs N/acre/year for landfills.

Septage Lagoons

Three septage lagoons are located on the Eastern Shore. These lagoons primarily receive the contents of septic tanks, pumped out according to proper maintenance procedures.

The nitrogen loading to ground water from septage lagoons is a product of the raw sewage load minus the amount attenuated in the septic tank, gaseous losses from the lagoon, and attenuation in the soil during percolation from the lagoon. The nitrogen concentration in raw sewage can vary from 20 to 100 mg/l (Metcalf & Eddy, 1979; Laak, 1980; Douglas, 1986), but the total load depends on the associated sewage flow. Nitrogen loads in untreated waste water have been reported from 8 to 13 lb/capita/year (Porter, 1978; Brandes, 1978; Laak, 1980; Camp and Meserve, 1974). Porter (1978) summarized a number of studies which found an average septic tank influent concentration of 65 mg/l, an average septic tank effluent concentration of 45 mg/l and an average removal of 31%.

Additional reduction occurs from gaseous losses from the lagoon and during percolation of septage into the soil. The estimated nitrogen concentration of septage reaching ground water can conservatively be set at 45 mg/l.

Pavement and Roof Runoff

Sources of nitrogen in pavement runoff include precipitation, soil erosion, leaf litter, street dirt, garbage, and animal waste. Nitrogen concentrations in road runoff can vary by an order of magnitude, depending on spacing between storms, the intensity and duration of a storm, and the timing of sample collection. The highest nutrient concentrations are generally found in the "first flush". A summary of typical road runoff values published in the literature is provided below:

Table 8-3: Total Nitrogen Concentrations in Road Runoff

Reference	Total Nitrogen Concentration
Koppelman, 1982	1.49 mg/l
Howie and Waller, 1986	1.13-2.15 mg/l
Lager et al., 1968	3-10 mg/l
Loehr, 1973	3 mg/l
Schmidt and Spencer, 1986	2.04 mg/l
Valiela and Costa, 1988	0.38 mg/l (27 um)*

*Dissolved Inorganic Nitrogen only

For the purposes of this analysis, a nitrogen concentration of 2.0 mg/l in road runoff was used. For roof-runoff, a nitrogen concentration of 0.75 mg/l was selected (Nelson et al., 1988).

ESTIMATION OF PAVED AREA/ROOF AREA

HWH estimated the total paved road area to be 15% of all land area (Nelson et al., 1988), multiplied by 55% since a typical 40 foot right of way includes a 22 foot width of actual pavement.

Driveway surface area was estimated to be 500 square feet and roof area to be 1500 square feet per residential unit (Nelson et al., 1988).

Businesses/Industrial/Institutional

The nitrogen loading from business, industrial, and institutional facilities was calculated to average the design sewage flow per acre for all current land uses in these areas. From the community, non-community, and non-transient non-community water supply list, population information was obtained for the number of persons served in motels, restaurants, campgrounds, trailer parks, hospitals, and nursing homes, as well as the number of employees working in offices and the number of students attending the schools. These data were then totaled per category and multiplied by the design flow per person, employee, or student, as estimated by the Virginia Water Control Board. From this, the total sewage flow for business, industrial, and institutional areas was obtained for each of the two counties. This number was divided by the number of acres currently under these land uses to obtain an average sewage flow of 423 gal/acre/day. The assumption was made that the sewage from these uses has a similar nitrogen concentration (40 mg/l) to residential sewage.

Precipitation

Nitrogen concentrations in precipitation vary regionally. As precipitation falls on vegetated areas much of the dissolved nitrogen is taken up by vegetative cover and within the root zone, and thus does not leach into the underlying aquifer. Based upon scientific literature, natural background levels on nitrate-nitrogen in ground water are typically 0.05 mg/l or less. This value was used in our analysis as a representation of natural background conditions.

NITROGEN LOADING ANALYSIS

The nitrogen loading rates used in our analyses were selected on the basis of the literature review outlined above, and also to correspond with a recently calibrated nitrogen loading model developed for the Town of Yarmouth, Massachusetts (Nelson et al., 1988). The loading rates for sewage and fertilizers originally used in this model have been slightly adjusted to reflect recent findings, which suggest that loading from on-site sewage disposal systems may be higher and loading from lawn fertilizers may be lower than previously thought. The loading rates used in our analysis are summarized in Table 8-4 below.

Once nitrogen has entered the ground water system, ultimate nitrate-nitrogen concentrations can be calculated using a simple mass balance equation, in which nitrogen levels are a function of the annual rate of nitrogen loading and the annual rate of dilution through recharge. Sources of recharge to ground water include precipitation, surface runoff from impervious areas and artificial recharge from on-site sewage disposal. Recharge rates used in the nitrogen loading analysis are summarized in Table 8-4. The nitrogen loading under existing conditions is presented in Tables 8-5 and 8-6.

Table 8-4: Nitrogen Loading Values

Source	Concentration	Loading Rate	Flow/Recharge
Sewage	40 mg N/liter	(6.72 lbs N/Person-yr)	55 gallons/person-day (165 gal/dwelling)
Business/Industrial/ Institutional	40 mg/l		423 gal/lot
Fertilizer (Lawns)		(0.9 lbs N/1000 sq ft-yr)	17 inches/year
Fertilizer (Agriculture)		84 lbs N/acre-yr, avg.	17 inches/year
Pavement Runoff	2.0 mg N/liter	(0.42 lbs N/1000 sq ft-yr)	34 inches/year
Roof Runoff	0.75 mg N/liter	(0.15 lbs N/1000 sq ft-yr)	34 inches/year
Landfills		1184 lbs N/acre-yr	24 inches/year
Septage Lagoons	45 mg/l		
Precipitation	0.05 mg/l		17 inches/year

Source: Adapted from Nelson et al., 1988

NITROGEN MODELLING RESULTS

Tables 8-5 and 8-6 present the results of the nitrogen loading model used by HWH to predict nitrogen concentrations in the ground water as a result of existing land use activities. The tables show that for Accomack, the total nitrogen from all sources is expected to result in a ground water concentration of 2.0 mg/l N. The results for Northampton show a similar average concentration of 1.9 mg/l N. These results represent an average nitrogen concentration across the entire county and do not reflect nitrogen concentrations at any specific location in the study area.

In Accomack County the majority of the loading of nitrogen is from agriculture (1,055,095 lbs per year). Septic system loading is the second highest source of nitrogen reaching the ground water. These findings reveal that on the average, across the entire county the nitrogen concentrations in the shallow ground water are acceptable. What the analysis does not reveal is that in order for the average conditions to reach 2 mg/l of nitrogen that there are many areas that will have significantly higher ground water nitrogen values.

Northampton County results show that the same categories of nitrogen inputs are contributors to the overall concentration of nitrogen in the ground water, however there are no septage lagoon and animal burial inputs. Even though the total nitrogen load in Northampton County is lower than in Accomack County (406,258 vs. 1,055,095 lbs/year) the resulting final recharge nitrogen loading concentration is approximately because the total recharge to the ground water is lower in Northampton County.

The results show that based on existing land use conditions, nitrogen concentrations in the shallow ground water are on the average acceptable and within state and local drinking water standards. These results are compared with existing water quality testing in the next section.

Table 8-5: Nitrogen Loading Calculations, Accomack Existing

INPUT FACTORS	
Number of Residential units	15,840
Sewage flow per house (gal/day)	165
Commercial/Industrial land (acres)	3,701
Com./Ind. sewage flow per acre (gal/day)	423
N-conc. in sewage effluent (mg/l)	40
Lawn area per house (square feet)	5,000
Pavement per house (square feet)	500
Road area (square feet)	130,680,000
Roof area per house (square feet)	1,500
Agricultural area (acres) [those acres that are fertilized]	47,420
Landfills (acres)	125
Septage lagoons (gallons/yr)	1,170,000
Septage N concentration (mg/l)	45
Animal burial (lbs /yr)	1,837,500
Total recharge area (acres)	234,269
Recharge rate for pervious area (in/yr)	17
Recharge rate for impervious area (in/yr)	34

INPUT	CALCULATIONS	RESULTS
Sewage (gal/day)		CALCULATED LOADING (LBS/YR)
3,929,123	x N-conc (mg/l) x 3.785 l/gal x 365 days/yr : 454000 mg/lb	478,254
Lawn area (sq ft)		
79,200,000	x 0.0009 lb N/sq ft	71,280
	application rate 3 lb/1000 sq ft x 30% leaching rate	
Pavement area (sq ft)		
138,600,000	x 0.00042 lb N/sq ft	58,212
Roof area (sq ft)		
23,760,000	x 0.00015 lb N/sq ft	3,564
Natural area (acres)		
177,478	x 43560 sq ft/acre x 0.000005 lb N/sq ft	38,655
Other Sources		
Agriculture (acres)		
47,420	x 89 lbs N/acre/year x 25% leaching rate	1,055,095
Landfills (acres)		
125	1184 lbs N/acre/year	148,000
Septage Lagoons (gal/year)		
1,170,000	x N-conc (mg/l) x 3.785 l/gal: 454000 mg/lb	634
Animal burial (lbs/year)		
1,837,500	x 3.3 % N concentration	60,638
	TOTAL NITROGEN LOADING (LBS/YR)	1,914,331
		TOTAL RECHARGE (MG/YR)
Recharge from sew/septage (gal/day)		
3,929,123	x 365 days/yr : 1,000,000 gal/million gal	1,435
Total pervious area (sq ft)		
9,956,344,860	x 17 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	105,504
Total impervious area (sq ft)		
Without landfills	x 34 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	5,149
242,967,780		
Landfills (sq ft)	x 24 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	81
5,445,000		
	TOTAL RECHARGE (MGAL/YR)	112,170
TOTAL NITROGEN LOAD/TOTAL RECHARGE X 454,000 MG/LB : 3,785,000 L/MGAL		
	=RECHARGE NITROGEN CONCENTRATION (mg/l or ppm)	2.0

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Table 8-6: Nitrogen Loading Calculations, Northampton Existing

INPUT FACTORS

Number of Residential units	6,183
Sewage flow per house (gal/day)	165
Commercial/Industrial land (acres)	940
Com./Ind. sewage flow per acre	423
N-conc. in sewage effluent (mg/l)	40
Lawn area per house (square feet)	5,000
Pavement per house (square feet)	500
Road area (square feet)	109,117,800
Roof area per house (square feet)	1,500
Agricultural area (acres) [those acres that are fertilized]	20,570
Landfills (acres)	78
Septage lagoons (gallons/yr)	0
Septage N concentration (mg/l)	45
Animal burial (lbs /yr)	0
Total recharge area (acres)	94,447
Recharge rate for pervious area (in/yr)	17
Recharge rate for impervious area (in/yr)	34

INPUT	CALCULATIONS	RESULTS
Sewage (gal/day)		CALCULATED LOADING (LBS/YR)
1,167,815	x N-conc (mg/l) x 3.785 l/gal x 365 days/yr : 454000 mg/lb	142,147
Lawn area (sq ft)		
30,915,000	x 0.0009 lb N/sq ft	27,824
	application rate 3 lb/1000 sq ft x 30% leaching rate	
Pavement area (sq ft)		
112,209,300	x 0.00042 lb N/sq ft	47,128
Roof area (sq ft)		
9,274,500	x 0.00015 lb N/sq ft	1,391
Natural area (acres)		
69,360	x 43560 sq ft/acre x 0.000005 lb N/sq ft	15,107
Other Sources		
Agriculture (acres)		
20,570	x 79 lbs N/acre x 25% leaching rate	406,258
Landfills (acres)		
78	1184 lbs N/acre/year	92,352
Septage Lagoons (gal/year)		
0	x N-conc (mg/l) x 3.785 l/gal: 454000 mg/lb	0
Animal burial (lbs/year)		
0	x 3.3 % N concentration	0
	TOTAL NITROGEN LOADING (LBS/YR)	732,206
		TOTAL RECHARGE (MG/YR)
Recharge from sew/septage (gal/day)		
1,167,815	x 365 days/yr : 1,000,000 gal/million gal	426
Total pervious area (sq ft)		
3,968,756,640	x 17 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	42,056
Total impervious area (sq ft)		
Without Landfills	x 34 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	3,009
141,957,000		
Landfills (sq ft)	x 24 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	51
3,397,680		
	TOTAL RECHARGE (MGAL/YR)	45,490
TOTAL NITROGEN LOAD/TOTAL RECHARGE X 454,000 MG/LB : 3,785,000 L/MGAL		
	=RECHARGE NITROGEN CONCENTRATION (mg/l or ppm)	1.9

PREPARED BY HORSLEY WITTEN HEGEMANN, INC.

EXISTING WATER QUALITY TESTING RESULTS

The following section summarizes four studies or data bases which include test results for nitrogen content. These sources were researched in order to determine the extent of nitrate-nitrogen present in wells The majority of wells sampled, show low nitrate concentrations, although several results show very high nitrogen values that are probably related to a specific high nitrogen loading source.

Virginia Department of Health, Public Water System Inventory

The Virginia Department of Health tests public water supply wells regularly for several contaminants. The facilities included in this inventory fall under the categories of community, non-community, and non-transient non-community water supplies. Sample analysis dates generally fall within the years 1988 to 1990. The Table 8-7 is a synopsis of the information obtained from the VDH data base.

In general, the nitrate concentrations from these samples are low, especially in Northampton County. In Accomack County, three facilities had samples which tested above 5 mg/l. Four readings taken for a Town of Parksley well had nitrate nitrogen levels of 6.6, 6.9, 5.65, and 6.2 mg/l. A NASA facility, Charles G. Ward Building F-16, registered the highest nitrate levels of the testing group. Eight samples from that facility ranged between 7.27 and 11.5 mg/l. Finally, a well at Stoney Point Decoys was measured to have a nitrate nitrogen concentration of 7.11 mg/l. Most of these wells draw water from the deeper confined aquifer where nitrogen concentrations are expected to be very low. The higher readings reflected in this data base are probably the result of influences from the shallow aquifer system.

Table 8 -7: Virginia Department of Health Public Water Test Results

	Accomack County	Northampton County
Average Nitrate-Nitrogen concentration	1.27 mg/l	0.04 mg/l
Range, Nitrate-Nitrogen concentration	0.01-11.5 mg/l	0.01-1.63 mg/l
Number of samples	92	31
Number of facilities	24	11
Number of samples above 5.0 mg/l NO_3	13	0
Number of samples above 10.0 mg/l NO_3	3	0

State Water Control Board, EPA STORET Database

The EPA maintains a database which contains a summary of ground water test results for public water supplies. This information is available to all states. Due to budget limitations, recent data has not been entered into the system, and the available information includes results from the late 1970's to late

1980's. Again, nitrate-nitrogen levels were low on average. Out of approximately 500 wells in Accomack and 150 in Northampton, only seven (7) wells reported nitrate-nitrogen levels above 5.00 mg/l. Table 8-8 summarizes results for the wells which tested high.

Most wells which tested high for nitrate-nitrogen are shallow; therefore they draw water from the unconfined Columbia aquifer. The one exception is the town of Parksley Well #1, which has a screen depth of 160 feet. In the Virginia Department of Health database, as described above, Parksley also reported high nitrate-nitrogen levels. The results from these two sources may be cause for further investigation into the quality of the drinking water supply for the town of Parksley.

Observation Well #103A is located on Church Neck, an area devoted mainly to agricultural practices (as delineated in the Northampton County Comprehensive Plan, 1990). The high nitrate levels here may indicate a correlation between fertilizer use and elevated nitrate-nitrogen levels in the ground water. However, the majority of wells in the two counties showed no contamination and it is likely that many were likewise located in agricultural areas.

Table 8-8: Nitrate-Nitrogen Levels Above 5 mg/l in STORET (EPA) File, Accomack and Northampton Counties

Facility	Date sampled	Nitrate -nitrogen level (mg/l)	Screen Depth (Feet)
Accomack County			
Town of Parksley #1	6/27/77	8.00	160
	11/14/77	6.50	
	2/23/78	6.00	
Town of Parksley #2	12/9/74	8.50	64
Observation Well #114S	2/13/80	9.50	40, 30, 40
	2/13/80	10.00	
	2/13/80	10.00	
	7/9/84	7.00	
Atlantic Fire House	8/4/81	5.00	69, 63, 69
Northampton County			
Observation Well #103A	9/28/77	13.00	40, 27, 37
	9/28/77	11.00	
	5/11/79	17.60	
	6/26/84	24.00	
Observation Well #104S	10/3/77	6.90	36, 26, 36
	10/3/77	6.90	
	8/18/80	7.50	
	8/19/80	9.00	
	8/4/86	8.25	
Brown &Root ST1 0-5	12/1/77	17.00	20, 40

Virginia Department of Health, Eastern Shore Health District

The Eastern Shore Health District conducted a shallow well baseline monitoring project in April of 1990. The testing was done in response to studies completed by the United States Geological Survey which indicate that wells installed at shallow depths may be at risk of having high levels of nitrates and pesticides. The Health Department intends to confirm or deny these results, and if necessary, change regulations to prohibit the use of water supplies proven to be at risk.

The written report of the baseline study is not yet available. Lab results were obtained, and are summarized below in Table 8-9. Present information available does not include the location of sampling sites. Twelve samples were taken in Accomack County, and ten in Northampton County. Wells sampled were domestic drinking wells drilled to a depth of 30 to 50 feet.

Table 8-9: Eastern Shore Health District, Shallow Well Monitoring Results

	Accomack County	Northampton County
Average Nitrate-nitrogen concentration	1.11 mg/l	4.36 mg/l
Number of samples	12	10
Number of samples above 5.0 mg/l NO_3	1	4
Number of samples above 10.0 mg/l NO_3	0	2

Average concentrations for nitrate nitrogen were much higher in Northampton County in this study than in the deeper wells in the county tested by the state. Although the sample size was small for this monitoring project, some of the levels of nitrogen were high, and the test should serve as a warning for residents with wells dug in the shallow aquifer. With knowledge of the locations of these sites, origins of the nitrate-nitrogen (agriculture, septic tanks, etc.) could be better determined and assessed. Two types of pesticides, triazines and carbanates, were tested, and none were detected in the 22 samples.

A baseline study of deeper wells was also conducted by the Eastern Shore Health District. At the time of publication of this report, no information about the baseline study has been made available. This Ground Water Management and Protection Plan is primarily concerned with large withdrawals from and preservation of the deeper Yorktown-Eastover aquifer. However, studies of the kind that the Eastern Shore Health District has conducted are invaluable as documentation for future use and for the determination of present contamination which may reach the lower aquifers at a later date.

USGS Water Quality Sampling

The United States Geological Survey is currently involved in a water quality study of shallow wells on the Delmarva Peninsula as a continuation of a water quality analysis through 1987 (USGS Open File Report 89-34). Table 8-10 presents the unpublished results of nitrate-nitrogen levels along two transects, and isolated locations along the mainland. Samples have been taken from August 1988 to

Table 8-10: USGS Nitrogen Sampling

ID	Lat	Long	Depth	Sample Date-1	NO3-N	Sample Date-2	NO3-N	Sample Date-3	NO3-N	Sample Date-4	NO3-N	Sample Date-5	NO3-N	Sample Date-6	NO3-N
Creek-Up	371151	755725	0.0									Jun-90	4.70		
Creek-Dn	371147	755700	0.0									Jun-90	5.30	Nov-90	4.80
Well 1	371145	755659	6.6									Jun-90	14.00	Nov-90	13.00
Well 2	371143	755658	8.9									Jun-90	6.60	Nov-90	13.00
Well 4A	371125	755702	16.8	Aug-88	9.70	Dec-88	10.00	Jun-89	9.60						
Well 4B	371125	755702	26.0	Aug-88	9.60			Jun-89	9.20					Nov-90	9.60
Well 4C	371125	755702	41.5	Aug-88	9.20									Nov-90	7.10
Well 4D	371125	755702	61.5	Aug-88	0.37			Jun-89	-					Nov-90	0.10
Well 4E	371125	755702	16.8											Nov-90	19.00
Well 5A	371121	755650	9.5	Aug-88	8.90	Dec-88	10.00	Jun-89	8.90					Nov-90	6.20
Well 5B	371121	755650	28.0	Aug-88	31.00									Nov-90	10.00
Well 6	371128	755721	15.0			Dec-88	34.00	Jun-89	29.00						
Well 7A	371136	755802	12.0	Aug-88	9.10	Dec-88	9.40	Jun-89	15.00						
Well 7B	371136	755802	31.0	Aug-88	3.50			Jun-89	2.60						
Well 8	371136	755748	12.0			Dec-88	18.00								
Well 11	371301	755844	13.0	Aug-88	12.00					Aug-89	7.80				
Well 12	371302	755832	13.0	Aug-88	38.00										
Well 13	371118	755635	6.6	Aug-88	0.10	Dec-88	0.15	Jun-89	0.10						
Well 14	371117	755631	6.7	Aug-88	0.10										
AC 201D	375744	753536	42.0							Sep-89	-				
AC 204S	375535	753249	22.5							Sep-89	0.13				
AC 204D	375535	753249	48.5							Sep-89	0.10				
AC 205S	375552	753018	22.0							Sep-89	9.60				
SOW 110S	375723	753444	36.0							Jan-90	0.10				
P32 D	373049	754841	30.0	Aug-88	11.00										
P32 S	373049	754841	22.0	Aug-88	9.20										
P31 D	373330	754946	40.0	Aug-88	0.10										
P31 S	373330	754946	13.0	Aug-88	15.00										
P31AD	373916	754108	30.0	Aug-88	6.20										
P31AS	373916	754108	13.0	Aug-88	8.10										
P30 D	374755	753710	28.0	Aug-88	0.10										
P30 S	374755	753710	15.0	Aug-88	0.29										

November 1990. The depth of the wells range from 6.6 to 61.5 feet. Nitrate-nitrogen levels are generally high. Out of a total of 51 samples, 69% of them have nitrate-nitrogen levels of 5 mg/l or greater, and 31% are greater than or equal to the recommended limit of 10 mg/l. The average of all the samples is 9.2 mg/l, with the highest reading at 38.0 mg/l.

The nitrate-nitrogen levels here are on average much higher than in the three studies previously described. Again, full analysis cannot be conducted because the USGS report has not yet been published.

NITROGEN LOADING ANALYSIS UNDER FUTURE BUILDOUT CONDITIONS

A nitrogen loading analysis was conducted in the spine recharge area of each of the five wellhead protection areas (WPA's) under permitted pumping conditions. This was done to predict the future nitrogen concentration in the ground water which can be expected if the land area in the spine is built out under the current regulations. A summary of the results of this analysis are presented in Table 8-11. The more detailed computer spreadsheets per area can be found in Appendix F. The nitrogen loading analysis indicates that the nitrogen concentrations in all but one WPA exceed the EPA drinking water standard of 10 mg/l nitrate-nitrogen.

Table 8-11: Nitrogen Concentration By Wellhead Protection Area

Wellhead Protection area	Predicted Average Nitrogen Concentration (mg/l)
A, all soils	5.6
A, w/o Arapahoe soils	5.5
B, all soils	13.5
B, w/o Arapahoe soils	13.5
C	8.3
D	7.8
E	7.1

A breakdown of the nitrogen loading by source and WPA are presented in Table 8-12. The major sources of nitrogen vary depending upon the land use in that area.

Table 8-12: Nitrogen Loading Under Future Buildout Conditions In Spine Of Wellhead Protection Areas Per Source (Percent of Total)

Wellhead Protection Area	load from sewage	load from lawns	load from agriculture	load from landfills	load from animal burial	TOTAL
A, all soils	20	4	65	0	10	99
A, w/o Arapahoe soils	5	0	83	0	10	98
B, all soils	20	2	16	58	3	99
B, w/o Arapahoe soils	20	2	16	58	3	99
C	67	12	14	0	5	98
D	69	14	9	0	6	98
E	77	17	4	0	0	98

Note: pavement, roofs, natural area and septage lagoons were left off this summary table because these sources contributed less than one percent of the total nitrogen load

The main sources of nitrogen under future buildout conditions are residential and commercial sewage, agriculture, and chicken burial. The actual percentage that these sources contribute vary by WPA.

In those WPA's where composting of dead chickens occurs, it can be a significant source of nitrogen, up to 10% of the total load. Agriculture contributes between 4 and 83 percent of the nitrogen load depending on the wellhead area. The landfill located within in the spine of WPA B is predicted to contribute 58 percent of the nitrogen concentration under future buildout conditions in this wellhead protection area. This analysis demonstrates that a landfill located on the spine recharge area has the potential to have a significant effect on water quality, assuming that the landfill is unlined.

In WPA E, in Northampton County residential sewage is the main source of nitrogen, comprising 77 percent of the nitrogen load. Sewage is the main source of nitrogen in this area because there are no poultry farms in Northampton County, and under future buildout conditions, the agriculturally zoned area can be completely subdivided into house lots, which was the scenario tested in this buildout. Considering the low residential growth rate and the current high level of agriculture, this may be an unlikely scenario.

Nitrogen loading scenarios discounting soils poorly suited to development (Arapahoe) were analyzed for northern Accomack County. Though the overall loading of nitrogen does not change, the major contributor (agriculture) increases from 65% to 83% when residential development is lowered. Thus, if agriculture is a more dominant land use in the future than residential development, nitrogen loading from farming will become the most significant contributor of this contaminant.

The future nitrogen loading results indicate that, nitrogen concentrations in the shallow Columbia aquifer are expected to increase to levels approaching the drinking water standard of 10 mg/l. In WPA B the concentration is expected to exceed this value (13.5 mg/l). Since these values are average recharge concentrations, individual measurements of ground water quality will most likely result in much higher concentrations at locations near major sources of nitrogen use or loading. The landfill located in WPA B should be assessed in more detail to determine its potential impact on water quality and nitrogen loading. In addition, the implementation of agricultural nutrient management plans will help to lower the average nitrogen concentration in the ground water. Other than sewering, little can be done to reduce the load from septic systems. Guiding development and sanitary wastewater discharges away from the spine recharge will help to reduce the nitrogen load from this source. As the area develops and more residential units are constructed, loading from lawns is expected to increase. Public education on the proper use of lawn fertilizers is the major mechanism to control this potential source of nitrogen.

These results indicate that under current conditions, nitrogen values in the ground water on the average are very good due to the large amounts of open and forested land found on the Eastern Shore. In addition, nitrogen concentrations in the vicinity of agricultural operations can be expected to be higher than background levels. More water quality testing and analysis in the Columbia aquifer is needed to obtain a better representation of water quality and how it changes across the Eastern Shore.

CASE STUDIES

9

SECTION 9: CASE STUDIES AND THEIR APPLICABILITY TO THE EASTERN SHORE OF VIRGINIA

This section describes a range of regulatory, non-regulatory, and legislative strategies which have been shown to be successful in protecting ground and surface water supplies in other parts of the United States. The case studies selected illustrate several different water resource protection strategies which may potentially benefit the Eastern Shore's efforts to protect its surface and ground waters.

AGRICULTURAL PRACTICES

Lancaster County, Pennsylvania: Fertilizer Effects on Water Quality

Lancaster County, Pennsylvania is an agricultural area located south and west of Philadelphia. The current technology, economic incentives, and social structure have led to a focus on dairy, livestock, and poultry production. Like the Eastern Shore of Virginia, Lancaster County covers a small percentage of the state (5%), but ranks high in agricultural production. In fact, Lancaster County raises 15.5% of the dairy cows in the state, 38.5% of the swine, 14% of the beef animals, 39% of the broilers, 48.75% of the laying hens, and 5.8% of the sheep. Manure disposal and excessive use of fertilizers pose a pollution problem to surface and ground water sources and to the Chesapeake Bay via outflow of the Susquehanna River.

A study was done by the USGS to determine the nutrient contents in two waterways, the Conestoga Headwaters and the West Branch of the Susquehanna River. The Conestoga River watershed has deep, well drained soils that are derived from limestone. The land is fertile and supports corn and alfalfa crops as well as some tobacco, soybeans, and vegetables. The West Branch of the Susquehanna, used as a control, drains lands from northern Pennsylvania where more land remains as forest and less intensive agriculture takes place. The results of the study are shown below.

Table 9-1: Sampling Results in Two Pennsylvania Rivers

Parameter (kg/ha)	Conestoga 1986	W. Branch 1985
Total P	1.8	0.13
Total N	38.9	5.2
Suspended Sediment	877	100

In a separate study, soil samples were taken at various depths from highly manured fields in 1982, 1984, and 1985. Access to the fields was obtained by adult education leaders working with farmers who were concerned about effects of their farming practices on ground water quality and ultimately the Chesapeake Bay. The results showed that many fields contained enough nitrate-nitrogen at the end of the growing season to produce *another crop* of field corn. While some of the nutrient will remain in the rooting zone for the next growing season, an unknown amount of nitrate-nitrogen will move with water and percolate through the soil profile.

Ground water wells in Lancaster County were sampled in 1982 and 1983 for nitrogen amounts. It was determined that in agricultural areas, 41 to 67% of the well samples had nitrate-nitrogen concentrations exceeding 10 mg/l. Comparatively, in non-agricultural areas in the county only 9 to 27% of the wells measured above 10 mg/l.

Given the elevated nitrogen levels in both the wells and the Conestoga River, and the over-fertilization of the crop lands, it was concluded that the fertilization practices played a role in the degradation of the water supplies.

As a result of this study, measures have been taken to reduce the amounts of nutrients moving to water sources. Beginning in 1988, crop-available nitrogen was calculated using previous nitrogen mineralization rates plus 25% of that amount. Therefore 45% of the manure nitrogen would be calculated as available nitrogen, reducing the need for inorganic fertilizer to 10 kg N/ha. These changes have been incorporated into a computerized expert system which aims to increase the nitrogen mineralization rates and includes all other management factors that are listed in the Manure Management Manual. The next step in the study is to implement a soil and crop monitoring program to see if residual nitrate-nitrogen levels drop.

Other water quality protection techniques include crop rotation, which can help control soil erosion and reduce the nutrient loading to the soils. A series of legume crops will build the nitrogen levels in the soil, and a succeeding corn crop then requires fewer nutrient additives. Manures can supply the nutrients for a second year of corn and small grains. The crop rotation schedule W, A, A, A, A, C, C, where W=wheat, small grains, soybeans; A= alfalfa; C=corn, is a desirable and beneficial schedule in Pennsylvania where part-time farm operators can use manure to fertilize their corn crops which will in turn provide food for the livestock.

Source:

Baker, Dale E. and Donald M. Crider, "The Environmental Consequences of Agriculture in Pennsylvania". In Majumdar, S.K., Miller, E.W., and Parizek, R.R., eds. *Water Resources in Pennsylvania.* Easton, PA: The Pennsylvania Academy of Science, 1990. Pages 334-353.

General Applicability to the Eastern Shore of Virginia

Lancaster County differs from the Eastern Shore in many respects. The topography is more hilly, livestock is an intense industry, and even the cultural practices of Amish and Mennonite peoples raise issues that would not be applicable to Accomack and Northampton Counties. This case study identifies the negative aspects of agriculture, and in particular the over-application of animal waste products. The situations presented in this case study are not found on the Eastern Shore, where most of the farmers are very concerned about water quality impacts from agricultural activities. However, the example serves to document the relationship between agriculture and water quality. Although conditions may vary nationwide, the issue of fertilization and its influence on ground water quality is becoming better understood. In fact, a report in California stated, "nitrate has accumulated in ground water to the degree that farmers reportedly no longer need apply fertilizer to satisfy crop needs" (Ground Water Pollution News, 1989).

This case study has general applicability to the Eastern Shore in controlling nitrogen loading from agriculture by incorporating frequent soil testing to determine the residual nitrogen that is available in the soil for uptake by a new crop. Cooperative extension agents could institute soil testing programs to track residual nitrogen levels in soils and help farmers better calculate fertilizer additions necessary to meet crop production requirements. Until 1990 soil testing was a service provided by the state at no cost to farmers and homeowners of Virginia for assuring water quality. In past years, approximately 98% of Eastern Shore farmers utilized this service. The service is no longer free and a fee is charged. Preliminary data indicates that the number of samples submitted for analysis under the fee system has declined by 67%. Nutrient management is a practice that is well established on the Eastern Shore and should continue to be a major focus for the protection of water quality.

Jefferson County, Wisconsin:
Controlling Disposal of Livestock Wastes

Jefferson County is an agricultural county located in southeastern Wisconsin. Homes, farms, and businesses generally depend on ground water for their water supplies. The county was concerned that there was no regulatory procedure for determining the impacts to water quality from the intensive agricultural activities occurring within wellhead protection areas (WHPA's).

The primary issue centered on the use and disposal of animal wastes. Rainwater percolates through tons of manure generated by feedlot operations annually (stored unconverted) and then infiltrates into the ground, carrying high concentrations of nutrients. Manure applied as fertilizer contributed to elevated nitrogen levels in ground and surface waters.

The county developed a zoning ordinance which required a conditional use permit for feedlots larger than a threshold size of 35 acres and possessing a minimum of 150 livestock units (1 livestock unit is equivalent to 1000 pounds live animal weight). Adopted in 1975, the ordinance's permit application required that the proponent provide background water quality data, particularly for bacteria and nutrient concentrations; rates and timing of manure applications; and existing nutrient levels in the soils. The county did not aggressively implement the ordinance until 1980 following complaints from some of the county's 60,000 residents about the odor resulting from the feedlots, especially poultry feedlots. The county then moved to prohibit feedlot operations on lots smaller than 35 acres in size, which were seen to be a significant source of pollutant loading. The county is currently preparing an ordinance which will regulate the design and siting of a manure containment facility for lots above threshold limits.

According to county officials, implementation has been difficult given the limited staff size of four for the entire county. The ordinance does not control the use of inorganic fertilizers, which are becoming more popular as a reaction to the stricter controls on animal manure applications.

<u>General Applicability to the Eastern Shore of Virginia</u>

Agricultural practices have been often cited as major non-point sources of ground and surface water pollution. Given the large areas of existing and zoned agricultural land uses on the Eastern Shore, this case study provides an appropriate example of agricultural land use controls. In particular, Accomack County may require development of similar ground water protection mechanisms which would control the uses of animal wastes and inorganic fertilizers within particularly vulnerable water resource protection areas from poultry wastes and set up a reporting and monitoring system. Specific implementation recommendations from Jefferson County can be readily applied throughout the Eastern Shore to control nitrogen leaching from poultry waste.

<u>For More Information</u>

Mr. Bruce Houkum, Zoning Administrator, Jefferson County, Wisconsin, (414) 674-2500.

Mr. Gordon Stevenson, Project Officer, Animal Wastes Management Office, Department of Natural Resources, Madison, Wisconsin, (608) 267-9306.

Delmarva Peninsula:
Composting Chickens

The poultry industry is currently enjoying a good economy. However, the problem of disposing of dead birds that never reach the factory is affecting the industry as a whole. Traditional methods of disposal, which include burial (risk of ground water contamination), incineration, deposition in the woods, and feeding dead chickens to hogs and other chickens (rendering) are health hazards and may also be illegal. However, a natural mortality rate that ranges from 0.1% to 8% can be expected in a flock which takes 45 days to raise. The Delmarva Peninsula, in particular, has a fragile ecology and chicken growers must be concerned with causing further contamination to the Chesapeake Bay.

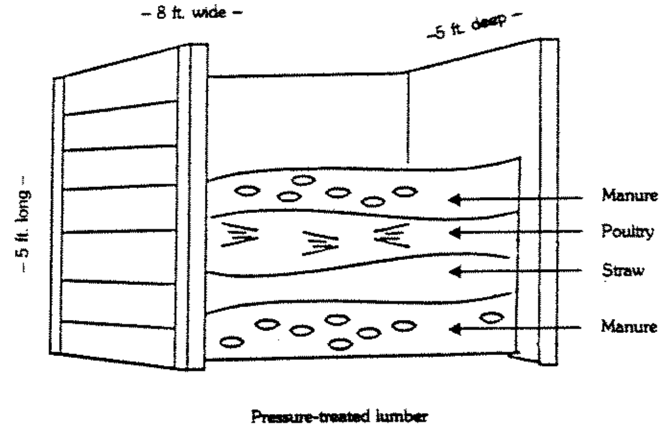
Dr. Dennis Murphy, a member of the faculty at the Department of Poultry Science at University of Maryland at College Park, has developed a method for disposing of dead poultry by composting. The idea of composting is itself not a new idea, but Dr. Murphy has applied it to the poultry industry such that it can handle the volumes of chickens in an inexpensive and environmentally sound way, and is not a health hazard.

The process of composting involves nitrogenous materials (in this case, manure and dead birds) and carboniferous material (cellulose paper, sawdust, or straw stover). These ingredients are converted to humic acids, bacterial biomass, and organic residue with the action of aerobic, thermophilic, spore-forming bacilli. Heat, carbon dioxide, and water vapor are all generated as byproducts.

In order to compost, the chicken grower must construct a composting structure. The facility can vary in many ways but it must have a roof, an impervious weight-bearing foundation such as concrete, and rot-resistant building materials. These requirements allow for year-round use, prevent contamination to surrounding areas, and help control the amount of moisture that goes into the system.

To begin the composting process, a bin is filled with several sequential layers of straw, chickens, and manure, the proportions of which have been determined by Murphy. Within two to four days of loading, the temperature within the bin should increase rapidly and reach a peak of 135-150°F. The chickens are effectively cooked, and pathogens are killed in conditions above 130°F. After ten days, the temperature drops. The contents of the bin are then removed with a front-end loader and stored in a second bin. The action of transferring the contents to a new location aerates the mixture, and in the secondary bin, the temperature rises again. Only two stages are needed, and within a matter of weeks, the chicken carcasses become compost material of similar texture to that of organic soil. The process is virtually odorless, according to Murphy.

Figure 9-1: Scheme of Simple Poultry Composter



Source: University of Maryland Cooperative Extension Service, Fact Sheet 537

The temperature of the chicken/manure/straw composition must be monitored during composting in order to assure that everything is going properly. Murphy estimates that the normal daily operation of a composter designed to handle 1,050 lbs. of carcasses per day requires twenty minutes. This estimate includes all activities, such as loading, monitoring temperatures, adding water, and moving compost. The cost of running a composter is 0.3 ¢/lb. spread over a ten year depreciation schedule. By comparison, incineration costs 3-8¢/lb. over a five year schedule.

One grower in Maryland has begun selling the composted chickens as a soil conditioner and enricher. The resulting compost is an excellent mild fertilizer. A five-county poultry region in southwest Missouri is launching a demonstration project that will dispose of dead birds by a composting process. In 1987, the region had a poultry population of 33 million broilers, 10 million turkeys, and 4 million layers. The objective is to compost two million dead birds from the area annually. The Missouri State Committee of the Agricultural Stabilization and Conservation Service has approved the composter for Agricultural Conservation Payment (ACP) cost-sharing. Hopefully more states will create incentives for composting via the cost-share program.

In short, composting chickens is a simple and economic method of disposing dead birds. It does not contribute to ground water contamination, and creates a salable product.

General Applicability to the Eastern Shore of Virginia

Several growers on the Delmarva Peninsula already employ the composting method to reuse and recycle waste products from the chicken raising industry. Chicken growers should seek assistance from County Extension Agents and the Cooperative Extension Service on methods, materials, and cost to compost chickens. Composting can create a valuable product that can be used as a mild fertilizer and soil conditioner.

For More Information

Dr. Dennis W. Murphy, Cooperative Extension Service, Route 2, Box 229-A, Princess-Anne, Maryland, 21853, (301) 651-9111.

ON-SITE WASTE DISPOSAL

Ontario, Canada:
Nitrogen Plumes from Septic Systems

One-third of the population of North America uses septic systems for disposing of liquid wastes. This practice accounts for the largest volumetric source of effluent discharged into the ground water zone. Septic systems located on sand and gravel aquifers are a potential source for producing large-scale contaminant plumes in aquifers that are also likely to be used for the drinking water supply.

Robertson, Cherry, and Sudicky (1990) used ground water monitoring networks to investigate ground water impacts caused by septic systems at two single-family homes in Ontario. The homes were located on shallow, unconfined aquifers. Several water-table piezometers were installed, and sediment cores were sampled continuously. The older site, at Cambridge, had a septic system in operation since 1977. The field investigation started in 1987. The younger site was located at Muskoka, and was monitored six months after the beginning of full-time use in 1987. Both septic systems were of the conventional design used in Canada and the U.S. for permeable soils.

The tests yielded several results. The plume shape at the Cambridge site demonstrated that the flow within the aquifer was predominantly horizontal except beneath the tile bed where the plume followed a vertical path such that it nearly reached the bottom of the aquifer. Using a bromide tracer, average tank residence time was found to be two days. In Cambridge, effluent residence time in the 2-m-thick unsaturated zone was 10 days, whereas at Muskoka, the bromide tracer experienced a longer residence time in the 3-m-thick unsaturated zone at this site, in the order of several weeks to months. Flow velocities were calculated at both sites.

Nitrogen in septic systems is about eighty percent (80%) inorganic, predominantly ammonium [NH_4^+-N]. At both sites, tile effluent concentrations for NH_4^+-N ranged from 30-59 mg/l and nitrate-nitrogen [NO_3^--N] concentrations from 0.1-1.0 mg/l. Comparatively, plume core chemistry revealed almost the opposite concentrations, with NH_4^+-N concentrations at 0.1-0.5 mg/l and NO_3^--N at 33-39 mg/l. This suggested that the ammonium in the effluent was being oxidized via microbial nitrification, as in the following equation:

$$NH_4^+ + 2O_2 \rightarrow NO_3^- + 2H^+ + H_2$$

Low dissolved oxygen content levels and high nitrate-nitrogen levels observed even in the shallowest water table zone below the tile fields indicated that the processes in the above equation are largely completed during residency in the unsaturated zone, but also continue below the water table.

A three-dimensional analytical model was used to obtain estimates of the aquifer dispersion parameters within the saturated zone. Modeling results indicated that transverse dispersion rates at both sites were low. The detailed findings were significant in that they were consistent with very detailed tracer tests recently performed at Twin Lakes, Ontario and Cape Cod, Massachusetts.

At the Cambridge site, which had been in operation for twelve years, the plume had sharp lateral and vertical boundaries, and was more than 130 meters (427 ft) in length and had a uniform width of about 10 meters. After 1.5 years of use, the Muskoka plume began discharging to a river located 20 meters (66 ft) from the tile field. At the organic-rich riverbed, denitrification, or nitrate attenuation, occurred such that little nitrate-nitrogen was actually discharged into the stream.

The model was employed to make nitrate-nitrogen predictions at the Cambridge site. Using the transmissivity rates at Cambridge, a source concentration of 33 mg/l NO_3^--N, and a background level of zero nitrate, *the steady state plume length which would exceed the drinking water standard of 10 mg/l NO_3^--N is 170 m (558 ft).*

The authors use their study to issue the following warning, "Therefore, for many unconfined sand aquifers, the minimum distance-to-well regulations for permitting septic systems in most parts of North America should not be expected to be adequately protective of well-water quality in situations where mobile contaminants such as NO_3^- are not attenuated by chemical or microbiological processes."

Source:

Robertson, W.D., Cherry, J.A., and Sudicky, E.A., "Ground-Water Contamination from Two Small Septic Systems on Sand Aquifers", Ground Water, January-February, 1991, p. 82-92.

General Applicability to the Eastern Shore of Virginia

This recent study presents important information for Eastern Shore residents. In areas where septic systems are dense and people rely upon private wells screened in the shallow aquifer, nitrogen levels can be expected to be 10 mg/l at close to 600 feet from the septic system. On the Eastern Shore, proper well spacing from septic systems may require a setback of up to 600 feet due to the very sandy soils, and shallow depth to the water table.

Falmouth, Massachusetts:
Performance Standards Within Zones of Contribution

Falmouth is a coastal town on Cape Cod, Massachusetts. The town typically experiences a large increase in population during the summer months with the influx of seasonal residents. The town's water supply, however, is limited to its aquifers which are part of the Cape Cod sole source aquifer. With the residential development boom of the early to mid 1980's, large amounts of previously undeveloped areas were subdivided and developed for residential and commercial use. The higher residential density and greater numbers of on-site sewage disposal systems began to affect ground water quality, particularly by raising nutrient concentrations in ground waters.

The situation was severely aggravated after a 500,000 gpd public water supply was forced to close because discharges from an upgradient sewage treatment plant had contaminated the aquifer. Serious concerns were raised about the main water supply, which was located downgradient of the town landfill, a sewage treatment plant, an industrial park, and extensive residential development. Worse still, the town's zoning allowed for a saturation build-out population three times that of the present. In short, existing and programmed land uses seriously threatened the town's ground water supplies.

In response to these concerns about existing and potential water supply contamination, the town delineated the zones of contribution and associated recharge areas for all drinking water supplies and surface water bodies. After identifying priority protection areas, the town developed and adopted a set of performance standards together with a methodology for determining cumulative loading impacts to ground water quality. The standards essentially limited further development within a zone of contribution or surface watershed if the added nutrient loading from the land use would increase the ground or surface water concentrations of those nutrients past certain thresholds.

In order to accommodate already planned developments within the Ground and Surface Water Resource Districts, the town adopted a transfer of development rights program, which was expected to encourage development outside of the delineated zones of contribution and surface watersheds.

General Applicability to the Eastern Shore of Virginia

Nutrient management by performance standards has been shown to be an effective and defensible method of managing development within vulnerable ground water recharge areas. Our nutrient loading analysis indicates that nitrogen loading performance standards should be adopted and enforced at some point in the future on the Eastern Shore. Saturation build-out would generate significant increases in ground water nitrogen concentrations given the potential programmed increase in associated loadings from septic systems, lawn and farm fertilizers, roadway and parking lot runoff, etc. By devising nitrogen loading performance standards for development located within the recharge areas, the Counties may successfully prevent contamination of their drinking water supplies from nitrogen. Specific control over nitrogen is more appropriate for the shallow water table aquifer than for the deeper aquifers used for drinking and industrial water use.

For More Information

Victoria Lowell, Barnstable County Commissioner, (508) 362-3828.

Long Island, New York:
Restrictions Within Recharge Zones

The Long Island Regional Planning Board has been working on ground water protection issues for the two counties of Nassau and Suffolk for several decades. Originally, primary issues of concern revolved around ground water quantity and the potential for salt water intrusion. More recently there has been a focus on ground water quality concerns.

Studies such as the regional 208 wastewater study, published in 1978, pointed to the need for increased water quality protection strategies for two types of recharge zones, deep recharge and shallow recharge zones. The zones are delineated according to the distance between surface level and ground water elevation over which infiltrating rainwater travels vertically. The shallow recharge zones are typically found closer to the ocean shoreline. The deep recharge zones were seen as more critical resources because they contained much larger quantities of ground water; many were found to still contain excellent water quality.

The Regional Planning Board worked with the state health agencies, water suppliers, municipalities, and counties in developing a number of land use controls to prevent water quality impacts from on-site septic systems. These waste disposal systems were considered an important source of contaminants.

Conventional septic systems provide minimal treatment of wastewater. Leaching facility effluents contain approximately 40 to 60 mg/l of nitrogen. The effluents also contain high phosphorus concentrations and large numbers of pathogenic bacteria and viruses. Septic systems can also introduce hazardous wastes into the ground water if the owner uses septic cleaners or pours household hazardous wastes down the drain. The cumulative effects of many small septic systems on nutrient, pathogen, or hazardous waste levels in downgradient waters can be very significant. These impacts are dependent upon septic system location and density relative to receiving water bodies.

Accordingly, several land use programs were implemented. The Regional Planning Council assisted in the development of recommended minimum lot sizes for undeveloped deep recharge areas. They recommended a minimum area of two acres as a means of ensuring adequate dilution of septic system effluents within the protection district. The planning board and the counties also worked together to organize bans on the sale and use of septic system cleaners, which have been shown to be significant sources of hazardous material contamination. Presently, the local and regional authorities are developing septage districts and accompanying regulations which would oversee the regular pumping out of household septic systems. This can greatly improve treatment performance and reduce the opportunity for breakouts.

General Applicability to the Eastern Shore of Virginia

The regular pumping of septic systems is a management technique currently being required by the Chesapeake Bay Preservation Act for the Eastern Shore. The Long Island example can be used to develop a septic system management program for this area. Potential and even existing residential development and the accompanying septic systems are a source of ground water contamination within the shallow recharge areas. By adopting similar land use controls and regulations on the siting and operation and maintenance of such systems, Accomack and Northampton Counties may be able to eliminate the possibility of nutrient and hazardous waste contamination in vulnerable ground water recharge areas.

For More Information

Ms. Edith Tannenbaum, Planning Director, Long Island Regional Planning Board, Long Island, New York, (516) 360-5189.

Gloucester, Massachusetts:
Siting of Septic Systems

The City of Gloucester, Massachusetts recently developed ordinances governing the siting of septic systems in order to protect sensitive ground water supplies.

Septic system effluent contains a large number of pathogenic bacteria and viruses. Under certain geologic conditions, the effluent may travel rapidly, reducing the potential for treatment by soil filtration and increasing the risk to human health. Much of Gloucester consists of shallow sandy sediments overlying bedrock. When a septic system leaching field is constructed in an area with shallow depths to bedrock, the effluent will quickly percolate through the sediments without receiving adequate treatment. The effluent then moves along the the bedrock surface, allowing it to quickly reach a water supply well.

The City's officials, concerned over the potential threat to drinking water supplies, adopted two health ordinances governing the siting of septic systems. Any proposed sewage disposal system which lies within 600 feet of a drinking water well or a surface water body would not receive a Disposal Construction Works Permit until the proponent had submitted sufficient hydrogeologic information to demonstrate that there was a minimum travel time of 50 days between the leaching facility and the downgradient water resource. Similarly, the Board of Health would not approve the subdivision plans until the performance standard of 50 days minimum travel time had been shown by the project proponent.

General Applicability to the Eastern Shore of Virginia

The soils on the Eastern Shore are very sandy and allow for the rapid movement of water. The shallow depth to water may also assist in the transport of viruses. The Counties should consider some form of private well/septic system ordinance to provide the maximum protective distances between these features.

For More Information

Board of Health, City of Gloucester, 41 Washington Street, Forbes Building Annex, Gloucester, Massachusetts, (508) 281-9771.

Locations Throughout the U.S.:
Constructed Wetlands, Alternative to Conventional Wastewater Treatment

Constructed wetlands are defined as those systems specifically designed for wastewater treatment. They are not subject to laws and regulations involving natural wetlands, and are generally located in areas where natural wetlands did not previously exist. Constructed wetlands provide secondary wastewater treatment , advanced waste treatment, or sludge management for smaller towns, rural communities, and industrial plants. Aquatic plants and tiny microbes are used to replace costly mechanical pumps and industrial chemicals required by conventional wastewater treatment plants. Part of their popularity is due to their low cost and the simplicity of operation.

The purification process is a simple one. In an initial holding tank, sludge undergoes primary treatment where the sediment settles out. Then waste water flows into pathways lined with rock and filled with emergent wetland plants. The rock is a home for bacterial slime that digests the organic wastes. Microbes on the aquatic plant roots perform a similar function. Meanwhile the plants draw nourishment from the effluent and absorbs the resulting proteins, starches, and sugars. The plants inject oxygen into the water to nourish the bacteria, and also contribute oxygen to the air, helping to regulate the level of carbon dioxide in the environment. The wetlands typically include some type of barrier to prevent ground water contamination beneath the bed. The barriers used thus far range from compacted earth to membrane liners. Other systems are completely enclosed in a series of containers.

Currently, constructed wetlands are being used throughout the country, with the greatest concentration in Tennessee, South Dakota, Louisiana, and Mississippi. The design capacities of the systems range from 10,000 gallons per day in El Dorado, New Mexico, to 20 million gallons per day in Orlando, Florida. In Anne Arundel County, Maryland, a water reclamation facility has been operational since December 1988 and handles a flow of approximately 500,000 gallons per day. The Mayo, Maryland facility is a septic tank effluent collection and treatment system, and utilizes the following components: recirculating sand filters, bulrushes (the emergent wetlands), peat wetlands, ultraviolet disinfection, and discharge through an offshore wetland into Chesapeake Bay. The system comes consistently under NPDES Permit effluent requirements for the facility.

In 1988, the mountain community of Monterey, Virginia began using a constructed wetlands system built at a capital cost of only $150,000, and with operating costs a fraction of running a mechanical facility. The decision to shift its water treatment facility to a constructed wetlands was mainly an economical one. The 190 customers had an average household income of $14,000, and the community did not have the resources to cover the costs to meet new state requirements ($500,000). For this system to operate successfully, special plants had to be considered to withstand periods of subfreezing temperatures in the winter. Between June 1989 and June 1990, the system treated 20,000 gallons per day, and fell within discharge standards.

In addition to municipal systems, the constructed wetlands have also been used at individual homes and as treatment facilities for subdivision areas. There are potential applications in agribusiness and for filtering heavy metals and toxic chemicals out of industrial effluent.

For more information:

NCW Systems, Inc., 5711 Staples Mill Road, Richmond, Virginia, 23228, (804) 264-7810.

General Applicability to the Eastern Shore of Virginia

Constructed wetlands offer a final wastewater treatment alternative that is very applicable to the Eastern Shore. Since a majority of the coastal marshes on the ocean discharge side of the Eastern Shore are in public conservation ownership, incorporating artificial wetland systems can be very appropriate for most discharge facilities. The use of these systems will allow residential and industrial development to proceed in areas where conventional surface water discharges would cause water quality effluent problems. In particular, the County of Northampton would benefit from artificial wetland systems because of the large amount of marshland that is found in the County and the high degree of final wastewater treatment that can be achieved from these systems. The low cost and simplicity of operation would also be of great value on the Eastern Shore.

SURFACE WATER MANAGEMENT

Chesapeake Bay Area, Maryland: Stormwater Pollutant Reduction

Stormwater management is one component of the US EPA's National Estuarine Program for the Chesapeake Bay Area of Critical Concern. The tremendous increase in development activities within the Bay area has had serious impacts on the Bay's water quality. Point and non-point sources of pollution were targeted for action, beginning with limiting various land uses in the near shore areas.

Stormwater was identified as one of the major non-point pollution sources to the Bay, along with agricultural practices. Runoff from roadways, parking lots, overloaded or poorly designed stormwater sewers, and poor soil conservation practices usually carries a very significant amount of pollutants, including metals, volatile organic compounds, oils and grease, nutrients, bacteria and viruses, and suspended solids.

Nutrients and suspended solids have been shown to cause adverse impacts to the Bay's water and habitat quality for a wide range of upper Bay organisms. Nitrogen, and to a lesser extent, phosphorus, acts to encourage the rapid growth of algae and aquatic plants, which can reduce the dissolved oxygen content of the waters. In turn, the lower oxygen content stresses or kills fish. Suspended solids from soil-laden runoff block light and harm plankton and other photosynthetic organisms.

With the passage of the Bay Critical Area Law in 1985, the State of Maryland took an aggressive step forward in reducing point and non-point source pollution to the Chesapeake by restricting land uses within the watershed. Local communities were required by law to assign their lands falling within the Critical Area to one of three broad land use areas: Intensely Developed, Limited

Development, and Resource Conservation Areas. The table below describes how the Commission defined each land use category and the pollutant reduction goals set for each.

Table 9-2: Pollutant Reduction Goals by Land Use Categories, State of Maryland

	INTENSELY DEVELOPED	LIMITED DEVELOPMENT	RESOURCE CONSERVATION
Characteristics	Dense residential institutional, commercial, or industrial uses.	Mixed land usage: not dominated by wetlands, agriculture, forest or open space.	Primarily open fields, wetlands, forest, and agriculture.
	4 or more dwelling units per acre.	1 dwelling unit per 5 acres up to 4 per acre.	Less than 1 dwelling unit per acre.
	Public water & sewer serving at least 3 dwelling units per acre.	Areas with public water, sewer or both.	No public water or sewer service.
Criteria	Reduce pollutant loadings by minimum 10% from predevelopment loadings.	Restrict removal of existing forest land to 20% when development occurs.	Residential development limited to overall density less than 1 dwelling unit per acre.
	Reduce nonpoint impacts to streams & tidal waters from redevelopment.	Restrict impervious area to 15% of land area being developed.	Encourage agriculture & forestry.
	Protect remaining wildlife & fish habitats.	Encourage clustering of dwelling units to conserve natural habitats.	

Within intensely developed areas, such as the City of Baltimore, the Critical Area Commission has developed and implemented what it calls the 10% rule: any new development or redevelopment of a site must employ stormwater pollution control methods to ensure that the resulting pollutant loading from the new activity is at least 10% less than that from the existing land use. This rule was developed as a means of meeting the pollutant reduction criterion listed in the table above.

The 10% rule procedure consists of nine steps which determine whether the proposed new development or redevelopment must comply. The procedure also estimates existing and post-development runoff rates and pollutant loadings, and compares pre- and post-development stormwater pollutant loadings to see if the latter loading is at least 10% less than the former. In essence, local jurisdictions with areas classified as Intensely Developed must evaluate each regulated proposed development using the 10% rule to ensure that the area's overall pollution loadings from stormwater runoff are decreasing.

General Applicability to the Eastern Shore of Virginia

Northampton County's Master Plan attempts to address the new issues associated with Virginia's Chesapeake Bay Preservation Act. Land development densities have decreased in the County as a result of the County's new ordinance. Some version of the 10% rule for new development adopted by the Chesapeake Bay Program in Maryland may be an effective mechanism for gradually but consistently achieving stormwater-related pollution reduction within intensely developed areas on the Eastern Shore.

For More Information:

Framework for Evaluating Compliance with the 10% Rule. Chesapeake Bay Critical Area Commission, Annapolis, Maryland, (301) 974-2426.

Maryland Department of the Environment, Stormwater and Sediment Division, Mr. Vince Berg, Director, (301) 631-3553.

Buzzards Bay, Massachusetts:
Stormwater Treatment System

Established in 1985, the US EPA/Commonwealth of Massachusetts-supported Buzzard's Bay Project was made part of the National Estuarine Project in order to protect the Bay's sensitive environmental resources. A draft Comprehensive Conservation and Management Plan (CCMP) for the project area, released in May, 1990, outlines the Buzzards' Bay environment, priority pollution problems and summarizes the project's action plans for addressing these problems.

According to the CCMP, stormwater runoff comprises one of the major pollution sources to the estuary and bay. As described above for the Chesapeake Bay Critical Area, the runoff contains a wide variety of pollutants which can adversely affect the bay's water and habitat quality. Runoff from stormwater drains was identified as a priority problem because it is known to carry large quantities of fecal coliforms, viruses, metals, pesticides, and VOC's.

The project identified two large stormwater drains which served two suburban areas and directly discharged runoff into the bay as sites for pilot demonstration projects in stormwater-runoff control technology. The two sites were Electric Avenue in Bourne and Red Brook in Wareham.

A stormwater treatment structure resembling a large septic system was constructed under the parking lot for the Electric Avenue beach. The structure serves to divert and hold runoff flows, allowing sediments and associated pollutants to settle out while the water infiltrates into the subsurface soils. The settling tanks will be emptied regularly. A ground water monitoring system was also put in place to gauge ground water quality impacts. Preliminary results have shown that the system is extremely efficient in removing indicator pollutants, such as fecal coliforms (a common indicator), by 98%.

The Red Brook pilot project, now underway, will utilize infiltration ponds to hold stormwater runoff until it infiltrates into the soil.

In response to the success of the Electric Avenue demonstration project, the Buzzards Bay Project is collaborating with the US Soil Conservation Service (SCS) to provide design expertise and funding for construction of similar sediment/stormwater control devices to several project area communities.

The project has also identified the importance of collaboration between various state agencies regarding construction and maintenance of roads. The Massachusetts Department of Public Works is primarily responsible for the design and construction of safe public roads. Concerns over the water quality impacts resulting from the newly constructed roads are usually only secondary in nature. DPW road projects are exempted from review by local conservation commissions. Accordingly, the CCMP has recommended that towns and the DPW work together to minimize stormwater runoff beginning at the preliminary design stage. Potential advantages include reducing the pollutant load through environmentally conscious road design and lowering mitigation construction costs by incorporating mitigation structures within the costs for road construction.

<u>General Applicability to the Eastern Shore of Virginia</u>

Stormwater runoff is not a major concern on the Eastern Shore of Virginia. However, if there develops a need for more effective management of sediment and stormwater associated pollution, the above case study may provide ideas for better management of stormwater.

<u>For More Information</u>

Buzzards Bay Comprehensive Conservation Management Plan, May 1990. Buzzards Bay Project, US EPA & Commonwealth of Massachusetts.

Dave Janik, Buzzards Bay Project, 2 Spring St. Marion, Massachusetts, 02738, (508)748-3600.

Chesapeake Bay Area, Maryland:
Vegetated Buffer Zones

Maryland's 1985 Chesapeake Bay Critical Area Law required local communities to control land uses and reduce pollutant loadings on lands located within the Critical Area. It also specified the establishment of different types of buffer zones for various land uses within the Critical Area.

Vegetated buffer strips offer tremendous value in protecting wetlands and surface waters from a variety of impacts for little cost. Buffer strips serve to contain and encourage infiltration of surface run-off, thereby attenuating levels of nutrients, metals, petroleum hydrocarbons, pesticides, and other pollutants. They are less expensive, outside of land costs, than technology-based stormwater control structures in both capital and operation and maintenance costs.

Buffer zone and land use regulations for the Chesapeake Bay Critical Area include:

1. Mandatory soil conservation and stormwater management plans and adoption of best management practices (BMP's) for all agricultural lands within five years.

2. 25-foot buffer zone along tidal waters and stream courses established until a soil conservation plan is implemented.

3. Livestock cannot be watered or fed within 50 feet of water's edge.

4. Prohibit new development and new marinas within 100 feet of shoreline in Resource Conservation Areas.

5. Delineate a 25-foot minimum buffer zone around non-tidal wetlands.

6. Establish a 100-foot minimum naturally vegetated buffer zone around all of the Bay's non-developed areas.

These requirements work not only to preserve vulnerable resource areas, but are also effective in limiting soil erosion. The buffer zones reduce or eliminate altogether the opportunity for direct discharges of stormwater runoff into sensitive surface waters. In addition, the buffer strips provide critical habitat for a wide range of wildlife species.

General Applicability to the Eastern Shore of Virginia

Buffer strips may be important on the Eastern Shore for the protection of coastal tidal wetlands. The buffer strips themselves will act as sinks to utilize nitrogen rich ground water that may be discharging to the shallow system. The specific application of this approach to the Eastern Shore would require more research.

For More Information

Chesapeake Bay Critical Area Commission, Annapolis, Maryland, (301) 974-2426.

HAZARDOUS MATERIALS HANDLING AND STORAGE

Portland, Oregon:
Land Use Controls Within Wellhead Protection Area

The Columbia South Shore Aquifer, located by the banks of the Columbia River, was designated as a back-up water supply for the City of Portland. The aquifer lies within the boundaries of the mixed use Columbia South Shore Development Area. Concerns focused on the Wellhead Protection Area (WHPA), which had been delineated rudimentarily using roads as boundaries; the true boundaries were not yet known.

The preliminary WHPA and surrounding areas contained a number of different industrial land uses and there was concern that ground water could become contaminated by solvents and petroleum hydrocarbons which were stored, utilized, and produced by different industries.

In response to these concerns, city and state agencies established a list of prohibited and/or controlled activities and substances. Certain land uses which involved hazardous materials were prohibited. Use of non-prohibited materials required a water quality impact review before being permitted. Additional regulations stipulated the containment requirements for the storage, use or transport of hazardous materials.

Activities and land uses which were prohibited within the WHPA were broad and included uses that heretofore were allowed to exist within Wellhead and Ground Water Resource Districts. For example, gas stations were prohibited, as were all production, storage, or disposal of hazardous materials.

The water quality impact reviews required for uses of non-prohibited hazardous materials were made mandatory upon request from the public or abutters. The use would be permitted only if the proponent could demonstrate that there would be no adverse impacts to ground water quality.

After much research, the City developed and published containment requirements for the storage, use, or transport of hazardous materials within the City Handbook. All containment plans had to pass review by the Bureau of Buildings, which would, in turn, consult with the Water Works Department and the Environmental Services Bureau.

General Applicability to the Eastern Shore of Virginia

The Eastern Shore does not presently possess the same density and range of industrial development found in Portland's South Shore Development Area. However, this case study offers a valuable example of protecting vulnerable ground water resources without banishing already existing industries from the Water Resource Protection Districts. In this way, local and County governments avoid a potential loss in tax revenue and a potential slowdown in economic growth. While the risk of ground water contamination from the hazardous materials has not been completely eliminated, the Portland approach minimizes that risk by only permitting the use of less hazardous materials (with regard to toxicity or quantity) within the Water Resource Protection Districts. The Portland approach could be applied in intensely developed recharge areas found along the spine of the the Shore.

Dayton, Ohio;
Overlay District For Aquifer Recharge Area

The City of Dayton draws upon a glacial outwash aquifer primarily composed of sand and gravel for a large part of its water supply. The aquifer is very permeable and permits rapid ground water travel. However, the aquifer recharge area has already been densely developed by industry. Citizens and local and state government officials were becoming increasingly concerned about the threat of ground water contamination from the large amounts and varieties of hazardous materials used by the industries.

The City delineated a 6,000-acre water resources protection overlay district based on estimated times of travel from potential sources to wells. The overlay district encompasses 550 businesses which use, handle, or store an estimated 200 million pounds of hazardous materials each year.

Rather than prohibiting industrial uses or resorting to downzoning (raising minimum lot size requirements and precluding industrial development) within the aquifer protection district, the city's water department devised a hazardous material control program that emphasizes notification and reporting on the types and volumes of hazardous materials used.

The Water Department administers the program. Businesses and industries located within the protection district are required to report the types and quantities of chemicals used on site. The department assigns intensity and use ratings based on the material's toxicity, threat to ground water and quantity produced, used or stored. The regulations set limits on the maximum amount of hazardous materials allowed on site. The City funds the program by applying a surcharge to Dayton residents' water bills.

Companies which do not use, handle, store or generate quantities exceeding the notification threshold are considered to be "conforming". They are not allowed to subsequently apply for an increase in amount or in number of hazardous materials used on site. An environmental advisory board was established to hear petitions for the deregulation of materials; the burden of proof is left with the petitioner.

The program established a rapid deployment emergency response program which included awarding a clean-up contract to a professional hazardous waste company, which is responsible for providing prompt and effective treatment and extraction of spills. An extensive inspection program was set up to prioritize problem areas and offer corrective solutions.

The program's defensibility has been one of its greatest successes. According to the City of Dayton Water Department, since the program's initiation in 1987 no suits have been brought against the City regarding the program. Mr. Hall attributes this to the program's emphasis on regulating and monitoring hazardous material use without directly prohibiting uses or downzoning the district.

General Applicability to the Eastern Shore of Virginia

The Dayton case study, as with Portland, Oregon, focuses on a heavily industrialized and residentially developed city. The lessons learned from these two case studies are applicable to the Eastern Shore because of the need to address existing industrial and commercial development. The Dayton approach is to monitor and require record keeping for all facilities without closing them down or requiring major infrastructure changes.

For More Information

Mr. Dusty Hall, Water Department, City of Dayton, Ohio, (513) 443-3600.

Palm Beach County, Florida:
Ground Water Protection Through Zoning Ordinance

Following the closure of 36 water supply wells contaminated with hazardous wastes, Palm Beach County, Florida, developed a zoning-based Wellfield Ordinance to protect its vulnerable ground water supplies. Implemented in 1988, the ordinance received strong support at public hearings and in a referendum, despite the protection area's existing residential and industrial development, and very high density.

The ordinance restricts the use, storage, handling, and production of hazardous materials within the protection district. No grandfathering of existing uses was allowed.

The protection district was divided into four zones based on hydrogeologic investigations and modeling. The zones were delineated as a function of proximity and extent of recharge contribution to public water supply wells. Uses and presence of hazardous materials are regulated according to the risk or threat posed to wells for each zone. All hazardous materials are prohibited in Zone 1, within which lie the most vulnerable recharge areas. In contrast, businesses and industries can use hazardous materials within a Zone 4 after first securing a permit and establishing a monitoring program.

The program is implemented by the county Department of Environmental Resources. Other program components include inspection and monitoring to ensure compliance; engineering and site planning requirements such as spill containment facilities and removal of underground storage tanks (UST's); exemptions for emergency uses or public safety; a phased compliance schedule; and funding for relocating priority industries outside of Zone 1.

General Applicability to the Eastern Shore of Virginia

The Palm Beach case study offers a valuable example to the Eastern Shore in effectively reducing risk of contamination to water supplies through ranking water resource protection districts by sensitivity or vulnerability to contamination. Intermediate protection zones should be considered as in the "zoned approach" recommended in this study, where more stringent land use controls could be implemented. This would allow for very stringent land use controls in close proximity to the wells and in the recharge area with less stringent controls required over the wellhead protection area.

For More Information

Mr. Allan Trefry, Manager, Department of Environmental Resources, Palm Beach County, Florida, (407) 355-4011.

COMPREHENSIVE MONITORING PROGRAMS

State of Rhode Island:
Salt-pond Watchers, Watershed Watch

Water quality monitoring has typically been left to professionals, but a recent upsurge in citizen monitoring groups across the nation may soon change that approach. Citizen monitoring groups are active across the nation in carrying out the otherwise expensive routine water sample collection. Their efforts provide water resource scientists and mangers with a previously unavailable, extensive, continuous water quality record for a variety of water resources.

Two citizen monitoring groups are currently collaborating with the University of Rhode Island (URI) in monitoring water quality in surface water bodies. The Rhode Island Salt Pond-Watchers is a group of over 100 senior citizens and other volunteers who regularly collect water quality samples for analysis from coastal ponds. Some analyses are carried out in the field with simple kits while others are performed at university, state, or federal laboratories. Samples are collected for nine months of the year, when the ponds are not frozen over.

Pond Watchers receive training in water quality sampling methodology to ensure that the data collected can be used for a wide range of purposes including:

- on-going formal monitoring;
- early warning (to alert local or state authorities to a problem);
- public health and shellfish monitoring.

The Rhode Island Department of Environmental Management was initially skeptical about the value of the volunteer monitoring program, but has since reversed its official stand and has begun exploring options for collaboration. Using funds from an EPA grant, DEM is in the process of recruiting a statewide volunteer monitoring program coordinator.

URI works with a similar group, named Watershed Watch, which focuses on freshwater ponds and lakes throughout the state. The Watch coordinates roughly 120 volunteers from land alliances, land trusts, town conservation committees, and watershed councils. After undergoing one indoor and one outdoor training session, the volunteers collect water quality measurements between May and October of each year. Volunteers measure lake transparency using a Secchi disk every week, collect samples for chlorophyll A concentration measurements, and take samples of water three times a year for chemical analyses. The analyses include measurements of nitrogen, phosphorus, alkalinity, pH, magnesium, and calcium. Volunteers also collect on-site measurements of dissolved oxygen every two weeks from ponds deeper than five meters.

The samples are forwarded to a university laboratory for analysis. A staff member and one graduate student are funded through the university's cooperative extension program. The baseline monitoring data are compiled and analyzed by the Watershed Watch university staff, who prepare an annual report.

Watershed Watch also conducts shoreline surveys. Volunteers walk stretches of lake or river reach shores and note the presence of any dumped materials, odors from tributaries or other surface waters, bank erosion, etc. The information is entered into the program's Geographic Information System database for analysis.

General Applicability to the Eastern Shore of Virginia

Volunteer water quality monitoring programs could provide the Counties with regular, up-to-date water quality data for its priority ground water recharge protection areas. One possibility is to develop a collaboration with the University of Virginia which would offer trained chemical analysis and sampling program development expertise.

For More Information

Salt Pond Watchers
Ms. Virginia Lee, Coastal Resources Center, University of Rhode Island, Narragansett, Rhode Island, (401) 792-6224.

Watershed Watch
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EPA Guidance Manual for States to Use Volunteer Monitoring.

CONCLUSIONS OF THE REPORT

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SECTION 10 - CONCLUSIONS OF THE REPORT

The following serves as a summary of what is included in the body of the report, sections 1 through 9.

SECTION 1 - Introduction

This section contains an overview of the study and results, an executive summary, and a description of the purpose of the project.

SECTION 2 - Water Resources on the Eastern Shore of Virginia

Ground water quality and quantity are of the utmost importance on the Eastern Shore of Virginia because there are no other fresh water sources for drinking supplies. Ground water is derived from precipitation that hits the land surface of the two counties. The water that does not evaporate or run-off to small streams moves through the unsaturated zone of the soil and recharges the unconfined, shallow Columbia aquifer. Most water in the Columbia aquifer flows laterally from the center of the peninsula and discharges to the Atlantic Ocean and the Chesapeake Bay; a small portion of this ground water contributes to the base flow of small streams. A fraction of water in the Columbia aquifer continues migrating vertically down through a confining layer and reaches the Yorktown-Eastover aquifers located beneath the Columbia aquifer.

The Columbia aquifer is primarily made of sands, with some clay and silt. The recharge rate from the Columbia (unconfined) to the Yorktown-Eastover (confined) aquifer is estimated to be 0.10 feet per year. Depending upon specific location, this figure may be higher or lower by a factor of two. The Yorktown-Eastover aquifer has three layers separated by confining units. The layers are referred to as the upper, middle, and lower Yorktown-Eastover aquifers. These permeable layers are composed of coarse, shelly sands and range in thickness from 10 to 120 feet. The confining units are between 10 and 70 feet thick. Since most of the ground water flows from the Columbia aquifer to the coasts, it is the water that is recharged from the center of the peninsula that reaches the Yorktown-Eastover aquifer. This area on the spine is later identified as an important area to protect.

Total water use was calculated for the Eastern Shore of Virginia. Currently, agriculture is the biggest water user in the two counties. In Accomack County, agricultural water withdrawals range from 6.04 to 6.86 million gallons per day (MGD), and in Northampton the range is 1.94 to 5.17 MGD, largely depending on the rainfall that year. Farmers use a combination of ground water from wells and from dug ponds, and surface water from dammed creeks for irrigation, so it is difficult to determine the impact of agriculture on specific aquifers. Public water supplies currently use 1.2 to 1.5 MGD, and are permitted to withdraw a total of 4.2 MGD. Industrial facilities are permitted for 10.7 MGD, but currently use water ranging from 3.1 to 3.4 MGD. These permitted facilities withdraw water from the Yorktown-Eastover aquifer. It is estimated that private homes use between 1.7 and 2.3 MGD, mostly from the Columbia aquifer, and non-community and non-transient, non-community public water supply facilities withdraw approximately 0.14 MGD. Chicken watering requires 0.234 MGD.

SECTION 3 - Contamination Threats

Several land uses pose a threat to the ground water in the Columbia aquifer. Because contaminants are discharged to the land or surface waters, the Columbia aquifer would be the first ground water source to become contaminated. The ground water systems are interconnected, and contamination could, after time, reach the confined Yorktown-Eastover aquifer system. Potential sources of contamination were identified and quantified for the Eastern Shore of Virginia. They are as follows:

Public Sewage Systems - Only the three towns of Onancock, Cape Charles, and Tangier Island have public sewage, and these serve less than 4,000 people.

On-site septic systems - Septic systems are the most common form of household wastewater disposal in the area. It is estimated that 12,105 septic systems exist in Accomack County, and 5,008 are located in Northampton.

Permitted discharges and mass drainfields - Facilities that discharge wastewater from a point source to surface waters must obtain a permit. There are 55 of these in the two counties. In addition there are 49 facilities that dispose of wastewater through mass drainfields, which are large septic systems.

Agricultural fertilizers - Agricultural practices apply 5.5 million pounds of fertilizers per year.

Pesticides - Many different pesticides are used on different crops against different pests. Quantities of pesticides used are not reported. Thus, there is no way of determining how much of a threat pesticides are to the ground water.

Animal wastes - With a 1990 chicken population of 21 million birds, there were 21,000 tons of chicken manure produced. The manure is used to fertilize crop land. A natural mortality rate of 5% accounts for the disposal of 1.8 million pounds of dead birds per year.

Underground storage tanks - There are 1,154 storage tanks on the Eastern Shore of Virginia. Of those, 684 (59%) are older than 15 years, and have a potential to leak. To date, 41 have been reported as leaking.

Toxic chemicals - The Eastern Shore does not have many industrial facilities. There are several companies that use toxic chemicals, and these are listed in Tables 3-7 and 3-8.

Solid waste - There are two public landfills in Accomack County, and one in Northampton County. The Northern Landfill in Accomack County is located on the spine recharge area (Zone 2 defined in section 5), which could be dangerous for the water supply should there be a leakage accident. The landfill is equipped with liners and runoff containers, and should not be a problem.

Septage disposal - There are three lagoons in the two counties owned by private companies. They are unlined and are a threat to the ground water supply. One, in particular, is located on the spine recharge area.

SECTION 4 - Existing Land Use

Accomack and Northampton Counties have Comprehensive Land Use Plans and Zoning Ordinances that cover all land under jurisdiction of the County. The Comprehensive Plans represent development policy, and as such are not legally enforceable. Twelve incorporated towns have growth plans and zoning ordinances separate from the Counties.

In Accomack County, current zoning for agricultural and residential land would allow for dense development to take place. In that case, it is possible that sufficient space required for a septic system and drainage field would be lacking. Accomack has a single residential district that can accommodate single family and multi-family housing. There are no minimum lot sizes for industries, which would also potentially create a high density situation.

Northampton County agricultural districts allow for a larger minimum open space potential than in Accomack. Residential districts are more detailed in the number and type of housing units permitted and the conditions under which units are permitted. Single family districts require larger lots than in Accomack County, but the primary building can take up as much as 66% of the lot (compared to 30% in Accomack), which leaves less space for septic systems.

Both counties have a significant number of approved subdivisions which are as yet undeveloped. Many of the land uses are allowed by right, meaning that permits and reviews by each county are not required to determine whether the development will have an impact on ground water use or quality. The review process may need strengthening in cases where potentially harmful uses are proposed.

The Chesapeake Bay Preservation Act is summarized in this section. The Act contains provisions for three general land categories: Resource Protection Areas (RPA), Resource Management Areas (RMA), and Intensely Developed Areas (IDA). Descriptions of each area is as follows:

RPA -Defined as the land at or near the Bay which can protect water quality. If disturbed, water quality will be degraded. An RPA must have a buffer zone. Only redevelopment and water-dependent development can take place within an RPA.

RMA - An RMA is the land which protects an RPA. Any development which is permitted by local zoning can take place within an RMA.

IDA - Significant development is allowed in, or pre-existed in an IDA. If an area has already been developed, an IDA may be located within an RPA or and RMA.

All local governments are to have enacted local programs in accordance with the Chesapeake Bay Preservation Act by November, 1991. Locally prepared programs must meet general performance criteria, all of which relate to the ultimate use and condition of the ground water. Northampton County incorporated its program into a Draft Comprehensive Plan in 1990, and drafted an overlay zoning district. Accomack County has also drafted an overlay zoning district which is being assessed by the County Board of Supervisors. In both counties, the attention has been paid to the requirements for RPA's. There is less mention of RMA's, and no requirements are included for IDA's in either county's draft.

SECTION 5 - Delineation of Ground Water Supply Management Areas

Ground Water Supply Management Areas consist of three zones, and are summarized below.

Zone 1: 200-foot radial distance around each well.
This prevents contaminants from moving into the aquifers via a poorly constructed well or bad seal. Zone 1 also serves as protection against accidental spills near the wellhead.

Zone 2: Hydrogeologic boundaries based on recharge areas.
This area was determined based on a recharge rate of 9 inches per year to the Columbia Aquifer. Using permitted pumping rates, the land area required to balance that volume of withdrawal with the rate of recharge was calculated. Calculations determined that a width of 5,000 feet along the spine is the boundary of Zone 2.

Zone 3: Hydrogeologic boundaries using contributing areas of flow.
Zone 3 is based on ground water divides created by pumping patterns under permitted conditions. There are large drawdown areas on the peninsula because of a moderate to low transmissivity

(water travel through the aquifer) within the Yorktown-Eastover Aquifers. Thus, Zone 3 covers virtually the entire peninsula, and is split into five different Wellhead Protection Areas (WPA).

The five WPA's are summarized according to wells, discharges, landfills, lagoons, and acreage. WPA A includes the Chincoteague area; WPA B - Holly Farms (Tyson Foods); WPA C - Perdue; WPA D - Exmore; WPA E - Cape Charles.

SECTION 6 - Water Budget/Balance

Columbia Aquifer - The water budget approach indicates that there is 17 inches of water recharged to the Columbia Aquifer per year, assuming 50% runoff. With an area of 400 square miles of land, the recharge to the Columbia aquifer is 324 MGD. With so much water being recharged to the Columbia aquifer, there is little concern over the quantity of available water in this aquifer.

Yorktown-Eastover Aquifer - The rate of recharge to the Yorktown-Eastover aquifer system is slow, but the volume of water entering the confined system is large. Since recharge only occurs in the central portion of the peninsula, the spine, the area of recharge is only 200 square miles. With a recharge rate of 0.10 feet per year, approximately 11 MGD are being recharged to this confined aquifer. Permitted withdrawals for industrial and public water supply currently exceed that amount, and are at 15.6 MGD. This is independent of any withdrawals by agriculture or private facilities. Serious consideration should be taken to evaluate the quantities allowed to withdraw from the Yorktown-Eastover aquifer system.

Salt Water Intrusion - Salt water can intrude laterally, vertically through the confining layers, or through upward vertical migration (upconing). If a well is pumped at too high a rate, salt water upconing will reach the well and contaminate the supply source. To prevent this from happening, it is best to maintain a stable pumping rate, rather than one of seasonal fluctuations. In general, water that has more than 250 mg/l of chloride tastes salty, and is unacceptable for drinking. In all likelihood, this is probably happening now at the Lower Yorktown-Eastover Aquifer, but since public and industrial wells are screened at three layers, the salt content is diluted before it reaches the faucet.

SECTION 7 - Buildout/ Developable Lot Analysis

The purpose of the buildout analysis is to evaluate the impacts of existing and potential land uses on ground water quality. For this, existing land uses within the spine recharge area (Zone 2) were assessed. According to current land use plans, potential development within the spine was then calculated. It was determined that, if the area within Zone 2 was developed to its full potential with single family houses, then the number of dwelling units in the spine alone would exceed the number currently existing in all of the two counties.

SECTION 8 - Nitrogen Loading

This section explains the potential dangers from nitrate-nitrogen contamination, including "blue baby syndrome" and possibly cancer. The current EPA standard limit for nitrate-nitrogen in water is 10 milligrams per liter (mg/l). Sources of nitrate-nitrogen are sewage, fertilizers (agricultural and lawn), animal wastes, landfills, septage lagoons, pavement and roof runoff, industries, and precipitation. All inputs from these sources were calculated for the Eastern Shore of Virginia, and added together to predict the current average nitrate-nitrogen concentration in the ground water. This was found to be 2.0 mg/l in Accomack County and 1.9 mg/l in Northampton County. This falls well below the EPA standard, but being an average for the area, this does not mean that there are no problem sites in either county. The largest contributors of nitrate-nitrogen are agriculture and septic systems.

Existing water quality tests show low nitrate-nitrogen concentrations, with several isolated high readings. There are problems in some areas, especially in the Columbia (shallow) aquifer.

Results from the buildout analysis were used to predict average nitrate-nitrogen concentrations under buildout conditions. These figures reflect the future concentrations if the land area in Zone 2 is built according to current land use plans. The HWH model predicts that WPA B would experience elevated nitrate-nitrogen concentrations of 13.5 mg/l.

SECTION 9 - Case studies and Their Applicability To The Eastern Shore of Virginia

A number of case studies are summarized in this section in order to illustrate different water resource protection strategies which may potentially benefit the Eastern Shore's efforts to protect its surface and ground waters. The subjects addressed in this section are agricultural influences, on-site waste disposal, surface water, hazardous materials, and monitoring programs.

RECOMMENDATIONS

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SECTION 11: RECOMMENDATIONS

The Eastern Shore of Virginia is situated over a very valuable ground water resource that is a sole source of water supply to the inhabitants of Accomack and Northampton Counties. Ground water is the only significant supply source for public water withdrawals, private on-lot wells, industrial water use, and agricultural irrigation. The future land use plans for both counties are to maintain a low density pattern of development with growth occurring in the established villages and population centers.

This study has identified the primary recharge area to the confined Yorktown-Eastover aquifer which is the principle source of water on the Eastern Shore. Protection of the excellent water quality in this aquifer will require the implementation of many actions designed to maintain the water quality, prevent against over use of the aquifer and provide for the future water needs to accommodate growth on the Eastern Shore of Virginia.

The shallow Columbia aquifer has experienced water quality degradation in a number of areas. Since this aquifer is used primarily for on-site private water use, recommendations are presented to ensure that this planned use can continue. The Columbia aquifer also provides recharge to the confined Yorktown-Eastover aquifer system. Maintaining a high water quality in the Columbia ensures that land use threats to the confined aquifer will be minimized.

Recharge estimates to both the Columbia and Yorktown-Eastover aquifers indicate that in combination there is sufficient water quantities to meet both the current and future water demands. In order to supply water for intended uses, proper water management is required in conjunction with protection of the water quality.

These recommendations for ground water protection and management will also apply to Tangier Island. Land use conditions are similar on Tangier Island, however, water is withdrawn from a much deeper aquifer.

Examples of most of the following recommendations that require local regulations are on file with the Accomack-Northampton Planning District Commission.

Recommendations for Water Quality and Quantity Protection

#1: Water Conservation for Major Industrial Water Users

The Ground Water Study Committee should pursue with major industrial users, fresh water conservation possibilities. These possibilities might include the use of lower quality water for effluent dilution, and the reduction in wastewater flows from treatment plants.

#2: Overlay Protection Zoning District. - Future Activities

Based upon the Wellhead Protection Area Map prepared by HWH, and the delineation of wellhead protection areas and recharge areas to the Yorktown-Eastover aquifer, the Counties should adopt a zoning overlay ground water protection district. This action would apply only to future activities and not have any effect on existing facilities and development. The delineated protection zones should be dealt with in a progressively more relaxed fashion in terms of land use restrictions. Zone 1 is a 200-foot radius around pumping wells, Zone 2 is the spine recharge area to the Yorktown-Eastover aquifer, and Zone 3 is the delineated wellhead protection areas.

- The area encompassing Zone 1 should have strict prohibitions, excluding virtually all future potentially harmful activities within the 200-foot radius. The only activities that should be permitted within Zone 1 are passive recreation and maintenance of the wellhead itself. All pesticides, insecticides, herbicides, all storage of potentially dangerous material (salt, chemicals, petroleum products) should not be permitted within Zone 1.

- Zone 2 should have land use restrictions commensurate with the delicate role it plays in recharging the Yorktown-Eastover aquifer. Such restrictions would be less onerous than those of Zone 1, but would include prohibiting the future siting of major polluting activities (landfills, septage lagoons, etc.) and requiring special permits based on performance standards for others (underground fuel storage tanks, toxic and hazardous materials, etc.)

- Zone 3 should have the least restrictive land use regulations, relying heavily on public awareness to avoid contamination of the aquifers on the Eastern Shore. It should be remembered that this area also recharges the Yorktown-Eastover aquifer and all land use activities should be managed with protection of ground water quality in mind. The ground water resources are a sole source of supply to the residents of the Eastern Shore and as such should be protected and managed.

#3: Restrict New Mass Drainfields in the Recharge Area (Zone 2)

The combined use of large septic systems by several businesses, homes, or industries provides a major point source of nitrogen loading and bacterial contamination to the Columbia Aquifer. This waste water disposal technique should, for the most part, not be allowed for future development in Zone 2. Overlay zoning can be employed to restrict mass drainfields within Zone 2. Any new mass drainfields installed within Zone 2 should prove that they can manage the facility and meet treatment levels allowed within that area. A performance standard could be established in the overlay zoning district for mass drainfields, or site plan reviews could incorporate the same requirements.

#4: Review and Revise County Zoning and Subdivision Regulations

Accomack and Northampton Counties should revise their current zoning and subdivision regulations to incorporate ground water quality and quantity protection. Most of the assessment of land use threats conducted during this study point to the need to control density, location, and the pattern of development. As zoning and subdivision regulations are revised, many of the suggested recommendations can be incorporated into the formal process of revisions.

#5: Require the Registration of Underground Storage Tanks Storing Volumes Less Than the State Requirements

The Virginia Water Control Board currently regulates tanks which store more than 1,100 gallons of product. In order to adequately assess the threat from existing tanks, the counties should establish a registration program for all tanks storing less than 1,100 gallons. At this point, only registration of tanks is recommended. When ever possible, above-ground storage tanks should be used in place of underground tanks.

#6: Incorporate Ground water Protection Into Site Plan Review

Both counties should revise their zoning ordinances to require that ground water protection be considered in all major site plan reviews. This will require developers of commercial and industrial sites to identify and mitigate potential negative impacts to ground water quality and quality from their development.

#7. Private Well Ordinance

Both counties should develop a health ordinance or revise subdivision regulations to require a minimum 300 foot separation distance in a downgradient ground-water flow direction for private wells finished in the Columbia aquifer from septic systems. Private on-site wells will continue to be a major water user on the Eastern Shore. Approximately 2 million gallons per day are withdrawn by private wells. In addition, where ever possible, new private wells should be finished in the Yorktown-Eastover aquifer to to eliminate the threat of nitrate contamination in the shallow aquifer. Water quality testing for nitrates for all new wells should be required prior to approval for use.

#8: Encourage Agricultural Nutrient Management Plans

The Soil Conservation Service, County Extension Agents, and the Eastern Shore Soil and Water Conservation District should continue their program of assisting farmers in developing nutrient management plans. These plans should incorporate: soil nutrient testing; crop productivity recommendations; animal waste management; and fertilizer use record keeping. Especially important in Accomack County is the control of chicken waste products and disposal of dead chickens to minimize impacts on surface water and ground water resources. Government programs are in general developed to assure the general population adequate surplus food at minimum cost. As a result, farmers cannot pass along increased costs of production. As a result and in view of preliminary data concerning the submitted soil samples, it is recommended that cost-share assistance be considered, with time by the two counties and/or state, for soil testing through the Eastern Shore Soil and Water Conservation District.

#9: Implement Chesapeake Bay Program

Both counties should implement the required provisions of the State of Virginia's Chesapeake Bay Act. The Act contains many provisions that will not only protect the quality of surface water drainage to the Chesapeake Bay, but also the ground water that ultimately discharges to the Bay. Specifically, the following provisions of the Act should be incorporated into local regulations: mandatory 5 year pump-out of septic systems; required reserve leach fields for septic systems; new development site plan review to include water quality protection; restrictions on impervious cover; stormwater quality management; and the protection of valuable wetlands.

Recommendations for Water Quantity Management

#1: Revise State Ground Water Act and Regulations

A revision to the State Ground Water Act (Chapter 3.4 of the State Water Control Board Statutes) which would allow re-authorizing of ground water withdrawals on the Eastern Shore is necessary to ensure that overuse of the confined aquifer does not result in saltwater intrusion, well interference, or create major drawdowns. The current permitted volumes may exceed the recharge rates to the Yorktown-Eastover aquifer as modelled by HWH.

#2: Eastern Shore Water Management District

Accomack and Northampton counties should explore the possibility of forming a water supply district or water authority to centralize public and industrial water uses under one regulatory agency. There are currently several dozen active water withdrawal permits on the Eastern Shore. This promotes incomplete data bases, complicated administrative tracking and management and poor utilization of the ground water resource. The purpose of this recommendation is to encourage the consideration of a single water supply and management authority, especially to cover the geographic area of the spine recharge zone. The Water Management District would be authorized to: plan for future water supply needs; obtain necessary state and federal permits; install and operate new public water supply systems that could service new areas; provide for the consolidation of the many systems that are currently in operation; and promote proper utilization of the ground water resource.

As development continues on the Eastern Shore and more withdrawal permits are requested, the need for centralized management will become more apparent.

#3: Water Quantity Management -Existing and New Water Supply Sources

- New water supply sources that tap the Yorktown-Eastover aquifer should be located in the central portion of the Eastern Shore peninsula. This approach will minimize both lateral intrusion from salt water and vertical intrusion of salt water through confining layers. It will also simplify wellhead and aquifer protection since the position of the recharge area will not be skewed to one side or the other of the peninsula.

- New water supply sources should be screened in the upper and middle Yorktown-Eastover, avoiding the lower Yorktown-Eastover. Screening only the higher layers minimizes many of the problems of upconing of high chloride content water.

- Wellfields rather than single wells to produce large volumes of water should be encouraged. A series of wells each pumping a moderate amount of water will create less upconing, less well interference and less lateral intrusion that one or two high volume wells.

- New and existing water supply users should be encouraged to pump at moderate volumes on an extended basis and to use surface storage (tanks, lined ponds) rather than pumping hard for short intervals to meet peak demands. The continual pumping of moderate volumes will allow a smaller upcone to develop and to stabilize, eliminating much of the problem of salt and fresh water mixing that occurs with intermittent pumping. A progressively enlarged mixing zone between fresh and salt water will promote the intrusion of high chloride water into the fresh water zone.

- The use of water supplies from the unconfined Columbia aquifer should be encouraged in situations where water quality is less of a concern. The Columbia receives considerably more recharge than the Yorktown-Eastover aquifer, and while its water quality is sometimes marginal as a potable water supply, the quality is perfectly adequate for a number of industrial, agricultural and even domestic uses. High volume users of water that do not need water of drinking quality standards should be urged to use the Columbia as a source where adequate flows can be achieved.

#4: Mandatory Reporting of Large Agricultural Water Withdrawals

Agricultural water withdrawals have been identified as the largest single source of water use on the Eastern Shore. Yet very little is known about how this water is used and from which aquifer it is obtained. State Water Control Board Regulations currently require that irrigators which withdraw more than 1 million gallons/day on the average for any month report this use to the VAWCB. The Ground Water Committee should develop public educational materials to inform irrigators of the need to collect accurate information on their water use.

#5: Consider Permitting of Large Agricultural Water Withdrawals

If after review of the reporting of large agricultural water withdrawals it becomes apparent that these withdrawals are significant contributors to the total withdrawal from the Yorktown-Eastover aquifer, the Virginia State Water Control Board should be encouraged to regulate the amounts and locations of existing and future agricultural withdrawals. This will provide for better management and control of withdrawals from the aquifer.

#6: Protect Open Space in the Spine Recharge Area

Local governments on the Eastern Shore should seek to acquire public open space in the Zone 2 Recharge Area. This can be accomplished with the assistance of public conservation groups such as The Nature Conservancy, which has already acquired most of the coastal marsh areas of the Eastern Shore. Public land ownership will ensure the protection of water quality and allow for the control and development of prime water supply development sites.

General Recommendations

#1: Implement a Land Use/Water Quality Data Base

The A-NPDC should consider the establishment of a centralized water quality data base for all water use on the Eastern Shore. Experience from the study identifies the need for centralized data to continue the planning and management of the the ground water resource. Data collection and synthesis was very time consuming and could greatly reduce future planning and analysis costs with the development of a central repository of water quality information. In addition, land use information could also be centralized and managed by the A-NPDC to allow the agency to assist the counties in implementing land use controls for water resource protection.

#2: Public Education on Ground water

The Eastern Shore of Virginia Ground Water Study Committee should continue to develop materials and provide information to the public on the importance of the ground water resource on the Eastern Shore. Additional publications, meetings, forums, etc. should be planned to encourage support for ground water protection and management. Continued support for research conducted by the US Geological Survey should be a primary activity for the Committee. This research will form the basis for many future decisions regarding ground water management.

Continued Research and Investigation

#1: Investigate the Nature of Recharge to the Yorktown-Eastover System

The rate, volume, timing and distribution of recharge from the unconfined Columbia aquifer to the Yorktown-Eastover aquifer remains a focal point to the water supply problems on the Eastern Shore. *If the rate of recharge is as low or lower than has been modelled analytically in this study, and if the area over which recharge occurs is smaller than the 200 to 300 square miles used, the issue of water quantity in the Yorktown-Eastover aquifer becomes even more important than has been argued here.* Because this is a key issue, additional work should be considered to attempt to better quantify the recharge component of the hydrologic cycle. It may be possible, for example, to employ the USGS finite difference model designed to model salt water intrusion, currently in review (Richardson, in press), using that database as a means to better quantify the rate, volume and areal distribution of recharge to the confined system. Results from the Richardson report should be incorporated into the Protection and Management Plan when this report is available.

#2: Research Dilute Salt Water Issues

Salt water movement into both the Columbia and Yorktown-Eastover aquifers is a very important and real threat on the Eastern Shore. Additional study is needed to quantify the limits of salt water in the 250 milligrams per liter range. This information is necessary to determine the limitations that may need to be set on individual water withdrawals.

#3: Investigate the Character of Pleistocene Paleochannels on the Eastern Shore

A major focus of continued research should focus on the paleochannels that cross the Eastern Shore. These could prove to be major sources of supply to the two counties, but their use would have to be coupled with a solid understanding of the geometry and flow patterns involved. It is likely that the deep central portions of the channels possess sands and gravels from the depositing stream that formed the channel, deposits that probably would have good permeability and would make excellent aquifers. However, development of such materials would have to be done carefully to avoid both upconing and vertical intrusion of salt water. Since the permeable deposits would be at the bottom of the channels, they would be closest to underlying salt water and subject to upconing problems that could ruin an otherwise good well. Since the channels are documented as connecting to the mainland, passing beneath Chesapeake Bay (Colman and others, 1990), a substantial portion of the channels lie beneath salt water. Excessive pumping of a well located in a paleochannel on the Eastern Shore peninsula could result in contamination from salt water intruding vertically in response to the gradients created by pumping.

#4: Evaluate Pesticides Use on the Eastern Shore

The impact of pesticide use on ground water quality on the Eastern Shore should be studied. Currently, information is not available to accurately assess this potential source of contamination. The VA Department of Agriculture and Consumer Services, Office of Pesticide Management should be contacted to provide assistance in this effort. Since agriculture is planned as the predominant land use in the future, this effort should be a priority for future investigations.

#5: Agricultural Nutrient Management Research

Additional research should be conducted on the specific nature of agricultural nutrient use and impacts on the water resources of the Eastern Shore. This study utilized general information regarding nitrogen application rates, leaching potential, chicken litter disposal and use, and dead chicken disposal. More specific information is necessary on: actual nitrogen application rates and amounts used by crop types; nitrogen leaching rates by soil types found on the Shore: an accurate assessment of chicken litter use and disposal of dead chickens; quantification of the success of nutrient management plans in reducing nitrogen use and loss; fate and transport of nitrogen in the ground water system (Columbia and Yorktown-Eastover).

#6: Revise Nitrogen Modelling

Nitrogen is a very good indicator of overall ground water quality. The nitrogen model used in this study to assess land use impacts should be revised as more detailed information becomes available. Virginia Tech is currently conducting a study of nitrogen contamination in the ground water of the Eastern Shore. This new data can be used to update and verify the results of the model. The model is designed to allow for easy revisions and scenario testing. The model can be used in planning new development and in the assessment of zoning changes.

WATER QUALITY

APPENDIX A

Regulated Contaminants

The following is a list of drinking water contaminants for which the U.S. Environmental Protection Agency is setting health-based standards (Maximum Contaminant Level Goals, or MCLGs) and enforceable standards (Maximum Contaminant Levels, or MCLs). For some contaminants, there is also a Secondary Maximum Contaminant Level (SMCL), a level set to prevent taste or odor problems. Unless otherwise indicated, the levels presented are milligrams per liter (mg/l). For some contaminants, the MCL is a prescribed treatment. See "Setting the standards for safe drinking water" and contaminant descriptions for more information.

Contaminant	MCLG	MCL	SMCL	Interim
acrylamide	0	.005% dosed at 1 mg/l		
adipates[2]	0.5	0.5		
alachlor	0	0.002		
aldicarb[1]	0.01	0.01		
aldicarb sulfone[1]	0.04	0.04		
aldicarb sulfoxide[1]	0.01	0.01		
alpha particle acitity (gross)[3]				15 pCi/l
antimony[2]	0.003	0.01 or 0.005		
arsenic[4]				0.05
asbestos	7 million fibers/liter			
atrazine	0.003	0.003		
barium[1]	5	5		1
benzene	0	0.005		
beryllium[2]	0	0.001		
beta particle and photon radioactivity[3]			4 mrem/yr	
cadmium	0.005	0.005	0.01	
carbofuran	0.04	0.04		
carbon tetrachloride	0	0.005		
chlordane	0	0.002		
chlorobenzene[1]	0.1	0.1	0.1	
chromium	0.1	0.1		0.05
copper[1]	1.3	1.3		
cyanide[2]	0.2	0.2		
dalapon[2]	0.2	0.2		
dibromochloropropane (DBCP)	0	0.0002		
o-dichlorobenzene	0.6	0.6	0.01	
p-dichlorobenzene	0.075	0.075	0.005	
1,2-dichloroethane	0	0.005		
1,1-dichloroethylene	0.007	0.007		
cis-1,2-dichloroethylene	0.07	0.07		
trans-1,2-dichloroethylene	0.1	0.1		
2,4-dichlorophenoxyacetic acid (2,4-D)	0.07	0.07		0.1
1,2-dichloropropane[1]	0	0.005		
dinoseb[2]	0.007	0.007		
dioxin (2,3,7,8-TCDD)[2]	0	0.00000005		
diquat[2]	0.02	0.02		
endothall[2]	0.1	0.1		
endrin[2]	0.002	0.002		0.0002
epichlorohydrin	0	.01% dosed at 20 mg/l		
ethylbenzene	0.7	0.7	0.03	

[1]proposed May 1989; may be finalized December 1990 [2]proposed July 1990 [3]to be proposed February 1991

Contaminant	MCLG	MCL	SMCL	Interim
ethylene dibromide	0	0.00005		
fluoride	4	4	2	
Giardia lamblia	0	treatment		
glyphosate[2]	0.7	0.7		
heptachlor	0	0.0004		
heptachlor epoxide	0	0.0002		
hexachlorobenzene[2]	0	0.001		
hexachlorocyclopentadiene[2]	0.05	0.05	0.008	
lead[1]	0	0.005		0.05
Legionella	0	treatment		
lindane	0.0002	0.0002		0.004
mercury	0.002	0.002		0.002
methoxychlor	0.04	0.04		0.1
methylene chloride[2]	0	0.005		
nickel[2]	0.1	0.1		
nitrate (as N)	10	10		10
nitrite (as N)	1	1		
pentachlorophenol[1]	0.2	0.2	0.03	
phthalates[2]	0	0.004		
picloram[2]	0.5	0.5		
polychlorinated biphenyls (PCBs)	0	0.0005		
polycyclic aromatic hydrocarbons (PAhs)[2]	0	0.0002		
radium 226 and 228[3]				5 pCi/l
radon[3]				
selenium	0.05	0.05		0.01
simazine[1]	0.001	0.001		
standard plate count		treatment		
styrene	0.1	0.1	0.01	
sulfate[2]	400 or 500	400 or 500		
tetrachloroethylene[1]	0	0.005		
thallium[2]	0.0005	0.002 or 0.001		
toluene	1	1	0.04	
total coliforms	0	treatment		
toxaphene	0	0.003		0.005
trichlorobenzene[2]	0.009	0.009		
1,1,1-trichloroethane	0.2	0.2		
1,1,2-trichloroethane[2]	0.003	0.005		
trichloroethylene	0	0.005		
2,4,5-trichlorophenoxypropionic acid (2,4,5-TP)	0.05	0.05		0.01
turbidity		treatment		
uranium[3]				
vinyl chloride	0	0.002		
viruses	0	treatment		
vydate[2]	0.2	0.2		
xylenes (total)	10	10	0.02	

[4]to be dealt with separately [5]longer than 10 µm

Source: What Do The Standards Mean?: A Citizens' Guide to Drinking Water Contaminants, VA Tech.

POPULATION

APPENDIX B

Table B-1: 1990 U.S. Census Population Counts
Accomack-Northampton Planning District

Locality	Population Counts	Housing Units	people/units Density
Accomack County	31,703	15,840	2.00
Accomack Town	466	205	2.27
Belle haven Town	526	245	2.15
Bloxom Town	357	175	2.04
Chincoteague Town	3,572	3,167	1.13
Hallwood Town	228	115	1.98
Keller Town	235	107	2.20
Melfa Town	428	191	2.24
Onancock Town	1,434	705	2.03
Onley Town	532	276	1.93
Painter Town	259	113	2.29
Parksley Town	779	393	1.98
Saxis Town	367	192	1.91
Tangier Town	659	277	2.38
Wachapreague Town	291	223	1.30
Outside of incorporated towns	21,570	9,456	2.28
Northampton County	13,061	6,183	2.11
Cape Charles Town	1,398	689	2.03
Cheriton Town	515	246	2.09
Eastville Town	185	94	1.97
Exmore Town	1,115	528	2.11
Nassawadox Town	564	227	2.48
Outside of incorporated towns	9,284	4,399	2.11
A-NPD TOTAL	44,764	22,023	2.03

Table B-2: Historical and Projected Population Figures

Year	1950	1960	1970	1980	1985	1990	1995	2000
Population								
Accomack County	33,832	30,635	29,004	31,268	31,200	33,000	33,300	34,000
						31,130*		31,990*
Northampton County			14,442	14,625	14,700	15,000	15,000	15,300
A-NPD			43,446	45,893	46,500	48,000	48,300	49,300

Sources: VSWCB Eastern Shore Water Supply Plan, 1988; Accomack County Comprehensive Plan, 1989 (*- A-N PDC linear TMI model). Both used the following sources: US Bureau of the Census, Virginia Department of Health, Tayloe-Murphy Institute.

LAWS AND REGULATIONS APPLICABLE TO STUDY

APPENDIX C

LAWS AND REGULATIONS APPLICABLE TO THE STUDY

Virginia State Water Control Board Statutes, July 1, 1990
Chapter 3.1 - State Water Control Law Article 4 , Regulation of Sewage Discharges

All sewerage and sewage treatment operations are under joint supervision of the State Department of Health and the Board. If a proposed facility will serve more than 400 people and if it has potential for or actual discharge to state waters, owners shall file an application to the Board and the State Department of Health for a certificate before any erection, construction, operation, or expansion can occur. In 1977, owners and operators of sewerage systems and sewerage and industrial waste treatment works conducted a survey in order to determine the physical, chemical, and biological properties of discharge.

Virginia State Water Control Board Statutes, July 1, 1990 Chapter 3.4 - The Groundwater Act of 1973

The basic premise behind this act is that the right of water control belongs to the public, but in order to ensure public welfare, safety, and health, provisions must be made for control of ground water. The Board and the State Department of Health administers and enforces the provisions of this chapter. Special care is taken to protect Groundwater Management Areas (GMA). The Board will initiate a study if it is believed that in a certain area ground water levels are declining, two or more wells are interfering, the ground water supply is or will be overdrawn, or the ground water is or is expected to be polluted. Should an area be deemed a GMA, one must obtain a permit in order to withdraw ground water from such area. No certificate is needed to withdraw from an area that is not declared a GMA, nor for those withdrawing less than 300,000 gallons/month or for agricultural or livestock purposes. The Board may establish regulations which will require only agricultural withdrawal greater than 300,000 gallons/month to be reported.

VR 680-14-01 - State Water Control Board Regulations - Pollution Abatement Permit Regulation

This regulation sets guidelines for pretreatment programs, and identifies procedures and requirements to be followed in connection with Virginia Pollutant Discharge Elimination System (VPDES) and Virginia Pollution Abatement (VPA) permits issued by the Board pursuant to the Clean Water Act or the State Water Control Law. Permits are required for discharge of anything that may alter state waters. Point sources are authorized by a VPDES permit, non-point by a VPA permit. Any spills, unplanned bypasses, or non-compliance which may endanger state waters must be reported by telephone within 24 hours. Animal feeding operations are subject to the VPA permit program if they are considered concentrated (100,000 laying hens or broilers) or intensified (30,000 hens, broilers). Under this regulation, animal feeding operations (animals are stationed or fed on premises for at least 45 days per year) shall maintain no point source discharge of pollutants to state waters except in the case of a 25 year, 24 hour storm event.

VR 680-14-03 - State Water Control Board Regulations , Pollution Abatement Toxics Management Regulation

The purpose of this regulation is to control the levels of toxic pollutants in surface waters discharged from all sources holding VPDES or NPDES permits. It provides standards and procedures to minimize or prevent any toxic discharge in levels dangerous to human health or the environment. Whenever VPDES permits are issued or modified, the Board will determine whether or not there is a need for toxics management. Toxics monitoring must be done if the discharge has actual or potential toxicity, if the permitted works falls into the Industry Class, if the industrial wastewater flow is greater than 500,000 gallons/day, if a Publicly Owned Treatment Works

(POTW) discharges greater than 1 million gallons per day, or if a POTW undergoes a pretreatment program.

State Water Control Board Regulations - Pollution Abatement Regulation No. 8 , Sewerage Regulations

These regulations were adopted jointly by the State Water Control Board and the State Board of Health. They were set up in order to ensure that the design, construction, and operation of sewage treatment works and sewerage systems are consistent with public health and water quality objectives of the Commonwealth of Virginia. The regulations assist owners in preparation of an application, plans, or data and lay the rules by which the Board will review and make decisions in regards to the specifications and applications.

State Water Control Board Regulations - Water Supply Data VR 680-15-01, Water Withdrawal Reporting

Under this regulation, water withdrawal information will be submitted to the Board for the purpose of formulating and preparing plans and programs for the management of water resources in the Commonwealth of Virginia. The data will also be available to local governments and local interests to assist them in their own water supply planning. The regulation applies to every user withdrawing ground water or surface water whose daily average withdrawal during any month exceeds 10,000 gallons/day. It also applies to every user withdrawing ground or surface water for the purpose of irrigating crops whose withdrawal exceeds 1 million gallons in any single month. Industrial VPDES permittees must report their source and location annually. Every nonexempt user other than crop irrigators shall have installed and shall operate a gaging device . Crop irrigators shall comply with measuring provisions by January 31, 1991. Every nonexempt user shall file with the board a reporting form every January 31 of each year.. The information reported includes source(s) and locations of withdrawal, cumulative volume of water withdrawn each month, method of withdrawal measurement, and maximum day withdrawal. Crop irrigators shall comply with reporting provisions by January 31, 1992

State Water Control Board Regulations - Groundwater Rules and Standards for Water Wells

So that equitable development and utilization of ground water is achieved in Virginia, these rules and standards set forth the authority for controlling ground water. Essentially, these rules and standards set provisions to prevent wells from becoming a source or channel for the entry of pollutants or contaminants. Under the jurisdiction of this regulation are: registration statements, construction and maintenance of wells, observational and abandoned wells, data and records, and general requirements. Methods for testing well yield are described.

VR 680-21-00 - State Water Control Board Regulations - Water Quality Standards

The State Water Control Law, Section 62.1-44.15(3), mandates the protection of existing high quality state waters and also provides for the restoration of all other state waters to a condition of quality which will allow all public uses: water-based recreation, public water supply, and growth of balanced populations of fish and wildlife. In this regulation, water quality requirements for surface waters and ground water are described and listed in tables in numeric limits and general terms for specific physical, chemical, biological, and radiological characteristics of water. These limits set the standards that must be met by all discharge applicants. Municipal and industrial discharge mixing zones are viewed separately, and must not threaten recreation and wildlife use. In addition, special standards for shellfish waters are set for the median fecal coliform value. Extra precautions must be made in surface waters so that eating shellfish is not hazardous. The

Board will convene a public hearing to talk about any proposal that would result in the Department of Health condemning shellfish beds.

Acknowledging that ground water quality varies in different areas, the Board has divided the state into four physiographic provinces by which they establish different criteria. The Eastern Shore is in the Coastal Plain region. In order to prevent the entry of pollutants into the ground water in any aquifer, a soil zone or alternate protective measure or device is established to preserve and protect the ground water.

State Board of Health - Waterworks Regulations

These regulations establish that the State Board of Health has the duty to ensure that all water supplies destined for human consumption be pure water. All wells must be constructed by registered Virginia contractors, and wells sampling done by approved laboratories.

Frequent sanitary surveys must be made by the owner to locate and identify health hazards. Once a hazard is identified, the rate it is removed will be determined by the Division of Water Supply Engineering. Sampling frequencies are listed in this regulation, and are based upon the number of people served and whether or not the water supply is community, non-transient community, or non-community. Categories for those to be sampled are coliform bacteria, inorganics, organics (pesticides, VOC's, UC's, THM's), radiological, and physical characteristics like turbidity. Nitrates must be sampled once every three years for community and non-transient community, and every five years for a non-community water works.

When a new water supply system is considered, the capacity of the source must be adequate to sustain anticipated growth. Construction and location requirements for drilled wells are the following:

1) There shall be a distance of at least 50 ft. from the well to the property lines of the well lot.
2) If an access road is needed, it will be counted as part of the well lot.
3) There must be a horizontal distance of 50 ft. from the well to any septic tank, barn yard, privy, pipe carrying sewage, petroleum or chemical storage tank, or pipe line. If plastic well casing is used, the distance is 100 ft.

A water well completion report must be submitted. The report will include yield and drawdown test data for a minimum period of 48 hours.

Chapter 14.1 - Virginia Pesticide Control Act, 1989 Session

This Act establishes a Pesticide Control Board which adopts rules concerning pesticides and the application of them. The Board also serves the public by informing them as to the desirability and availability of non-chemical and less toxic alternatives to chemical pesticides. It promotes the use of Integrated Pest Management techniques and the safe and proper use of pest control products. The Board has the power to restrict or prohibit the use of any particular pesticide. All pesticides must be registered, and all applicators must have a license to do so (researchers excluded). The Board acts as enforcer of rules, and can levee fines as a result of violations. Pesticide accidents must be reported.

VR 115-04-03 - Virginia Department of Agriculture and Consumer Services Rules and Regulations for Enforcement of the Virginia Pesticide Law

These regulations list guidelines for the application, storage, disposal, and sale of pesticides. The concept of "pest" is defined, and the types of pest control are placed into categories. Rules are established for toxicity codes and for labeling pesticides.

VR 115-04-21 - Public Participation Guidelines, Pesticide Control Board
Department of Agriculture and Consumer Services, Pesticide Control Board

These guidelines establish methods for identification and notification of those persons or groups interested in the development of regulations of the Pesticide Control Board. Mailing lists, public meetings, committees, and the process of making a regulation are all described here.

VR 115-04-22 - Virginia Department of Agriculture and Consumer Services Regulations Governing Licensing of Pesticide Business Operating Under Authority of Virginia Pesticide Control Act, September 1990

These regulations introduce procedures and requirements for obtaining a pesticide business license. A license is required for anyone who sells, stores, mixes, applies or recommends pesticides, and this includes pest management consultants. Businesses must demonstrate evidence of financial responsibility and keep records according to the rules. Failure to be properly licensed, financially responsible, or to submit records when asked can result in revocation, suspension, or denial of a business license by the Board.

VR 115-04-23 - Regulations Governing Pesticide Applicator Certification Under Authority of Virginia Pesticide Control Act (Proposed, as of 2/91)

Several sections of VR 115-04-03 are superseded by these proposed regulations. VR 115-04-23 sets standards of certification for persons specified by the statute to require certification, and standards of financial responsibility for commercial applicators. Those who must meet the requirements are individuals, employees, or representatives of government agencies who use or supervise the use of pesticides in the performance of their official duties. All must pass a general examination, and then be tested in a specific category of pesticide application. The general tests assure that all applicators are able to handle accidents, know labels, application techniques, laws and regulations, can identify pests, and are aware of environmental affects of pesticides. Commercial applicators not for hire are required to keep records for two years, while commercial applicators must maintain records of each restricted-use pesticide.

EASTERN SHORE OF VIRGINIA GROUND WATER STUDY COMMITTEE

APPENDIX D

EASTERN SHORE OF VIRGINIA GROUND WATER STUDY COMMITTEE

Membership:

The Committee consists of the following representatives from Accomack and Northampton Counties:

- 2 members from each Board of Supervisors
- 1 citizen appointee from each Board of Supervisors
- the County Administrator from each county
- the Executive Director of the Accomack-Northampton Planning District Commission

Members:

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HYDROGEOLOGIC CALCULATIONS

APPENDIX E

Table E-1: Water Balance for the Eastern Shore of Virginia

Recharge to the Columbia (Unconfined) Aquifer
(After Dunne and Leopold, 1978)

	Average Monthly Precipitation (inches)	Average Monthly Precipitation (mm)	Potential ET (from Thornthwaite method) (mm)	Precipitation minus Potential ET (mm)	Accumulated Potential Water Loss (mm)	Soil Moisture (mm)	Change in soil moisture (mm)	Actual ET (mm)	Soil Moisture Deficit (mm)	Soil Moisture Surplus (mm)	Available for runoff or recharge (mm)	Assume 50% Runoff (mm)	Detention (recharge) (mm)	Detention (recharge) (inches)
January	3.41	86.6	6	81		200	0	6	0	81	136	68	68	2.7
February	3.31	84.1	8	76		200	0	8	0	76	144	72	72	2.8
March	4.13	104.9	24	81		200	0	24	0	81	153	77	77	3.0
April	2.92	74.2	46	28		200	0	46	0	28	105	52	52	2.1
May	3.47	88.1	77	11		200	0	77	0	11	63	32	32	1.2
June	3.51	89.2	103.5	-14	-14	190	-10	99.2	4.4	0	32	16	16	0.6
July	4.10	104.1	118.7	-15	-29	185	-5	109.1	9.6	0	16	8	8	0.3
August	4.28	108.7	111	-2	-31	183	-2	110.7	0.3	0	8	4	4	0.2
September	3.41	86.6	84	2	-29	185	2	84	0	0.2	0.2	0.1	0.1	0.005
October	3.57	90.7	52	39		200	15	52	0	39	39.1	20	20	0.8
November	2.96	75.2	25	50		200	0	25	0	50	70	35	35	1.4
December	3.37	85.6	10	75		200	0	10	0	75	110	55	55	2.2
TOTAL	42.44	1078	665	413		2343		651	14.3	442	876	438	438	**17 inches per year**

Note: Assumes soils with 200 mm (8 inches) of available water capacity

E-1

Table E-2: Thorthwaite Method for Evapotranspiration (ET) Calculation

LOCATION: *Eastern Shore, Virginia*
CLIMATOLOGICAL DATA FROM: *Painter, Virginia*
YEARS OF RECORD: *6 (1985-1990)*

	Mean Monthly Air Temperature	Positive Air Temperature Values	Monthly Heat Index	Uncorrected ET (cm/month)	Latitude Correction Factor Latitude =	40° N	Potential ET (cm/month)	Potential ET (in/month)
January	3.94	3.94	0.70	0.76	*January*	0.80	0.61	0.24
February	4.28	4.28	0.79	0.85	*February*	0.89	0.76	0.30
March	9.11	9.11	2.46	2.40	*March*	0.99	2.38	0.94
April	13.72	13.72	4.55	4.21	*April*	1.10	4.63	1.82
May	18.67	18.67	7.21	6.41	*May*	1.20	7.69	3.03
June	22.50	22.50	9.55	8.28	*June*	1.25	10.35	4.08
July	25.17	25.17	11.29	9.65	*July*	1.23	11.87	4.68
August	25.17	25.17	11.29	9.65	*August*	1.15	11.10	4.37
September	22.17	22.17	9.33	8.11	*September*	1.04	8.44	3.32
October	16.83	16.83	6.18	5.56	*October*	0.93	5.18	2.04
November	10.72	10.72	3.14	3.00	*November*	0.83	2.49	0.98
December	5.89	5.89	1.28	1.32	*December*	0.78	1.03	0.41

ANNUAL HEAT INDEX, I = 67.77
"a" factor = 1.37

Total Potential ET = 67 cm/year | 26 in/year

Table E-3: Water Balance for the Eastern Shore of Virginia
Recharge to the Yorktown-Eastover Aquifer

Recharge Rate Calculations:

Derived Equation:
Recharge (R) = [8 T h] ÷ [L^2 - 4 x^2]

Transmissivity (T) in ft2/day
Head (h) in feet (at ground water divide)
x = 0 in all cases (at ground water divide)
Width of peninsula (L) in feet

Recharge values (below) in feet per year

For peninsula width of *4* *miles*

	T = *500*	T = *1000*	T = *2000*	T = *3000*	T = *4000*	T = *5000*
h = *15*	0.05	0.10	0.20	0.29	0.39	0.49
h = *18*	0.06	0.12	0.24	0.35	0.47	0.59
h = *20*	0.07	0.13	0.26	0.39	0.52	0.65
h = *22*	0.07	0.14	0.29	0.43	0.58	0.72
h = *24*	0.08	0.16	0.31	0.47	0.63	0.79
h = *26*	0.09	0.17	0.34	0.51	0.68	0.85
Average R =	0.07	0.14	0.27	0.41	0.55	0.68
Overall Average R =	**0.29**	*feet per year*				

For peninsula width of *6* *miles*

	T = *500*	T = *1000*	T = *2000*	T = *3000*	T = *4000*	T = *5000*
h = *15*	0.02	0.04	0.09	0.13	0.17	0.22
h = *18*	0.03	0.05	0.10	0.16	0.21	0.26
h = *20*	0.03	0.06	0.12	0.17	0.23	0.29
h = *22*	0.03	0.06	0.13	0.19	0.26	0.32
h = *24*	0.03	0.07	0.14	0.21	0.28	0.35
h = *26*	0.04	0.08	0.15	0.23	0.30	0.38
Average R =	0.03	0.06	0.12	0.18	0.24	0.30
Overall Average R =	**0.13**	*feet per year*				

For peninsula width of *8* *miles*

	T = *500*	T = *1000*	T = *2000*	T = *3000*	T = *4000*	T = *5000*
h = *15*	0.01	0.02	0.05	0.07	0.10	0.12
h = *18*	0.01	0.03	0.06	0.09	0.12	0.15
h = *20*	0.02	0.03	0.07	0.10	0.13	0.16
h = *22*	0.02	0.04	0.07	0.11	0.14	0.18
h = *24*	0.02	0.04	0.08	0.12	0.16	0.20
h = *26*	0.02	0.04	0.09	0.13	0.17	0.21
Average R =	0.02	0.03	0.07	0.10	0.14	0.17
Overall Average R =	**0.07**	*feet per year*				

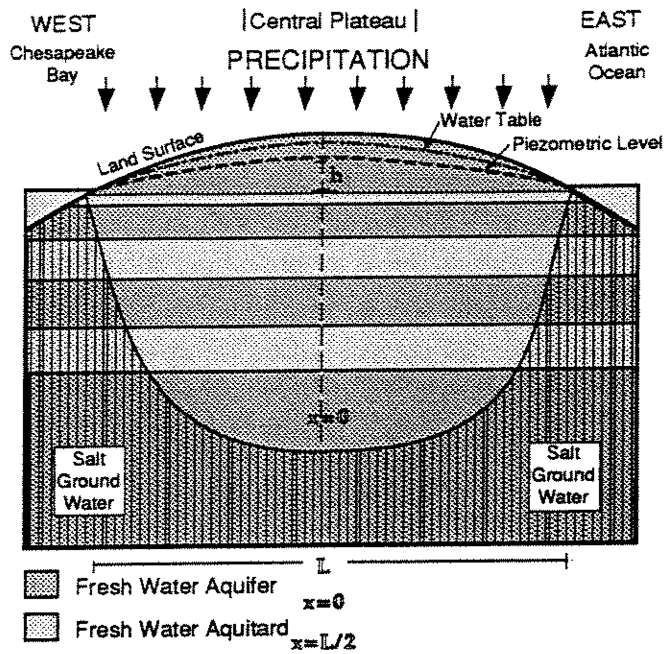
Table E-4: Recharge Calculations for the Yorktown-Eastover Aquifer

Volumetric Recharge Calculations
(All figures in million gallons per day)

Recharge Rate (feet/year)	*Area for Recharge (mi2) 100*	*Area for Recharge (mi2) 150*	*Area for Recharge (mi2) 200*	*Area for Recharge (mi2) 300*	*Area for Recharge (mi2) 400*
0.05	3	4	6	9	11
0.10	6	9	11	17	23
0.20	11	17	23	34	46
0.30	17	26	34	51	69
0.40	23	34	46	69	91
0.50	29	43	57	86	114
0.60	34	51	69	103	137

Comparison of Water Usage on the Eastern Shore with Recharge Volumes
Area of confining layer receiving recharge = 200 square miles
Variable recharge rates
(All figures in million gallons per day)

	Year 1985	*Year 1986*	*Year 1987*	*Year 1988*	*Year 1989*	*Year 1990*	*Permitted Amount*
Public Sources:	1.243	1.264	1.259	1.241	1.415	1.114	4.462
Industrial Sources:	3.412	3.052	3.157	3.064	3.433	3.430	11.143
Total Withdrawals:	4.655	4.316	4.417	4.306	4.848	4.544	15.604
Recharge							
at 0.05 ft/yr	6	6	6	6	6	6	6
Excess or Deficit:	1.1	1.4	1.3	1.4	0.9	1.2	-9.9
at 0.10 ft/yr	11	11	11	11	11	11	11
Excess or Deficit:	6.8	7.1	7.0	7.1	6.6	6.9	-4.2
at 0.20 ft/yr	23	23	23	23	23	23	23
Excess or Deficit:	18.2	18.5	18.4	18.5	18.0	18.3	7.2
at 0.30 ft/yr	34	34	34	34	34	34	34
Excess or Deficit:	29.6	30.0	29.9	30.0	29.4	29.7	18.7
at 0.40 ft/yr	46	46	46	46	46	46	46
Excess or Deficit:	41.1	41.4	41.3	41.4	40.9	41.2	30.1
at 0.50 ft/yr	57	57	57	57	57	57	57
Excess or Deficit:	52.5	52.8	52.7	52.8	52.3	52.6	41.5
at 0.60 ft/yr	69	69	69	69	69	69	69
Excess or Deficit:	63.9	64.2	64.1	64.3	63.7	64.0	53.0



The governing differential equation for steady state flow in one dimension is:

$$d^2h/dx^2 = -w/T. \quad (1)$$

where

h = the hydraulic head of the Yorktown-Eastover aquifer,
x = the lateral distance from the center spine of the peninsula (always positive),
w = the recharge rate of the Yorktown-Eastover aquifer,
T = the transmissivity of the Yorktown-Eastover aquifer, and
L = width of the peninsula.

Integrating once, the equation becomes

$$dh/dx = (-w/T)x + C_1. \quad (2)$$

At the ground water divide, x = 0 and dh/dx = 0. Substituting these values into equation (2) results in the following equation, upon which the constant C_1 can be solved for:

$$0 = -w/T(0) + C_1$$

$$\therefore\ C_1 = 0.$$

Integrating again, the equation becomes

$$h = (-w/2T)x^2 + C_1x + C_2. \quad (3)$$

BUILDOUT NITROGEN LOADING CALCULATIONS

APPENDIX F

Table F-1: WPA (A) Future Nitrogen Loading Calculations

NITROGEN LOADING CALCULATIONS
WPA A Future (spine only, all soils)

INPUT FACTORS

Number of Residential units	579
Sewage flow per house (gal/day)	165
Commercial/Industrial land (acres)	60
Com./Ind. sewage flow per acre	423
N-conc. in sewage effluent (mg/l)	40
Lawn area per house (square feet)	5,000
Pavement per house (square feet)	500
Road area (square feet)	1,481,040
Roof area per house (square feet)	1,500
Agricultural area (acres)	2,359
Landfills (acres)	0
Septage lagoons (gallons/yr)	0
Septage N concentration (mg/l)	45
Animal burial (lbs /yr)	222,081
Total recharge area (acres)	3,417
Recharge rate for pervious area (in/yr)	17
Recharge rate for impervious area (in/yr)	34

INPUT	CALCULATIONS	RESULTS
Sewage (gal/day)		CALCULATED LOADING (LBS/YR)
120,915	x N-conc (mg/l) x 3.785 l/gal x 365 days/yr : 454000 mg/lb	14,718
Lawn area (sq ft)		
2,895,000	x 0.0009 lb N/sq ft	2,606
Pavement area (sq ft)		
1,770,540	x 0.00031 lb N/sq ft	549
Roof area (sq ft)		
868,500	x 0.00015 lb N/sq ft	130
Natural area (acres)		
871	x 43560 sq ft/acre x 0.000005 lb N/sq ft	190
Other Sources		
Agriculture (acres)		
2,359	x 89 lbs N/acre/yr x 25% leaching rate	52,482
Landfills (acres)		
0	1184 lbs N/acre/year	0
Septage Lagoons (gal/year)		
0	x N-conc (mg/l) x 3.785 l/gal: 454000 mg/lb	0
Animal burial (lbs/year)		
222,081	x 3.3 % N concentration	7,329
	TOTAL NITROGEN LOADING (LBS/YR)	78,003
		TOTAL RECHARGE (MG/YR)
Recharge from sew/septage (gal/day)		
120,915	x 365 days/yr : 1,000,000 gal/million gal	44
Total pervious area (sq ft)		
144,898,680	x 17 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	1,535
Total impervious area (sq ft)		
3,945,840	x 34 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	84
	TOTAL RECHARGE (MGAL/YR)	1,663
TOTAL NITROGEN LOAD/TOTAL RECHARGE X 454,000 MG/LB : 3,785,000 L/MGAL		
	=RECHARGE NITROGEN CONCENTRATION (mg/l or ppm)	5.6

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NITROGEN LOADING CALCULATIONS
WPA A Future (spine only, Arapahoe soils considered undevelopable)

INPUT FACTORS

Number of Residential units	27
Sewage flow per house (gal/day)	165
Commercial/Industrial land (acres)	60
Com./Ind. sewage flow per acre (gal/day)	423
N-conc. in sewage effluent (mg/l)	40
Lawn area per house (square feet)	5,000
Pavement per house (square feet)	500
Road area (square feet)	1,481,040
Roof area per house (square feet)	1,500
Agricultural area (acres)	2,819
Landfills (acres)	0
Septage lagoons (gallons/yr)	0
Septage N concentration (mg/l)	45
Animal burial (lbs /yr)	222,081
Total recharge area (acres)	3,417
Recharge rate for pervious area (in/yr)	17
Recharge rate for impervious area (in/yr)	34

INPUT	CALCULATIONS	RESULTS
Sewage (gal/day)		CALCULATED LOADING (LBS/YR)
29,835	x N-conc (mg/l) x 3.785 l/gal x 365 days/yr : 454000 mg/lb	3,632
Lawn area (sq ft)		
135,000	x 0.0009 lb N/sq ft	122
Pavement area (sq ft)		
1,494,540	x 0.00042 lb N/sq ft	628
Roof area (sq ft)		
40,500	x 0.00015 lb N/sq ft	6
Natural area (acres)		
499	x 43560 sq ft/acre x 0.000005 lb N/sq ft	109
Other Sources		
Agriculture (acres)		
2,819	x 89 lbs N/acre/yr *25 % leach	62,733
Landfills (acres)		
0	1184 lbs N/acre/year	0
Septage Lagoons (gal/year)		
0	x N-conc (mg/l) x 3.785 l/gal: 454000 mg/lb	0
Animal burial (lbs/year)		
222,081	x 3.3 % N concentration	7,329
	TOTAL NITROGEN LOADING (LBS/YR)	74,557
		TOTAL RECHARGE (MG/YR)
Recharge from sew/septage (gal/day)		
29,835	x 365 days/yr : 1,000,000 gal/million gal	11
Total pervious area (sq ft)		
146,002,680	x 17 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	1,547
Total impervious area (sq ft)		
2,841,840	x 34 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	60
	TOTAL RECHARGE (MGAL/YR)	1,618
TOTAL NITROGEN LOAD/TOTAL RECHARGE X 454,000 MG/LB : 3,785,000 L/MGAL		
	=RECHARGE NITROGEN CONCENTRATION (mg/l or ppm)	5.5

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NITROGEN LOADING CALCULATIONS
WPA B Future (spine only, all soils)

INPUT FACTORS

Number of Residential units	1,236
Sewage flow per house (gal/day)	165
Commercial/Industrial land (acres)	692
Com./Ind. sewage flow per acre (gal/day)	423
N-conc. in sewage effluent (mg/l)	40
Lawn area per house (square feet)	5,000
Pavement per house (square feet)	500
Road area (square feet)	2,134,440
Roof area per house (square feet)	1,500
Agricultural area (acres)	2,334
Landfills (acres)	150
Septage lagoons (gallons/yr)	450,000
Septage N concentration (mg/l)	45
Animal burial (lbs /yr)	319,449
Total recharge area (acres)	4,915
Recharge rate for pervious area (in/yr)	17
Recharge rate for impervious area (in/yr)	34

INPUT	CALCULATIONS	RESULTS
Sewage (gal/day)		CALCULATED LOADING (LBS/YR)
496,656	x N-conc (mg/l) x 3.785 l/gal x 365 days/yr : 454000 mg/lb	60,453
Lawn area (sq ft)		
6,180,000	x 0.0009 lb N/sq ft	5,562
Pavement area (sq ft)		
2,752,440	x 0.00042 lb N/sq ft	1,156
Roof area (sq ft)		
1,854,000	x 0.00015 lb N/sq ft	278
Natural area (acres)		
1,492	x 43560 sq ft/acre x 0.000005 lb N/sq ft	325
Other Sources		
Agriculture (acres)		
2,334	x 89 lbs N/acre/yr * 25 % leach	51,934
Landfills (acres)		
150	1184 lbs N/acre/year	177,126
Septage Lagoons (gal/year)		
450,000	x N-conc (mg/l) x 3.785 l/gal: 454000 mg/lb	244
Animal burial (lbs/year)		
319,449	x 3.3 % N concentration	10,542
	TOTAL NITROGEN LOADING (LBS/YR)	307,620
		TOTAL RECHARGE (MG/YR)
Recharge from sew/septage (gal/day)		
496,656	x 365 days/yr : 1,000,000 gal/million gal	182
Total pervious area (sq ft)		
187,902,624	x 17 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	1,991
Total impervious area (sq ft)		
26,194,776	x 34 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	555
	TOTAL RECHARGE (MGAL/YR)	2,728
TOTAL NITROGEN LOAD/TOTAL RECHARGE X 454,000 MG/LB : 3,785,000 L/MGAL		
	=RECHARGE NITROGEN CONCENTRATION (mg/l or ppm)	13.5

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NITROGEN LOADING CALCULATIONS
WPA B Future (spine only, Arapahoe soils considered undevelopable)

INPUT FACTORS

Number of Residential units	1,211
Sewage flow per house (gal/day)	165
Commercial/Industrial land (acres)	692
Com./Ind. sewage flow per acre (gal/day)	423
N-conc. in sewage effluent (mg/l)	40
Lawn area per house (square feet)	5,000
Pavement per house (square feet)	500
Road area (square feet)	2,134,440
Roof area per house (square feet)	1,500
Agricultural area (acres)	2,355
Landfills (acres)	150
Septage lagoons (gallons/yr)	450,000
Septage N concentration (mg/l)	45
Animal burial (lbs /yr)	319,449
Total recharge area (acres)	4,915
Recharge rate for pervious area (in/yr)	17
Recharge rate for impervious area (in/yr)	34

INPUT	CALCULATIONS	RESULTS
Sewage (gal/day)		CALCULATED LOADING (LBS/YR)
492,531	x N-conc (mg/l) x 3.785 l/gal x 365 days/yr : 454000 mg/lb	59,951
Lawn area (sq ft)		
6,055,000	x 0.0009 lb N/sq ft	5,450
Pavement area (sq ft)		
2,739,940	x 0.00042 lb N/sq ft	1,151
Roof area (sq ft)		
1,816,500	x 0.00015 lb N/sq ft	272
Natural area (acres)		
1,474	x 43560 sq ft/acre x 0.000005 lb N/sq ft	321
Other Sources		
Agriculture (acres)		
2,355	x 89 lbs N/acre/yr * 25 % leach	52,407
Landfills (acres)		
150	1184 lbs N/acre/year	177,126
Septage Lagoons (gal/year)		
450,000	x N-conc (mg/l) x 3.785 l/gal: 454000 mg/lb	244
Animal burial (lbs/year)		
319,449	x 3.3 % N concentration	10,542
	TOTAL NITROGEN LOADING (LBS/YR)	307,463
		TOTAL RECHARGE (MG/YR)
Recharge from sew/septage (gal/day)		
492,531	x 365 days/yr : 1,000,000 gal/million gal	180
Total pervious area (sq ft)		
187,952,624	x 17 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	1,992
Total impervious area (sq ft)		
26,144,776	x 34 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	554
	TOTAL RECHARGE (MGAL/YR)	2,726
TOTAL NITROGEN LOAD/TOTAL RECHARGE X 454,000 MG/LB : 3,785,000 L/MGAL		
	=RECHARGE NITROGEN CONCENTRATION (mg/l or ppm)	13.5

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NITROGEN LOADING CALCULATIONS
WPA C Future (spine only, all soils)

INPUT FACTORS

Number of Residential units	10,157
Sewage flow per house (gal/day)	165
Commercial/Industrial land (acres)	1,064
Com./Ind. sewage flow per acre (gal/day)	423
N-conc. in sewage effluent (mg/l)	40
Lawn area per house (square feet)	5,000
Pavement per house (square feet)	500
Road area (square feet)	4,138,200
Roof area per house (square feet)	1,500
Agricultural area (acres)	2,629
Landfills (acres)	0
Septage lagoons (gallons/yr)	0
Septage N concentration (mg/l)	45
Animal burial (lbs /yr)	618,024
Total recharge area (acres)	9,509
Recharge rate for pervious area (in/yr)	17
Recharge rate for impervious area (in/yr)	34

INPUT	CALCULATIONS	RESULTS
Sewage (gal/day)		CALCULATED LOADING (LBS/YR)
2,125,977	x N-conc (mg/l) x 3.785 l/gal x 365 days/yr : 454000 mg/lb	258,774
Lawn area (sq ft)		
50,785,000	x 0.0009 lb N/sq ft	45,707
Pavement area (sq ft)		
9,216,700	x 0.00042 lb N/sq ft	3,871
Roof area (sq ft)		
15,235,500	x 0.00015 lb N/sq ft	2,285
Natural area (acres)		
4,089	x 43560 sq ft/acre x 0.000005 lb N/sq ft	891
Other Sources		
Agriculture (acres)		
2,629	x 89 lbs N/acre * 25 % leach	58,496
Landfills (acres)		
0	1184 lbs N/acre/year	0
Septage Lagoons (gal/year)		
0	x N-conc (mg/l) x 3.785 l/gal: 454000 mg/lb	0
Animal burial (lbs/year)		
618,024	x 3.3 % N concentration	20,395
	TOTAL NITROGEN LOADING (LBS/YR)	390,419
		TOTAL RECHARGE (MG/YR)
Recharge from sew/septage (gal/day)		
2,125,977	x 365 days/yr : 1,000,000 gal/million gal	776
Total pervious area (sq ft)		
366,585,920	x 17 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	3,885
Total impervious area (sq ft)		
47,626,120	x 34 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	1,009
	TOTAL RECHARGE (MGAL/YR)	5,670
TOTAL NITROGEN LOAD/TOTAL RECHARGE X 454,000 MG/LB : 3,785,000 L/MGAL		
	=RECHARGE NITROGEN CONCENTRATION (mg/l or ppm)	8.3

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NITROGEN LOADING CALCULATIONS
WPA D Future (spine only, all soils)

INPUT FACTORS

Number of Residential units	12,296
Sewage flow per house (gal/day)	165
Commercial/Industrial land (acres)	525
Com./Ind. sewage flow per acre (gal/day)	423
N-conc. in sewage effluent (mg/l)	40
Lawn area per house (square feet)	5,000
Pavement per house (square feet)	500
Road area (square feet)	4,530,240
Roof area per house (square feet)	1,500
Agricultural area (acres)	1,673
Landfills (acres)	0
Septage lagoons (gallons/yr)	0
Septage N concentration (mg/l)	45
Animal burial (lbs /yr)	677,946
Total recharge area (acres)	10,431
Recharge rate for pervious area (in/yr)	17
Recharge rate for impervious area (in/yr)	34

INPUT	CALCULATIONS	RESULTS
Sewage (gal/day)		CALCULATED LOADING (LBS/YR)
2,250,915	x N-conc (mg/l) x 3.785 l/gal x 365 days/yr : 454000 mg/lb	273,982
Lawn area (sq ft)		
61,480,000	x 0.0009 lb N/sq ft	55,332
Pavement area (sq ft)		
10,678,240	x 0.00042 lb N/sq ft	4,485
Roof area (sq ft)		
18,444,000	x 0.00015 lb N/sq ft	2,767
Natural area (acres)		
6,153	x 43560 sq ft/acre x 0.000005 lb N/sq ft	1,340
Other Sources		
Agriculture (acres)		
1,673	x 84 lbs N/acre x 25 % leach	35,129
Landfills (acres)		
0	1184 lbs N/acre/year	0
Septage Lagoons (gal/year)		
0	x N-conc (mg/l) x 3.785 l/gal: 454000 mg/lb	0
Animal burial (lbs/year)		
677,946	x 3.3 % N concentration	22,372
	TOTAL NITROGEN LOADING (LBS/YR)	395,407
		TOTAL RECHARGE (MG/YR)
Recharge from sew/septage (gal/day)		
2,250,915	x 365 days/yr : 1,000,000 gal/million gal	822
Total pervious area (sq ft)		
413,817,620	x 17 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	4,385
Total impervious area (sq ft)		
40,556,740	x 34 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	860
	TOTAL RECHARGE (MGAL/YR)	6,066
TOTAL NITROGEN LOAD/TOTAL RECHARGE X 454,000 MG/LB : 3,785,000 L/MGAL		
	=RECHARGE NITROGEN CONCENTRATION (mg/l or ppm)	7.8

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NITROGEN LOADING CALCULATIONS
WPA E Future (spine only, all soils)

INPUT FACTORS

Number of Residential units	13,409
Sewage flow per house (gal/day)	165
Commercial/Industrial land (acres)	239
Com./Ind. sewage flow per acre (gal/day)	423
N-conc. in sewage effluent (mg/l)	40
Lawn area per house (square feet)	5,000
Pavement per house (square feet)	500
Road area (square feet)	4,704,480
Roof area per house (square feet)	1,500
Agricultural area (acres)	728
Landfills (acres)	0
Septage lagoons (gallons/yr)	0
Septage N concentration (mg/l)	45
Animal burial (lbs /yr)	0
Total recharge area (acres)	10,796
Recharge rate for pervious area (in/yr)	17
Recharge rate for impervious area (in/yr)	34

INPUT	CALCULATIONS	RESULTS
Sewage (gal/day)		CALCULATED LOADING (LBS/YR)
2,313,582	x N-conc (mg/l) x 3.785 l/gal x 365 days/yr : 454000 mg/lb	281,610
Lawn area (sq ft)		
67,045,000	x 0.0009 lb N/sq ft	60,341
Pavement area (sq ft)		
11,408,980	x 0.00042 lb N/sq ft	4,792
Roof area (sq ft)		
20,113,500	x 0.00015 lb N/sq ft	3,017
Natural area (acres)		
7,567	x 43560 sq ft/acre x 0.000005 lb N/sq ft	1,648
Other Sources		
Agriculture (acres)		
728	x 79 lbs N/acre x 25 % leach	14,370
Landfills (acres)		
0	1184 lbs N/acre/year	0
Septage Lagoons (gal/year)		
0	x N-conc (mg/l) x 3.785 l/gal: 454000 mg/lb	0
Animal burial (lbs/year)		
0	x 3.3 % N concentration	0
	TOTAL NITROGEN LOADING (LBS/YR)	365,777
		TOTAL RECHARGE (MG/YR)
Recharge from sew/septage (gal/day)		
2,313,582	x 365 days/yr : 1,000,000 gal/million gal	844
Total pervious area (sq ft)		
433,545,860	x 17 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	4,594
Total impervious area (sq ft)		
36,727,900	x 34 in/yr /12 in/ft x 7.48 gal/cu ft : 1,000,000 gal/million gal	778
	TOTAL RECHARGE (MGAL/YR)	6,217
TOTAL NITROGEN LOAD/TOTAL RECHARGE X 454,000 MG/LB : 3,785,000 L/MGAL		
	=RECHARGE NITROGEN CONCENTRATION (mg/l or ppm)	7.1

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APPENDIX G

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