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.

General Applicability to the Eastern Shore of Virginia

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.

For More Information

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.

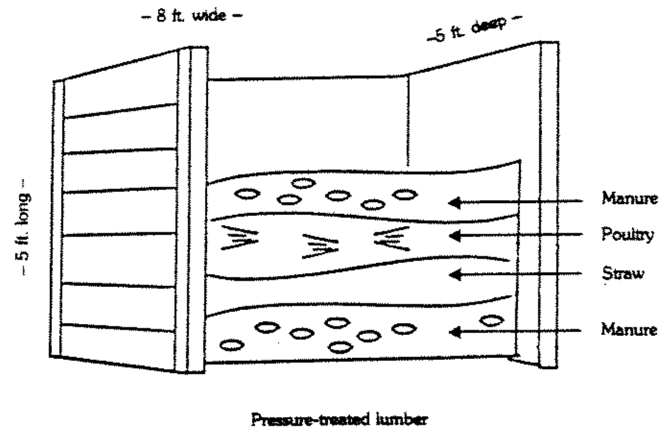
Dr. Dennis Murphy, a member of the faculty at the Department of Poultry Science at University of Maryland at College Park, has developed a method for disposing of dead poultry by composting. The idea of composting is itself not a new idea, but Dr. Murphy has applied it to the poultry industry such that 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.

General Applicability to the Eastern Shore of Virginia

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.

For More Information

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
Dr. Art Gold, Department of Natural Resources, University of Rhode Island, Narragansett, Rhode Island, (401) 792-2903.

EPA Guidance Manual for States to Use Volunteer Monitoring.

CONCLUSIONS OF THE REPORT

10

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.