NORTH KINGSTOWN
GROUNDWATER PROTECTION PLAN

ACKNOWLEDGEMENTS

This Groundwater Protection Plan was prepared with the help of many people committed to protecting the groundwater resources of North Kingstown.

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North Kingstown Groundwater Protection Plan

EXECUTIVE SUMMARY

The Town of North Kingstown is entirely dependent on groundwater resources for its water supply needs. Protection of this valuable resource and specifically the prevention of groundwater contamination is critical to the long-term public health and welfare of North Kingstown's residents, business and institutions. In June, 1988, the North Kingstown Town Council duly constituted a Groundwater Committee and charged the Committee with developing a plan to protect the Town drinking water resources. The following is a summary of the recommended actions that are embodied in the comprehensive Groundwater Protection Plan.

FINDINGS

1. The Town of North Kingstown is underlain by all or portions of four major sand and gravel aquifers. They are named the Hunt, Annaquatucket, Pettaquamscutt and Chipuxet. These aquifers provide the sole source for the public water supply.

2. The Town currently utilizes three aquifers to supply ten (10) municipal public wells. Other water suppliers also draw from the aquifers.

3. The quality of the North Kingstown water supply is generally very good. Steps should be implemented now to prevent water quality degradation.

4. Groundwater resources in North Kingstown are vulnerable to contamination from a wide range of potential pollution sources. To prevent and rectify pollution associated with these sources, a mix of protection strategies and management techniques are required.

5. The existing aquifer overlay ordinance provides an important measure of protection to three of the Town's major aquifers and the prohibitions in the ordinance should be continued. The Chipuxet Aquifer which is not included in the current overlay provisions is not provided such protection.

6. Effective protection of the Town's vital groundwater resources will require regional cooperation with adjacent municipalities and water suppliers as well as enhanced coordination with state and federal agencies and other entities.

7. Due to the high costs and technical difficulties of groundwater clean-ups, protection efforts must emphasize the prevention of groundwater contamination from both existing and new land use activities.

8. A high priority should be placed on protecting areas designated as wellhead protection areas (WHPAs). These areas consist of the portions of the aquifer which most directly contribute to the Town's water supply.

9. Public education should play a significant role in protection efforts as it may often be the most cost effective means of controlling certain activities which pose potential risks.

RECOMMENDATIONS FOR ACTION

The Groundwater Protection Plan includes numerous recommendations that when implemented will foster the protection of the Town's drinking water supplies. The recommendations are organized, in part, on a pollution source basis. The Groundwater Committee, following various discussions, recommends that the following five actions be given the highest priority for implementation by the Town:

1. Wellhead Delineation. Wellhead protection delineation studies, which have been initiated or planned, should be completed. The results of the studies will provide a basis for further amendments to the aquifer overlay zoning provisions.

2. Land Use Ordinances/Regulations. The list of prohibitions currently in the groundwater ordinance should continue to be used. The ordinance should be expanded to include the Chipuxet recharge area. In conjunction with the other recommendations, the zoning ordinance should be revised to incorporate specific performance criteria for potentially polluting land uses; and the subdivision regulations should be revised to clarify submission requirements and include standards to ensure that the groundwater impacts of a project are adequately assessed and addressed.

3. Underground Storage Tanks (USTs). Information on Town tanks should be centralized to ensure all sites are properly monitored for leaks. A capital improvement program, that provides funds to upgrade tanks, should be instituted in the budget process. New tanks purchased by the Town should provide for secondary containment, e.g. be double-walled. Homeowners should be encouraged via public education and other means, to properly maintain and replace homeowner USTs.

4. Septic Systems/Wastewater Management. The Town should promote proper maintenance of septic systems through public education and explore the establishment of wastewater management district(s). To prevent nitrate contamination, zoning in the aquifer recharge area should provide for a 2 acre density in residential zones. Zoning and subdivision regulation should be revised to include a

minimum 150 foot setback from waterbodies and wetlands; exclude wetlands from density calculations; and restrict large systems as well as the clustering of systems or mounded (filled) systems in wellhead protection areas.

5. Public Education. Public education in the community rather than regulations should be utilized to change the actions of individuals which may pose potential threats . For example, homeowners need to be made aware of proper septic system maintenance, means to minimize household hazardous waste and how to properly apply fertilizers and pesticides. Businesses and others need to be educated as to the proper handling, storage, and disposal of hazardous materials, proper spill prevention and response, and best management practices to reduce nonpoint pollution, such as stormwater runoff.

ADDITIONAL PRIORITIES

The Groundwater Committee has also ranked the following recommendations as high priorities. They are listed in no particular order.

6. Commercial/Industrial Discharges to Groundwater. Zoning should prohibit new discharges to groundwater via the aquifer overlay provisions. Existing discharges should be properly monitored and eliminated where possible.

7. Monitoring Program. The Town should compile and organize groundwater quality data as well as other information on pollution sources so that the data can be used to evaluate protection efforts and provide for early detection of potential pollution problems.

8. Regional Involvement. North Kingstown planning and water department staff should continue participation in regional initiatives pertaining to the Hunt and Chipuxet Aquifers.

9. Hazardous Materials Planning. The Hazardous Materials Emergency Response Plan should be developed to identify locations in which spill events would seriously jeopardize the Town's wellfields and to propose mitigative measures to minimize the risks posed by such spills.

10. Land Acquisition. The acquisition of land in the aquifer areas although one of the most expensive options offers the most protection. In addition, it will likely be the only means of acquiring new well sites.

Finally, it is recommended that the Town Council modify the charge to the Groundwater Committee and extend its term. The Committee has served a very valuable role for the past two years, and it should be continued to focus on the following areas:

a) providing oversight of on-going wellhead delineation studies,

b) providing guidance and oversight of implementation of the plan,

c) assisting in public education efforts,

d) further investigating implementation issues, including means of funding protection activities.

The Committee would be available to further assist in identifying which Town departments have responsibilities for implementing the recommendations and estimating the costs associated with specific actions. As proposed, the Groundwater Committee would meet on an as needed basis, but no less than quarterly during the year. With a new charge to the Committee focussed on implementation, there is an opportunity to recruit new members to serve.

In looking forward to the adoption and implementation of the Groundwater Protection Plan, the Groundwater Committee would like to gratefully acknowledge the leadership displayed by the Town Council, in particular as evidenced by its support of wellhead delineation and related groundwater protection efforts. Additionally the Committee wishes to acknowledge the cooperation of the various Town departments which contributed to the plan and most especially the expertise and insight which staff from the Water Department and Planning Department provided in developing the plan.

The Committee looks forward to continuing to work with all Town officials on enhancing the protection of the Town's vital groundwater resources.

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NORTH KINGSTOWN GROUNDWATER PROTECTION PLAN

I. ACKNOWLEDGEMENTS

The Plan that follows represents the collective effort of many committed to protecting the groundwater resources of North Kingstown. Particular credit is due to the North Kingstown Groundwater Committee who over the past two and a half years developed, with the assistance of the North Kingstown Department of Planning and Development and the Department of Water Supply, the North Kingstown Groundwater Protection Plan. Membership in the Groundwater Committee included:

Susan Kiernan, Chair
Frederick Schick, Jr., Vice Chair
Jack Bash (resigned)
Michael Desmond
Kevin Fetzer
Betty Givan
Steven Granger
James Kanes
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Everett Stuart
Florence Johnson, Town Council Member
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Samuel White

In addition, during the analysis of information and the preparation of the Plan, this effort was enhanced by the assistance of people like Margaret Bradley, Ernest Panciera and Terry Simpson along with Susan Kiernan of the RIDEM's Division of Groundwater; their help was invaluable to the Town.

Without question, our understanding of and education about was significantly furthered by the contributions of the United States Environmental Protection Agency (USEPA) Region I whose staff supported the Town's efforts through information dissemination, educational programs, and participation in this program. The preparation of the petition for the Hunt, Annaquatucket, Pettaquamscutt Sole Source Aquifer designated May, 1988, was accomplished through the encouragement of and the assistance of Region I staff such as Karen Wilson and Kim Franz. Karen Wilson in her capacity as the Region I Rhode Island Coordinator contributed immensely sharing her depth of knowledge. It was the Sole Source Aquifer designation that led the North Kingstown Planning Commission and the North Kingstown Town Council to better understand the need for long term protection of the Town's public water supply. Acknowledgement is also made of the contribution by

Douglas Heath who served as the lead in the joint Town-State-USEPA Wellhead Delineation Project in the Annaquatucket and shared his expertise with the Town. Melissa Paley at Region I through the development of the Power to Protect raised our collective consciousness about drinking water protection and allowed us to share with others the travails of a regional effort. And finally we acknowledge Robert Mendoza at Region I who gave freely of his staff's time and expertise to the benefit of North Kingstown.

II. INTRODUCTION

In June, 1988, the North Kingstown Town Council duly constituted a Groundwater Committee and charged the body with the responsibility of developing a plan for protecting the public drinking water supply of the Town. The Plan below represents the efforts of the Groundwater Committee, with the assistance of Town departments, other Town boards, and State and Federal agencies. In meeting the charge to develop a plan to protect Town drinking water resources, the Plan is intended to serve several objectives: to provide a rationale for the adoption of regulatory and non-regulatory protection programs; to meet the requirements of the Public Drinking Water Act of 1987 through the submittal of a water quality protection plan to the State Water Resources Board; and to meet the requirements of the state wellhead protection program. Additionally, the plan is intended for incorporation into the Natural Resources and Community Facilities sections of the North Kingstown Community Guide Plan and Hazardous Materials Emergency Response Plan both now in preparation. It is expected that when and as new technical information becomes available, this plan may be amended.

III. HISTORICAL BACKGROUND ON GROUNDWATER PROTECTION EFFORTS IN NORTH KINGSTOWN

The Town of North Kingstown is underlain by four major sand and gravel groundwater aquifers: The Hunt, Annaquatucket, Pettaquamscutt, and Chipuxet. The Town currently uses the Hunt, Annaquatucket, and Pettaquamscutt aquifers for its public drinking water supply. North Kingstown was at the forefront in groundwater protection when it adopted groundwater reservoir and groundwater recharge overlay districts for these three aquifers into its zoning ordinance in 1974. The districts were delineated based on transmissivity and saturated thickness as set out in the United States Geological Survey (USGS) Water Supply Paper #1775 for the Potowomut-Wickford area. Such delineation included lands upstream of public well sites within the drainage basins of the Hunt, Annaquatucket, and Pettaquamscutt Rivers. Permitted uses in the reservoir overlay district were limited to recreation, conservation, agriculture, and single-family residential units at a density of no greater than one unit per three acres. Uses in the recharge overlay district were limited to those of the underlying zone provided the discharge of "effluent into the ground meets the

chemical standards of the United States Environmental Protection Agency."

By 1987, the Town began to review the mapping upon which the zoning was based and investigate the effectiveness of the regulations in place. At least three factors led to a decision by the North Kingstown Town Council to direct the accomplishment of wellhead delineation studies for the four wellfield areas in which the Town's 10 wells are located. First, the Town's consciousness was raised by efforts to halt the expansion of a demolition debris landfill located within the Annaquatucket Recharge area but not adequately regulated by the Town's zoning ordinance.

Secondly, a growing awareness of the vulnerability of local groundwater resources, as well as a recognition of limited water supply alternatives, was one product of research conducted by North Kingstown along with the Town of East Greenwich. This research led to a successful petition to the United States Environmental Protection Agency (USEPA) for Sole Source Aquifer designation for the Hunt-Annaquatucket-Pettaquamscutt (HAP) Aquifer system (May, 1988).

Finally, Town planning officials recognized that new techniques, particularly wellhead delineation methods, were available for improving the designation of areas of contribution to water supply wells. With that in mind, the Town Council, at the request of the Planning Commission, created a Groundwater Committee to review information and studies available; and where necessary, the Committee was to call upon experts to assist in developing a Town groundwater protection plan.

IV. EXISTING TOWN WATER SYSTEM

The Town of North Kingstown comprises 58.3 square miles in south central Rhode Island. The current population of North Kingstown is approximately 24,000. The North Kingstown water system originated in 1939 and currently has 10 municipal wells serving 7,300 municipal connections with approximately 100 miles of pipe. Consumption has varied between 2.1 million gallons per day (mgd) and 7.3 mgd with an average of 3.0 mgd. Peak demand is required generally in July.

The water system has emergency connections with Kent County Water Authority (KCWA) and the water system operated by the Rhode Island Port Authority and Economic Development Corporation (RIPA) at the Quonset Point/Davisville Industrial Park. North Kingstown provides an average of .5 mgd as a seasonal (summer) supply of water to the Town of Narragansett. The North Kingstown Department of Water Supply, KCWA, and RIPA share the Hunt aquifer. KCWA has one well with the pumping capacity to withdraw 1.00 mgd. The RIPA has three wells with the total capacity to withdraw 4.30 mgd. The North Kingstown Department of Water Supply has the capacity to

withdraw 3.67 mgd from its three wells in the Hunt groundwater reservoir.

Figure 1 illustrates the general locations of the North Kingstown wells, water towers and transmission lines. A listing of the well sites and pumping stations follows.

FIGURE 1

NORTH KINGSTOWN PUBLIC WATER SERVICE

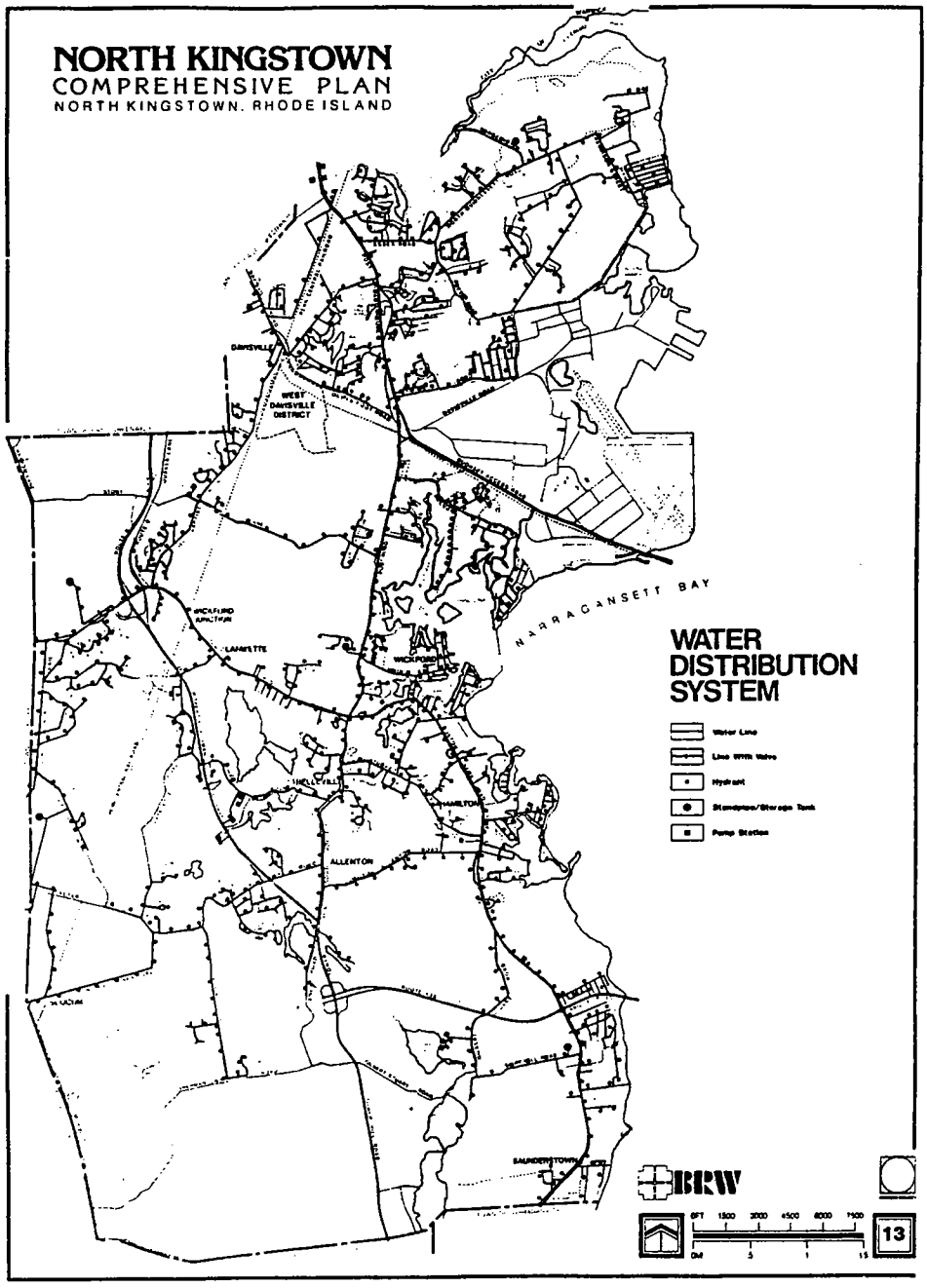


TABLE 1

Well Sites and Pumping Stations	Pumping Capacity (Gals per min.) (gpm)	Year Built/ Acquired
No. 1 - Oak Hill Road (Field Office)	700	1944
No. 2 - Oak Hill	700	1957
No. 3 - Carr Pond	250	1959
No. 4 - Secret Lake	700	1967
No. 5 - Kettle Hole	800	1969
No. 6 - Stony Lane	750	1979
No. 7 - Carr Pond	250	1982
No. 8 - Carr Pond	250	1982
No. 9 - Kent County (Warwick)	1,700	1983
No. 10 - Kent County (East Greenwich)	1,800	1983

V. HYDROGEOLOGIC BACKGROUND

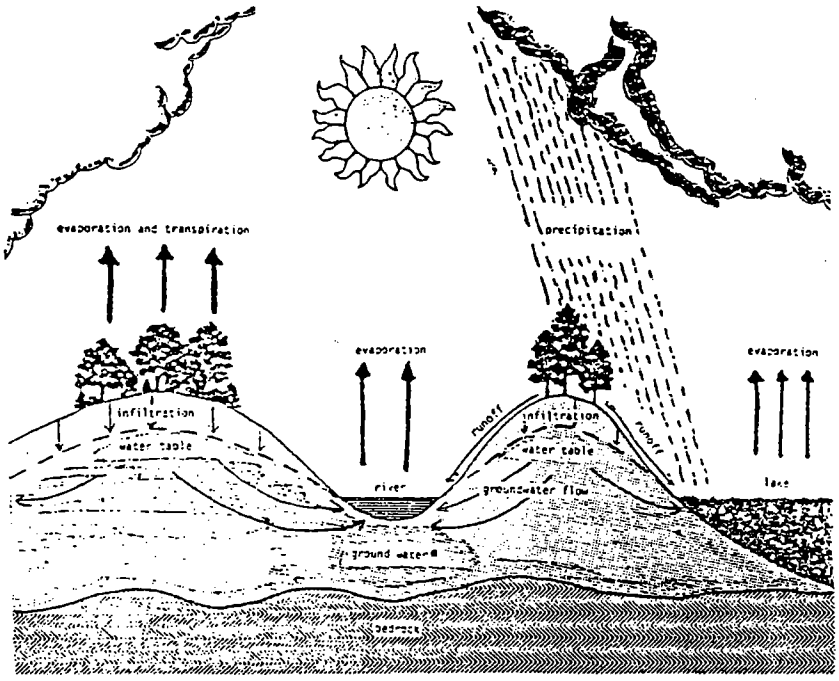
North Kingstown is entirely dependent upon sand and gravel aquifers for its public water supply. Devising an effective protection plan requires an understanding of hydrogeologic principles - or more simply, it is important to understand the movement of water into, through, and out of an aquifer.

A. HYDROLOGIC CYCLE

The natural movement of water in the environment is described by the hydrologic cycle. As pictured in Figure 2, it can be seen that the groundwater in aquifers is replenished by the infiltration of precipitation or runoff into soils and sediments. Groundwater will generally move from higher elevations to lower elevations. It typically flows to and discharges into a surface water body, such as a river, stream or lake. During dry periods, the water flowing into streams consists primarily of groundwater which has discharged to the surface. Thus, there is a hydraulic connection between surface water and the aquifer.

There is also a reverse effect: aquifers can be recharged by surface waters. This is often the result when wells are installed and pumped near streams or rivers. In such a case, the pumping action of the well may cause surface water to be pulled into the aquifer and ultimately drawn into the well. Known as "induced infiltration", this process also constitutes a hydraulic connection between the ground and surface water resources. Figure 4 which appears later in the text on page 12 illustrates induced infiltration. Protecting groundwater in an aquifer therefore also requires protecting the surface waters associated with that aquifer.

FIGURE 2
THE HYDROLOGIC CYCLE



Source: Connecticut DEP

B. GROUNDWATER RESERVOIRS AND RECHARGE AREAS

Aquifers are areas which yield a useful supply of groundwater. Portions of an aquifer particularly sand and gravel aquifers, will however, vary in their water supply potential. These differences may be described by the terms groundwater reservoir, recharge area, and upstream drainage area. For purposes of groundwater classification, the Rhode Island Department of Environmental Management (RIDEM) has mapped groundwater reservoirs, recharge areas, and upstream drainage areas to the groundwater reservoirs in North Kingstown.

Groundwater reservoirs generally represent the portion of an aquifer with the greatest water supply (yield) potential. These areas which are defined using hydrogeologic criteria, have been mapped by the state. All or portions of the four groundwater reservoirs of the Hunt, Annaquatucket, Pettaquamscutt, and the Chipuxet Aquifers lie within North Kingstown boundaries. All of the

Town municipal wells are located within groundwater reservoirs. Figure 3 shows North Kingstown groundwater reservoirs.

Associated with each groundwater reservoir is a recharge area. Recharge areas consist of the land which contributes water directly to the groundwater reservoir. The recharge area is extremely important in determining the quality of the aquifer and therefore, must be addressed in any groundwater protection plan.

Finally, due to the hydraulic connection with surface waters, it is important to recognize that each sand and gravel aquifer lies within a watershed or drainage basin. Land which drains upstream of an aquifer may still affect the groundwater by feeding streams which travel over the aquifer. Pollutants discharged upstream could be carried into the waters which feed an aquifer and any wells associated with it.

C. NORTH KINGSTOWN GROUNDWATER RESOURCES

The state of Rhode Island has identified and mapped 21 groundwater aquifers in RI. North Kingstown benefits from having four of these within its boundaries - Hunt, Annaquatucket, Pettaquamscutt, and Chipuxet (see Figure 3). Table 2 provides a summary of the characteristics of the four groundwater aquifer areas. The importance of protecting these resources was demonstrated in two separate petitions to the USEPA for Sole Source Aquifer designations.

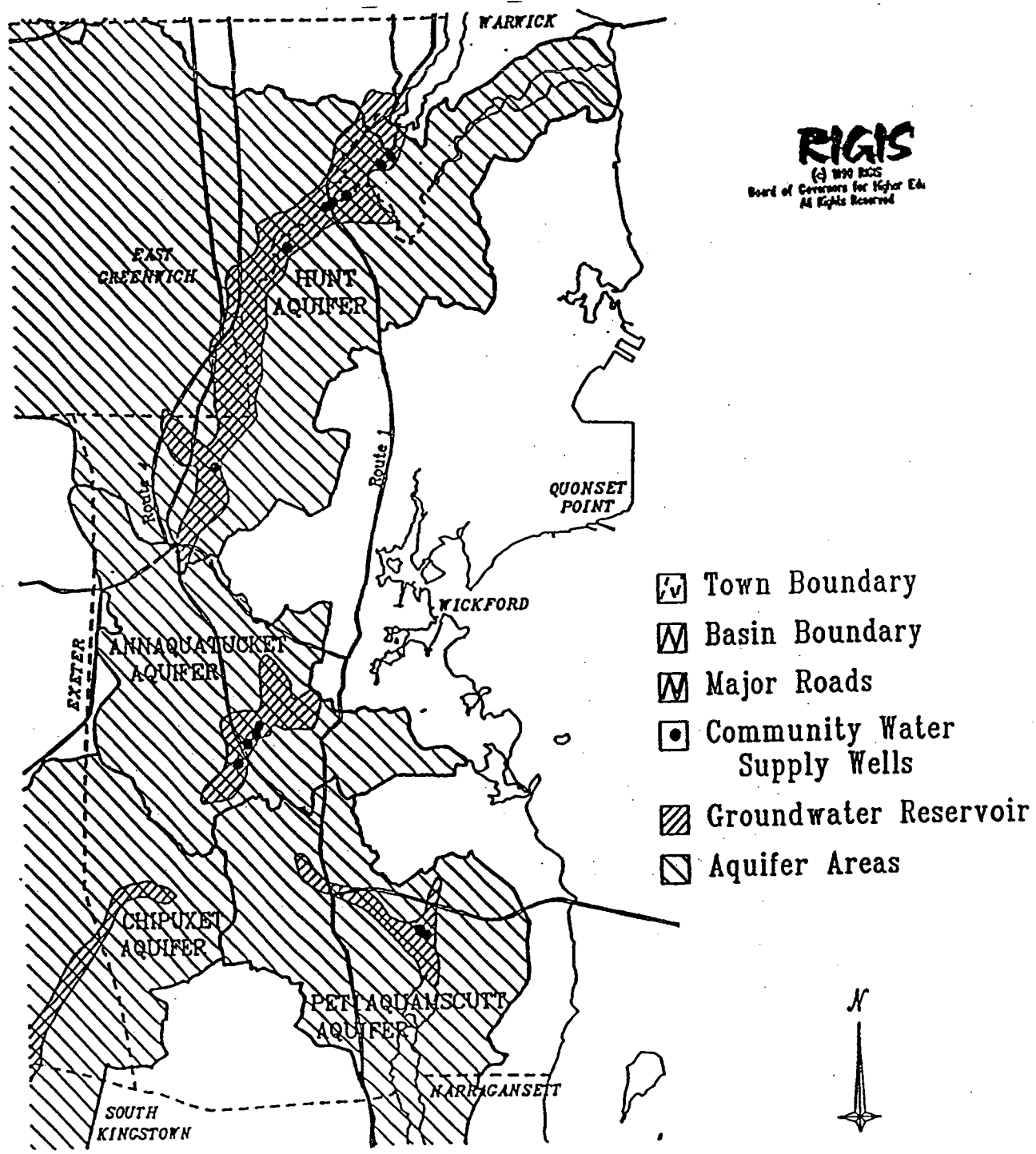
1. HUNT - ANNAQUATUCKET - PETTAQUAMSCUTT

The Hunt - Annaquatucket - Pettaquamscutt (HAP) is a designated sole source aquifer system that spans an area of over 60 square miles in North Kingstown, East Greenwich, Warwick, West Greenwich, and Exeter. The Hunt Aquifer reservoir includes an area beginning at the northern boundaries of North Kingstown, with East Greenwich and Warwick, moving south and west to its intersection with the Annaquatucket near Routes 102 and 2. The Annaquatucket extends south and west overlaying the portion of the Town west of Route 4 and east over Secret Lake. The Pettaquamscutt Aquifer extends from the Annaquatucket south and east including the Mattatuxet River and the lands that drain the watershed to Carr Pond.

The geologic materials underlying the HAP aquifer system consists primarily of sands and gravel. Portions of the aquifer system contain areas where stratified sand or gravel interspersed with very fine sand and silt is as much as 75 feet from the natural land surface to the water table.

In addition to the sands and gravel, the geology is also composed of areas of stratified sand or gravel interspersed with

FIGURE 3
NORTH KINGSTOWN GROUNDWATER RESOURCES



till; till areas, some mixed with clay; and bedrock. Only the stratified sand and gravel areas are sufficiently permeable to yield appreciable quantities for public supply purposes (Rosenshein et al, 1968).

a. HUNT

USGS Water Supply Paper #1775 reports that the Hunt reservoir contains a principal reservoir whose areas of highest transmissivity or capacity to transmit water are located at the intersection of the Hunt and Potowomut Rivers, approximately at the intersection of Post and Frenchtown Roads. This reservoir has a reported safe yield of 8.0 mgd.

The Town shares the principal reservoir of the Hunt Aquifer resource with the Kent County Water Authority (KCWA) and the Rhode Island Port Authority (RIPA). The KCWA has one well located in Warwick that has a pumping capacity of 1.0 mgd; this well is used primarily in the summer. The RIPA has 3 wells in this area, 2 in Warwick and one in East Greenwich near the intersection of the Hunt River and Frenchtown Brook. Each of these wells has a pumping capacity of 1.5 mgd for a total available draw of 4.5 mgd. The RIPA currently uses .8 mgd (personal communication William Harricos, RIPA, 3/14/91).

North Kingstown has 2 wells (#9 and #10) in this area, one in East Greenwich and one in Warwick, both with reported yields of 1.5 mgd. The combined potential withdrawal for this reservoir is 9.75 mgd based on well capacity. The fact that the pumping capacity exceeds the aquifer safe yield of 8.0 mgd indicates a need for a water supply management program.

Water Supply Paper #1775 also reports the availability of a secondary groundwater reservoir whose highest transmissivities are located in the area near the confluence of the Hunt River and Scrabbletown Brook. This secondary reservoir is reported to have a safe dry-weather yield of between 4.3 and 5 mgd depending upon the length of the dry period (150-100 days of drought). Well #6 is located in this secondary groundwater reservoir. Based on the pumping capacity of well #6 at 750 gpm, it appears that additional resource availability exists in this portion of the Hunt Aquifer.

Finally, the protection of these resources is complicated by the fact that the Hunt reservoir is located in three separate municipalities each with its individual land use regulations and governmental structure. A regional initiative to protect the Hunt Aquifer is described later.

b. ANNAQUATUCKET

The Annaquatucket Aquifer reservoir lies wholly within the Town of North Kingstown. Preliminary results of the wellhead

delineation study indicates a portion of the associated recharge area extends into the Town of Exeter. The Town presently has four wells in the Annaquatucket, three at the Oak Hill Road wellfield and one adjacent to Kettle Hole Pond. At the Oak Hill wellfield, well #1 receives induced infiltration from Oak Hill Brook and Wells #2 and #4 from Secret Lake. Induced infiltration from Kettle Hole Pond contributes to well #5.

Water Supply Paper #1775 indicates a total groundwater reservoir safe yield of 3.6 mgd. About half this total amount can be withdrawn by the existing pumping facilities, suggesting additional capacity for future use.

c. PETTAQUAMSCUTT

The Town currently has three wells in the Pettaquamscutt Aquifer (#3, #7, and #8). Only well #3 is operable; the use of wells #7 and #8 are dependent on securing easements over the lands that lie within the 400 foot radius of the wells. If fully operational, the three wells would have a pumping capacity of 750 gpm. Water Supply Paper #1775 reports a dry-weather safe yield of 1.3 mgd indicating additional capacity in the Pettaquamscutt reservoir.

The report, however, indicates that "extensive development is complicated" by 1) the location of the highest transmissivity and productivity directly below Carr Pond; and 2) the possibility of salt water intrusion from the Upper Pond of the Pettaquamscutt River from extensive pumping at the southern edge of the reservoir.

2. CHIPUXET

The Chipuxet Aquifer reservoir is a part of the Pawcatuck Sole Source Aquifer system (designated May, 1988). As mapped by the RIDEM, the Chipuxet reservoir extends into the western portion of North Kingstown, underlying fields currently used for turf growing. The aquifer is geologically composed of outwash deposits containing layers of sand and gravel of varying thicknesses (Water Supply Paper #1821).

Recent studies of the Chipuxet conducted by the USGS (Water Supply Paper 1821) have mathematically computed a safe withdrawal of 3.0 mgd from the reservoir. Both the University of Rhode Island and Kingston Water District have public water supply wells along the Chipuxet River in South Kingstown near the University of Rhode Island in Kingston. While North Kingstown does not currently use the Chipuxet Aquifer as a public water supply, water from the Chipuxet of an undetermined amount is withdrawn for turf irrigation purposes within the Town.

TABLE 2

SUMMARY OF AQUIFER CHARACTERISTICS

	HUNT	ANNAQUATUCKET	PETTAQUAMSCUTT	CHIPUXET
Estimated Safe Yield	8.0	3.6	1.3	3.0
Basin Area Size(sq.miles)	23.2	9	2.7	10
Range of Saturated Thickness	0-100+ feet	0-100+ feet	0-60+ feet	up to 150+ feet
Range of Transmissivity	up to 300,000 gpd/ft	up to 300,000 gpd/ft	up to 80,000 gpd/ft	up to 200,000 gpd/ft
Associated Surface Water Bodies	Hunt River	Secret Lake Oak Hill Brook Kettle Hole Pond	Carr Pond Pettaquamscutt Pond	Chipuxet River
Regional Issues	underlies 3 Towns			underlies 3 Towns

The table above indicates regional issues which require coordination among jurisdiction not only for aquifer protection but supply management as well. The lack of legal oversight over withdrawals which could include agricultural and industrial uses emphasizes this need. In addition, concerns about interbasin transfer of water further indicates the need for regional coordination.

3. UTILIZATION OF GROUNDWATER RESOURCES BY PRIVATE WELLS

Although a large portion of the Town is serviced by public water, there continues to be portions of the Town which rely on private wells. Typically, private wells are drilled into bedrock. Such wells may be located within or outside the aquifer areas described above. These groundwater dependent areas also need to be addressed in the protection plan.

While most private wells are associated with single family residential units, some private wells provide water to industrial and commercial land use activities which may qualify as non-community wells under RIDOH regulations. In addition the State Fish Hatchery, located on Hatchery Road, depends upon a private well.

D. WELLHEAD PROTECTION

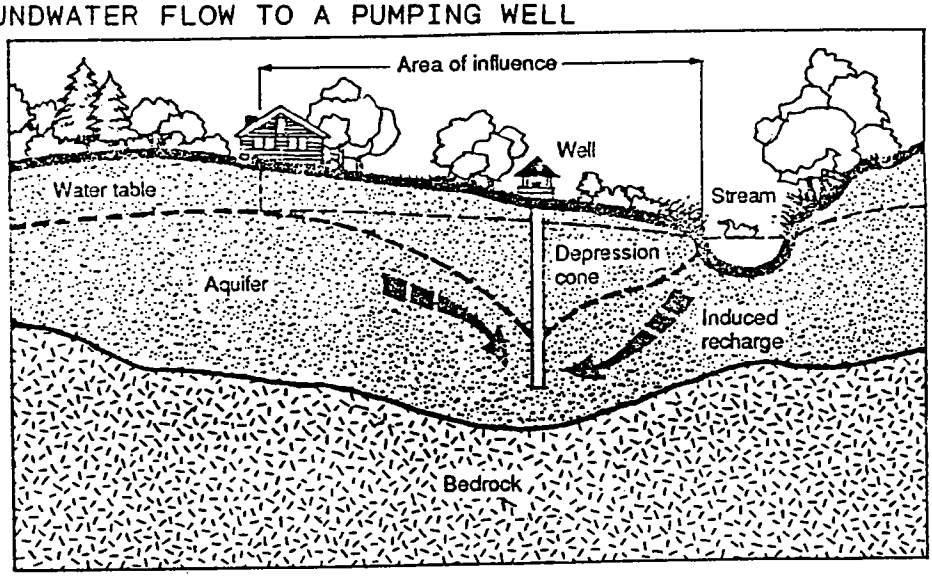
When a well is installed in an aquifer, the influence of pumping creates an area identified as a wellhead area or zone of contribution. A wellhead area represents the portion of an aquifer that directly contributes water to a well. Protecting such areas is critical to protecting water supplies. Figure 4 below depicts groundwater flow to a pumping well. Activities conducted on land in a wellhead area have the greatest potential to affect the water quality at the well. All pollution sources in a wellhead area should be eliminated where feasible or carefully and strictly managed in order to preserve the groundwater resource which supports the well.

FIGURE 4

GROUNDWATER FLOW TO A PUMPING WELL

WELLS: INDUCED RECHARGE (Infiltration)

The cone of depression from a pumping well may extend to a nearby stream or lake. This lowers the adjacent water table below the stream or lake level. As a result, the stream or lake begins to lose water to the adjacent groundwater aquifer in the vicinity of the well. This is known as **induced recharge**. Streams and wetlands have been completely dried up by induced recharge from well pumping.



Source: Massachusetts Audubon

1. STATE WELLHEAD PROTECTION PROGRAM

When the Safe Drinking Water Act (SDWA) was amended in 1986, the legislation required the development of state wellhead protection programs. The RIDEM received USEPA approval of the Rhode Island Wellhead Protection (WHP) Program in 1989. The goal of the WHP Program is to improve and foster the protection of public water supplies by identifying and better managing wellhead protection areas. The program relies on the coordination of state and local government, water suppliers, and the private sector for implementation. The emphasis will be on preventing contamination. Additional detail on the state WHP program requirements may be found in Appendix 1.

As applied in North Kingstown, the use of wellhead delineation techniques as a tool for protecting groundwater resources is based on the assumption that the greatest protection should be afforded those areas of an aquifer or other water resource that most directly contribute to the water quality at a public water supply well. Inherent in this theory is the recognition that some water in every aquifer will move in a direction not likely to ever reach a well. Wellhead delineation therefore provides the means to focus management and protection efforts on the portions of an aquifer upon which the water supply depends.

Prior to the mandate for state wellhead protection programs, Rhode Island used a very simple form of wellhead protection via the Rhode Island Department of Health (RIDOH) rules that prohibit groundwater discharges within a certain radius of a well. The RIDOH Rules and Regulations Pertaining to Public Drinking Water, (1983, as amended), requires that a 400-foot radius circle for gravel packed wells (200 feet for bedrock wells) be owned or controlled by the public water supplier to protect the well from contamination.

These distances were established some years ago based on available research to allow for die off and filtration of bacteria and viruses from septic systems. Recent experience and research indicate that various contaminants may actually travel thousands of feet in an aquifer; thus, it is quite evident today that distances such as 400 feet are inadequate to fully protect a water supply well.

2. WELLHEAD PROTECTION AREA DELINEATION METHODS

Under the state WHP program, a wellhead protection area must be identified for all public wells. The USEPA, in support of WHP, has provided guidance on the variety of methods available to accomplish this.

The USEPA in their manual Guidelines for Delineation of Wellhead Protection Areas identifies six primary types of wellhead delineation methods:

* arbitrary fixed radii
* calculated fixed radii
* simplified variable shapes
* analytical methods
* hydrogeological mapping
* numerical flow/transport models

As listed, the methods range from the most simple - the arbitrary fixed radius - to the most sophisticated - the numerical models. As described above, the state's 400-foot protection zone around public water supply wells would be considered an arbitrary fixed radius. As another example, the Town, since its adoption of

groundwater overlay districts in 1974, has based its delineation of its recharge areas on hydrogeological mapping prepared by the USGS in Water Supply Paper #1775. The availability in the 1980s of computer modeling advanced the technology of wellhead delineation. Computer-generated analytical and numerical models have introduced additional precision based on site-specific information for a wellhead area.

The use of wellhead delineation methodologies has benefits beyond that associated with establishing the zone of contribution to the well. Modeling techniques also allow the delineation of time of travel (TOT) zones.

The delineation of TOT zones provides a valuable indication of the estimated time it will take for groundwater to move from a given location in the aquifer to the public well. This also provides a rough estimate of how long it might take pollutants to travel to a well, although there are a number of other factors which might affect contaminant transport besides TOT. Identifying various TOT zones provides the town with information to use in their decisionmaking about the levels of protection each zone should be afforded.

In advance of the State's preparation of a WHP Program the Town proceeded to initiate a wellhead delineation program. In their request to the Town Council for funds, the Planning Commission sought sufficient monies to allow the use of state of the art numerical modelling. This work will result in several benefits. The collection of new hydrogeologic data will provide an improved understanding of the groundwater movement in and around the wellhead area. This data will result in more precise delineations which will provide a scientifically sound basis for groundwater protection efforts, including applicable ordinances. Such delineations will facilitate implementing steps to prevent degradation of water quality at the wells.

3. NORTH KINGSTOWN WELLHEAD PROTECTION STRATEGY

In preparing a strategy for accomplishing wellhead delineation in North Kingstown, the Groundwater Committee established a schedule of prioritization to guide Town efforts. This schedule was based on a review of resource availability and use, information from the Water Department, and an assessment of potential threats to the water supply system. Such review led to a decision by the Groundwater Committee that accomplishing a wellhead delineation in the Hunt Aquifer should be the Town's highest priority. The Town wells in the Hunt Aquifer provide more than 50 percent of the water supply safe yield. Two of the three Hunt wells are located adjacent to highly developed areas of Post Road and Frenchtown Roads in North Kingstown, East Greenwich, and Warwick; this location includes proximity of the wells to automobile services, industrial uses, and a high density of residential, commercial, and

industrial septic systems.

The four wells in the Annaquatucket Aquifer which have a total safe yield of 3.6 mgd and were considered proximate to potential contamination sources was designated as the wellhead area deserving next priority for accomplishment.

While the Groundwater Committee was able to set priorities for the accomplishment of WHP for each of the four aquifers which lie within the town, other factors effected the timing of each study. These efforts are summarized below.

a. ANNAQUATUCKET

In a joint venture, the Town, the RIDEM, and the USEPA have conducted as a demonstration project a wellhead delineation for the four public water supply wells in the Annaquatucket Aquifer. The project was initiated in February, 1989 and a final report, at this writing, is anticipated in November, 1991.

The demonstration project was designed to test one means by which a municipality with limited resources could obtain detailed hydrogeological data to support a wellhead delineation. The project involved the collection of field data and production of a water table map. Following this step the data was applied to a computer model to produce a refined delineation. The project results in North Kingstown will be evaluated to determine if this method can be easily applied in other towns.

b. HUNT

The Hunt Aquifer Reservoir stretches from Stony Lane in North Kingstown northeastwardly into the Town of East Greenwich and City of Warwick. The groundwater in this area serves seven public water supply wells belonging to three separate water suppliers. The KCWA has one well located in Warwick. The RIPA has three wells, one in East Greenwich and two in Warwick. The Town of North Kingstown has three wells one each in North Kingstown, East Greenwich, and Warwick.

The Groundwater Committee recognized that accomplishing a wellhead delineation would require a cooperative effort, particularly for the five wells clustered in East Greenwich and Warwick. To that end the Town as represented by its Planning and Water Departments has participated in a regional partnership between and among the municipalities and the water suppliers to prepare a Hunt Aquifer wellhead delineation.

A consultant has been selected to develop the delineation and a plan for protecting the zones of contribution to the wells. A project start-up date of November, 1991, is anticipated. The use of 2 or 3-dimensional numerical models has been accepted as the

wellhead delineation method of choice.

c. PETTAQUAMSCUTT

A wellhead delineation for the wells in the Pettaquamscutt Aquifer is scheduled within the Water Department's Capital Improvement Program for Fiscal Year 92/93.

d. CHIPUXET

A part of the Chipuxet groundwater reservoir and recharge areas, as mapped and classified by the RIDEM lies in the southwestern portion of the Town. North Kingstown does not currently draw a public water supply from this resource. However, six public water supply wells lying in the Town of South Kingstown are used by the University of Rhode Island and the Kingston Water District to serve the public. The Wakefield Water Company and the State Water Resources Board have undeveloped potential well sites in the Chipuxet.

North Kingstown is participating in a study of the Chipuxet Aquifer in conjunction with the other communities that overlay the Chipuxet - South Kingstown and Exeter - and with the water suppliers - Kingston Water District, University of Rhode Island, Wakefield Water Company - that derive, or could derive, a public supply from the Chipuxet Aquifer. The University of Rhode Island is providing the coordination and research behind the study with funding from the suppliers and the municipalities.

The results of the study are expected to provide information about the long term viability of the resource from both a quantity and quality perspective. A delineation of existing wellheads as well as those for potential well sites is anticipated to support water quality protection efforts. An additional component of the study will be a management assessment of acceptable withdrawals. The results will assist North Kingstown in assessing whether there is additional capacity in the Chipuxet for North Kingstown's public supply use.

e. NON-MUNICIPAL COMMUNITY WELLS

The WHP Program provisions apply to all public water systems that are dependent on groundwater - not just major municipal systems. Examples of such other water systems include nursing homes, trailer parks, and restaurants. There are five such wells located in North Kingstown. They are located at the following establishments:

Allie's Donuts, 3661 Quaker Lane
American Legion Post #12, Route 2
Camp Nokewa, Gilbert Stuart Road
Newport Boys Club, Camp Miner Road
Rolling Greens, 1625 Ten Rod Road

VI. PRESENT WATER QUALITY ASSESSMENT

The quality of the water from North Kingstown's ten municipal wells is at present rated good to excellent. There have been no violations of state and federal primary drinking water standards to date.

The RIDOH performs routine chemical analyses at the Town wells which are compared to water quality criteria in order to assess the continued potability of public water supplies. Water testing for bacteria is carried out on a monthly basis. A more complete analysis of water quality for inorganic and organic constituents is conducted once a year.

The federal Safe Drinking Water Act established standards against which water quality is judged. The standards are set by the USEPA and are referred to as maximum contaminant levels (MCLs), secondary MCLs, and non-mandatory maximum contaminant level goals (MCLGs). MCLs represent the upper limit of contaminants allowed in public drinking water supplies. In Rhode Island, the RIDOH administers the program which enforces the MCLs. The parameters tested by the RIDOH can be categorized as inorganics, volatile organic compounds (VOCs), metals, and pesticides. The entire list of USEPA standards is contained in Appendix 2.

Beyond assessing the physical attributes it is also important to assess the quality of the resource to assist in targeting necessary regulatory and mitigation measures. The presence of pollutants is an indication of the effect of land use on groundwater. Water quality data provides an information base for prioritizing protection efforts as well as a baseline for monitoring changes over time.

A. INORGANICS

The levels of inorganic compounds in North Kingstown wells generally do not pose a problem. One area of concern is nitrate which may be contributed to groundwater by a number of sources, including septic systems, fertilizers and runoff.

Nitrate concentrations above 10 milligrams per liter (mg/l) are considered unhealthy, particularly for infants. Ingested nitrates decrease the ability of hemoglobin to carry oxygen. This oxygen deprivation can result in a disease known as methahemoglobinemia or "blue baby syndrome". Nitrates also contribute to the formation of nitrosamines, cancer causing compounds, to which long term exposure may prove detrimental. Nitrate removal is a very expensive technology, therefore it is important to maintain nitrogen concentrations below the standard.

Except for the wells in the Pettaquamscutt Aquifer, all Town wells show some evidence of nitrate above expected background

levels. Concentrations of nitrates found in wells #9 and #10 were within the USEPA standard of 10 mg/l, but ranged up to 4.8 mg/l. Table 3 shows the range of nitrate levels in Town wells between 1979 and 1990. Higher concentrations likely reflect the stress of land use activities in the area surrounding the wells. Wells #9 and #10 are located in close proximity to the Hunt River, in a densely developed, unsewered, and populated area, making nitrate contamination from septic systems highly probable. Fluctuations over time can be a reflection of rainfall, dilution, and well pumping rates.

A second area of concern with inorganics is the level of sodium (or salt, sodium chloride). The USEPA has not yet promulgated a standard for sodium but because of health concerns, the RIDOH has established a health advisory level for sodium of 100 mg/l. The American Heart Association recommends a maximum sodium level of 20 mg/l for those individuals on salt restricted diets. Sodium levels should be monitored to ensure that it does not become a health concern.

Current sodium levels in the North Kingstown wells range from 3.8 to 34.9 mg/l. Table 3 shows the range of sodium levels in Town wells from 1979 to 1990. Figures indicate that sodium levels in North Kingstown well #1 and #9 have been over 20 mg/l. Preliminary findings of the Annaquatucket Wellhead Study show that Well No.1 draws from the stream that runs directly along Oak Hill Road connecting Oak Hill Pond and Secret Lake; this stream is likely impacted by road salting along Oak Hill Road. Wells #9 and #10 are adjacent to heavily travelled Post Road and also receive stormwater discharges from Frenchtown Road. This likely contributes to elevated levels.

TABLE 3
RANGE OF NITRATE AND SODIUM IN NORTH KINGSTOWN MUNICIPAL WELLS
1985-1990 (in milligrams/liter)

WELL #	NITRATE	SODIUM
1	0.3 - 0.6	18.7-25.8
2	.03- 1.4	8.1-12.1
3	<.1 - .3	8.6- 9.8
4	1.7 - 2.4	8.6- 9.8
5	.6 - 2.4	5.2- 6.8
6	1.1 - 1.8	10.6-15.1
7	*	*
8	*	*
9	2.9 - 4.9	15.7-35.3
10	3.8 - 5.0	14.2-19.1

USEPA STANDARD FOR NITRATE = 10 MG/L
RIDOH HEALTH ADVISORY LEVEL FOR SODIUM = 100 MG/L
*Data unavailable (wells not in use)

B. METALS

The overall level of metals in North Kingstown water supply wells is very low with concentrations often reported as non-detectable. The data did show that the secondary MCL for iron and manganese were exceeded in wells #3, #5, and #6. These elevated levels are attributed to naturally occurring conditions and reflect the composition of the earth material from which the water is withdrawn. Iron and manganese can contribute to nuisance conditions, such as taste and color problems, but are not considered a health threat at the levels detected in the Town wells. According to the RIDEM, there are many areas in the state which report high iron and manganese levels.

C. ORGANIC COMPOUNDS

1. Pesticides

The Safe Drinking Water Act requires periodic monitoring for eight pesticides in public supply wells. The RIDOH data reveal none of these pesticides have been detected in any of the Town wells. However, agricultural activities conducted in Town are not adjacent to Town wells. It is unknown whether pesticides are present in groundwater in other parts of the aquifer.

2. Volatile Organic Compounds

Volatile organic compounds (VOCs) are a group of contaminants that pose a growing concern with respect to groundwater protection. VOCs do not naturally occur in water and are chemical constituents of widely used industrial and household products, including solvents and degreasers as well as gasoline. Once VOCs are in groundwater they are difficult to remove due to the lack of oxygen needed to break down the chemicals. Many of the VOCs are known or potentially toxic at very low concentrations and several have been identified as carcinogenic. The RIDEM has reported that a majority of well closures throughout the state are a result of VOC contamination.

In response to this growing concern, the Congress amended the federal SDWA in 1986 to require additional standards and monitoring for VOCs. The RIDOH has also expanded its testing of public wells for VOCs.

Well testing shows that in recent years VOCs have only been detected in the Town's two wells that are located in the Hunt Aquifer. The compounds found include low levels of 1,1,1-trichloroethane, 1,1 dichloroethylene, and 1,1-dichloroethane. On several occasions, only 1,1,1-trichloroethane was present. All VOC concentrations were well within the safe drinking water standards established for the compound. For example, the highest

level reported, 32 ppb of 1,1,1-trichloroethane is well below the standard of 200 ppb.

Other wells sharing the Hunt Aquifer have also shown the presence of VOCs. There has been persistent evidence of 1,1,1 trichloroethane in KCWA well #1. In addition well #9A which is operated by the RIPA has reported tetrachlorethane above a proposed drinking water standard. State and local officials are cooperating to investigate the source of this contamination problem. The North Kingstown wells located nearby have not shown the presence of tetrachlorethane. The only other VOC with elevated levels is 1,1-dichloroethane.

From December 1988 through July 1989 in a collaborative effort, the North Kingstown Water Department, the KCWA, and the RIPA participated in a monthly sampling program with analyses done at a laboratory associated with the University of Rhode Island School of Oceanography. For North Kingstown wells #9 and #10 results indicated very low levels of VOCs. A summary of VOC sampling results is contained in Appendix 3.

D. OTHER SOURCES OF WATER QUALITY DATA

The quality of water drawn from the Town wells is not necessarily reflective of the entire aquifer. Water quality data which may also be available includes that from the RIDEM which may require groundwater monitoring and sampling as part of the investigation of pollution incidents such as UST leaks, or as a requirement of UIC permits and solid waste licensing. In the Annaquatucket the Town has installed monitoring wells to assess the impacts of the Homevest/Hometown landfill on Dry Bridge Road.

The Town needs to set up a process with the RIDEM whereby the Town will receive such water quality data. Another source of data is any private well testing performed by the RIDOH. This data is now public information. Related surface water quality data include the Watershed Watch Program sampling results for six freshwater bodies located in the aquifer areas. Included in these six are Secret Lake, Kettle Hole Pond, and Carr Pond which are associated with Town wells. Other possible sources of water quality information which should be investigated by the town are environmental assessments prepared by private consultants as a part of real estate transactions. The Town could request copies of such assessments during the review of development proposals.

The collection and compilation of water quality data gives the town a baseline by which to evaluate changes to these resources over time. In order for this data to be useful it needs to be organized and made accessible. The data can then be utilized along with the results of the wellhead studies to determine where monitoring wells may be needed or where protection or mitigation efforts should be directed.

Additionally, one outcome ofthe wellhead studies will be the identification of locations for monitoring wills for each wellfield.

E. WATER TREATMENT

At the present time the only water treatment to the municipal water supply is the adjustment, or increase, of the pH values. This is accomplished in order to reduce the corrosivity, or aggressiveness, of the groundwater which has a pH value of approximately 5.8. If not treated, water with a pH this low causes the leaching of lead and copper into water from plumbing systems and deterioration of plumbing systems as well. The pH of the finished (treated) water is approximately 7.3 which renders it non-aggressive. This adjustment is accomplished through the addition of sodium carbonate to the water as it is pumped from the municipal wells.

The addition of sodium carbonate raises the sodium content of the municipal water supply somewhat. The raw water as pumped from the 10 municipal wells contains an average sodium content of approximately 15 mg/l. After treatment the finished water contains a sodium content of approximately 35 mg/l. The RIDOH regulations pertaining to drinking water requires public notification if a sodium content of 100 mg/l is reached.

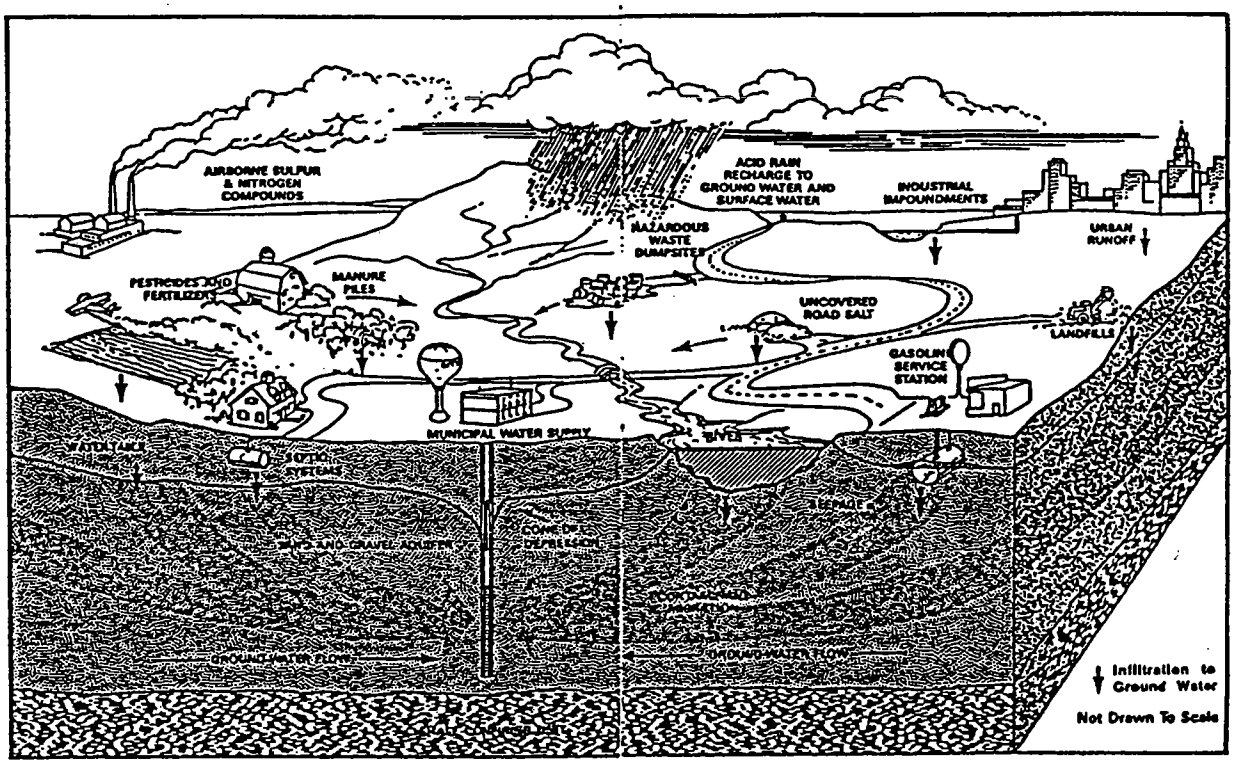
VII. THE EFFECT OF LAND USE ACTIVITIES ON WATER QUALITY

As mentioned previously, in the Town of North Kingstown, groundwater is the sole source of drinking water. The public water system consists of 10 sand and gravel wells which are all located adjacent to streams and ponds. The sediments overlying the aquifer are highly permeable. Water moves rapidly through these loose sand and gravel type soils which have less of an ability to filter contaminants. This leaves the groundwater vulnerable to contamination. In addition, in some areas the water table is relatively high which increases the risk of contamination.

Because aquifers are recharged by precipitation percolating through the land overlying them, land use activities may have a major impact on both the quality and quantity of groundwater.

Certain land use activities present higher risks of groundwater contamination. Figure 5 depicts these impacts. As the figure indicates, contaminants associated with land use activities can enter groundwater by a variety of pathways including infiltration, direct or indirect discharges, seepage, runoff, leaching, or spills into surface waters subject to induced infiltration. These various pathways require a range of protection strategies be applied in an overall groundwater protection plan.

FIGURE 5
LAND USES WHICH MAY HAVE AN EFFECT ON GROUNDWATER



Source: USEPA

The following details the primary groups of land use activities that pose a threat to groundwater. In February of 1990 the Town of North Kingstown adopted interim amendments to the existing Groundwater Ordinance which prohibit many of these threatening activities.

All land uses, to varying degrees, have the potential to pollute, but some in more silent ways than others. Commercial and industrial activities may require the storage, use, or disposal of hazardous materials. In addition, commercial and industrial developments often create large expanses of impervious surfaces which increase the volume and degrade the quality of stormwater runoff. Pollutants such as heavy metals and hydrocarbons from vehicular use may impact groundwater resources. High density residential development is a known risk for nitrate contamination from septic systems and cesspools, lawn fertilizers, runoff, and household hazardous waste disposal.

Agricultural activities including fertilizer and pesticide use, irrigation practices, and livestock wastes, as well as soil erosion from farming activities also have the potential to alter groundwater quality.

The information base for this plan relies on information available from the RI Wellhead Protection Program, State of Connecticut 1989 Report of the Aquifer Protection Task Force and numerous USEPA documents.

A prohibition on siting those types of activities having the potential to contaminate the groundwater will reduce future threats. However, in each aquifer area there are existing uses which endanger groundwater. The program below seeks to reduce the risks of contamination to the aquifer through both prevention and mitigation.

VIII. RECOMMENDED ACTIONS FOR ADDRESSING POTENTIAL SOURCES OF GROUNDWATER CONTAMINATION

In order to determine the threat posed by land use activities to the Town's drinking water, the Groundwater Committee inventoried potential threats. These threats include:

Underground Storage Tanks
Landfills
Underground Injection Control Wells
Septic Systems
Hazardous Materials Storage and Transport
Household Hazardous Materials Use and Disposal
Road Salt Storage and Application
Pesticides and Fertilizers
Junkyards and Salvage Yards
Sand and Gravel Operations
Stormwater Discharges

The program that follows describes for the reader the ways that these activities have the potential to impact groundwater and management strategies for each.

The program is based upon the following overall goals.

* ESTABLISH THAT GROUNDWATER IS A PUBLIC NATURAL RESOURCE THAT SHOULD BE PROTECTED AGAINST CONTAMINATION OR POLLUTION

* RAISE PUBLIC AWARENESS AND EDUCATE ALL SECTORS ABOUT PERSONAL RESPONSIBILITY IN GROUNDWATER PROTECTION

* DEVELOP A DATA MANAGEMENT SYSTEM TO MONITOR WATER QUALITY, CONTAMINANT SOURCES, AND MITIGATION EFFORTS

* ENCOURAGE VOLUNTARY COMPLIANCE WITH REGULATIONS ESTABLISHED TO PROTECT THE TOWNS GROUNDWATER RESOURCES

* STRICTLY ENFORCE GROUNDWATER PROTECTION REGULATIONS

A. UNDERGROUND STORAGE TANKS (UST)

Underground storage tank leakage is a major cause of groundwater pollution. The USEPA estimates that 35 percent of the unprotected (bare) steel underground storage tanks are leaking. Compounding the problem is the fact that underground leaks occur out of sight and may go undetected for years.

Leaking underground storage tanks are also considered a serious risk to human health. Oil and gas are toxic if ingested or absorbed through the skin. Components of gasoline are known or potential carcinogens. Other hazards range from unhealthful odors to possible explosion.

Numerous factors influence the likelihood of tank leakage, including the age of the tank, the soil conditions, improper installation, and misuse of testing procedures.

One of the major causes of leakage is corrosion. External corrosion may occur due to tank age and exposure to corrosive soils. Corrosive soils are those that are acidic, moist, and good conductors of electrical charges. Internal corrosion, or wearing of the tank from the inside, may be caused by dipstick testing for fuel-content level or high velocity filling of the tank.

The majority of underground storage tanks are steel, and have no protection against corrosion. A single-walled steel tank has a life expectancy of 18 years and costs about $1 per gallon to replace. A cleanup operation will generally cost many thousands of dollars more. In addition, it is a slow and difficult process.

The RIDEM Regulations For Underground Storage Facilities Used For Petroleum Products And Hazardous Material apply to new, existing and abandoned commercial or industrial facilities which store petroleum products or hazardous materials underground. The RIDEM regulations do not apply to residential underground storage tanks used to store heating oil, or farm or residential underground tanks holding less than 1,100 gallons for non-commercial use. The regulations also do not apply to any tanks used for storing No. 4, No. 5, or No. 6 fuel oil (except for reporting of leaks or spills).

Any new underground storage facility must obtain a certificate of registration from the RIDEM before commencing installation. Facilities existing prior to regulations were to

have applied for a certificate of registration by April 9, 1985. Regulations also require line leak detection systems and either annual precision testing for the tank and associated piping or a continuous monitoring system or systems. Table 4 indicates how and when RIDEM regulations apply to different UST types.

TABLE 4

REGULATION OF UNDERGROUND STORAGE TANKS

*Underground storage tanks (USTS) require all owners and operators of USTS, regardless of size or use, to report and respond to leaks and spills (section 14 of regulations).
Other major provisions of State regulations apply as described below:

	Regulated	Leak Detection	Pre-Install Approval	Closure	Invent. Monitor.	Federal Report
Gasoline or motor fuels > 1,100 gals. on any property	YES	YES	YES	YES	YES	YES
Gasoline or motor fuels < 1,100 gals. on residential or farm properties	NO	NO	NO	NO	NO	NO
Gasoline or motor fuels < 1,100 gals. at locations other than residential or farm properties	YES	YES	YES	YES	YES	
Heating Oil (no 2) > 1100 gal.at any property contained on site.	YES	NO	NO	YES	NO	NO
Heating Oil (no 2) < 1100 gal.at 1, 2 or 3 unit residential dwelling or farm property.	NO	NO	NO	NO	NO	
Heating Oil (no 2) < 1100 gal.at non-residential or non-farm properties	YES	NO	NO	YES	NO	NO
Tanks storing hazardous materials	YES	YES	YES	YES	?	NO defined

Heating Oil > 1100 gal.at any property storing fuel used off-site	YES	NO-State YES-Fed	NO	YES	NO	YES
Jet Propulsion Fuels						
No. 4, 5, 6 Fuel Oils	NO*	NO	NO	NO	NO	NO
hydraulic lift fluid	NO	NO	NO	NO	NO	NO
Waste Oil Tanks	YES	YES	YES	YES		

Many unregistered and unknown tanks exist, and while the technology for new, safer tanks does exist, this does not solve the problems that existing or unknown abandoned tanks pose.

Because even a relatively small leak poses a major threat to drinking water quality, it is important to inventory all underground storage tanks in North Kingstown groundwater areas, regardless of size. Leaking underground storage tanks also pose a threat to other sensitive natural resources as well.

The Groundwater Committee believes it is important for information such as the number of tanks on a site, the age, condition, size and contents of the tanks to be documented. A centralized system of monitoring and upgrading these tanks should be established.

Some of this information is available through the RIDEM database of registered tanks (those falling under the agency's jurisdiction), and from an underground storage tank inventory which was prepared in April 1989 for the Town of North Kingstown.

The state has records on 396 registered underground storage tanks in North Kingstown. Of these 217 have been removed/closed leaving 179 active USTs. In addition, 15 unregistered tanks have been identified. There are 33 underground storage tanks registered to the Town of North Kingstown; more than half of these Town owned tanks are over 20 years old (RIDEM, Division of Groundwater, Registered UST Database).

The North Kingstown Groundwater Recharge Overlay District ordinance presently prohibits any new underground storage tanks in the groundwater overlay district.

POLICIES/OBJECTIVES

* PROHIBIT THE INSTALLATION OF NEW USTs WITHIN THE TOWN'S GROUNDWATER AQUIFER AREAS

* PROHIBIT NEW RESIDENTIAL USTs THROUGHOUT THE TOWN

* MONITOR, WHERE POSSIBLE, EXISTING USTs

* EDUCATE THOSE INVOLVED IN THE OWNERSHIP, USE, INSTALLATION, AND SERVICING OF USTs ABOUT THE IMPACTS OF GROUNDWATER CONTAMINATION FROM LEAKING UNDERGROUND TANKS

RECOMMENDED ACTION:

1. PROHIBIT THE INSTALLATION OF NEW USTS

2. CENTRALIZE RESPONSIBILITY AND ALL INFORMATION REGARDING TOWN OWNED USTS

3. MAKE PROVISIONS IN THE CAPITAL BUDGET FOR A TOWN UST REPLACEMENT PROGRAM

4. TAKE IMMEDIATE ACTION OR STEPS TOWARD MONITORING TOWN USTS FOR LEAKS

5. INVENTORY USTS NOT UNDER STATE JURISDICTION DURING RE-EVALUATION PROCESS

6. DEVELOP INCENTIVE PROGRAMS TO ENCOURAGE HOMEOWNERS TO REPLACE EXISTING USTS WITH ABOVE GROUND UNITS OR DOUBLE WALLED TANKS

7. FOR BUILDING PERMIT APPROVAL REQUIRE DISCLOSURE OF HEATING FUEL TYPE

8. PREPARE EDUCATIONAL MATERIALS TO BE DISTRIBUTED THROUGH OIL DISTRIBUTORS

9. PETITION THE RIDEM TO IMPOSE STRICTER STANDARDS ON EXISTING USTS IN GROUNDWATER AQUIFER AREAS INCLUDING REQUIREMENTS FOR:

A. THE INSTALLATION OF OBSERVATION WELLS ON UST SITES; THESE WELLS MAY BE CHECKED BY THE USE OF A BAILER TO DETERMINE THE PRESENCE OF LEAKING PETROLEUM PRODUCT ON THE WATER TABLE

B. REPLACEMENT OF OLDER STEEL USTS WITH DOUBLE WALLED TANKS AND REPLACEMENT OF OLD PIPING

C. REMOVAL OF ALL ABANDONED USTS

D. PERIODIC TIGHTNESS TESTS FOR ALL USTS AND ASSOCIATED PIPING SYSTEMS

E. MANDATORY UPGRADE TO SECONDARY CONTAINMENT

10. SUPPORT STATE LEGISLATION FOR UNDERGROUND STORAGE TANK REGULATIONS TO PROTECT THE ENVIRONMENT

B. LANDFILLING

The disposal of wastes by landfilling is a potential source of groundwater contamination. Both active and inactive landfill sites may impact groundwater quality.

Deposited wastes are degraded through biological and chemical reactions, resulting in solid, liquid, and gaseous by-products. Various factors affect the breakdown of landfilled materials including their physical, chemical, and biological properties, compaction in the landfill, the availability of oxygen, moisture level, temperature, and microbial populations within the landfill. While some materials degrade quite easily, others are very resistant to decomposition.

As precipitation infiltrates through the landfill it becomes contaminated. As this contaminated liquid or leachate moves downward toward the water table, various physical, biological, and chemical reactions result in the temporary or permanent attenuation of contaminants. The extent to which contaminants are attenuated depends on the natural and physical conditions of the landfill site, including soil type, depth to groundwater, the type of contaminant and its ability to move through soil or water or become dissolved. Sands and gravel have less ability to attenuate contaminants. Landfilling into groundwater or surface water reduces attenuation potential and introduces contaminants directly into groundwater flow.

Over the years waste has been disposed of at a number of location in North Kingstown. The federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) addresses the cleanup of toxic releases of uncontrolled or abandoned hazardous waste sites. The USEPA CERCLIS list has identified 29 sites in North Kingstown. Twenty three sites are associated with former activities of the Department of Defense at the former Quonset Point/Davisville Naval Station; the federal government is conducting investigations of these sites. The remaining six includes the Town's two former landfills.

There are occasions where land owners seek to fill a site to make it suitable for development. The Town needs to recognize

that certain materials may be unsuitable for such filling in an aquifer area due to potential for leachate from the fill. One such waste material is asphalt generated as a waste during road reconstruction projects. Material like asphalt is presently not regulated by the RIDEM (solid or hazardous waste). The Town needs to prohibit the use of asphalt as a fill material. The Town can instead encourage, and require in its own projects the recycling of asphalt. All efforts at recycling reduce requirements for landfilling.

Because of the long term impacts of filling, the present ordinance requires a special exception for filling in excess of 20 cubic yards except where part of an approved plan.

POLICIES/OBJECTIVES

* PROHIBIT LANDFILL SITING IN THE GROUNDWATER AQUIFER AREAS BY TOWN ORDINANCE

* TO ADEQUATELY MONITOR GROUNDWATER QUALITY AROUND ACTIVE AND INACTIVE LANDFILLS

* REGULATE THE FILLING OF LAND IN AQUIFER AREA

RECOMMENDED ACTION:

1. MAINTAIN PROHIBITION ON LANDFILL SITING IN THE GROUNDWATER AQUIFER AREAS

2. INSTALL GROUNDWATER MONITORING WELLS IN APPROPRIATE LOCATIONS IN AND AROUND LANDFILL SITES TO OBTAIN CONTAMINATION PLUME INFORMATION NECESSARY FOR THE PROTECTION OF DRINKING WATER

3. SET STANDARDS BASED ON SITE CONDITIONS FOR MONITORING WELLS TO INCLUDE HOW TO SITE WELLS, NUMBER OF WELLS REQUIRED, TYPE OF WELLS, DEPTH OF WELLS, TESTING REQUIREMENTS

4. ADOPT LEGISLATION THAT ESTABLISHES CLEAR LIABILITY AND RESPONSIBILITY FOR POLLUTION FROM LANDFILLS

5. CONTINUE REGULATION OF FILL ACTIVITIES THROUGH SPECIAL EXCEPTION REQUIREMENTS

6. INVESTIGATE MEANS TO ENCOURAGE THE RECYCLING OF ASPHALT TO DISCOURAGE ITS USE AS FILL MATERIAL

C. UNDERGROUND INJECTION CONTROL PROGRAM

An Underground Injection Control (UIC) Well is a well, cesspool, septic system, pit, holding pond, catch basin or other stormwater control unit into which industrial or commercial waste

fluids (semisolid, liquid, sludge, gas, stormwater or other form) are injected for disposal. Stormwater management is also addressed in a section further in this document. The subsurface disposal of industrial and commercial wastes by this method is regulated by the UIC Program, authorized under the federal SDWA. The Program is administered by the RIDEM, Division of Groundwater and Freshwater Wetlands. Although residential sewage disposal systems are not controlled by this program, large septic systems (over 5000 gallons) are required to obtain a UIC permit.

This subsurface discharge is a potential source of contamination to groundwater. This type of waste disposal ranges from simple to complex. To give some examples, UICs may include disposal of cooling water into a drywell of floor drains at an auto repair shop. The types of waste disposed of in this manner can include petroleum products, cleaning solvents and degreasers, industrial and agricultural chemicals, stormwater runoff, and other chemicals. Many of the constituents of these products are persistent in groundwater.

Various factors influence the potential for groundwater contamination from these sources. These factors include design, construction and operation of the disposal system, quality and volume of the material discharged, where the disposal occurs in relation to the aquifer, and the hydrogeologic conditions at the site.

Waste disposal of this type requires that an order of approval be obtained from the Director of the RIDEM. The applicant must submit plans, specifications, and sample analysis for priority pollutants, as well as any other information requested to ensure that groundwater quality will not be endangered. In addition proof that no other federal or state standards or regulations will be violated must be shown. The requirements of this program were established by legislation adopted in 1985 and apply to new and existing facilities.

POLICIES/OBJECTIVES

* PROHIBIT UIC COMMERCIAL AND INDUSTRIAL WELLS IN WELLHEAD AREAS

* REGULATE UIC WELLS IN RECHARGE AREAS THROUGH THE USE OF DESIGN STANDARDS AND MONITORING PROGRAMS

RECOMMENDED ACTION:

1. REVISE REGULATIONS TO INCORPORATE PROHIBITION OF UICS IN WELLHEAD AREAS

2. THE TOWN WILL REQUEST THAT MONITORING WELLS BE APPROPRIATELY LOCATED AT UIC SITES WITHIN THE AQUIFER AREAS AND THAT THE MONITORING RESULTS BE FORWARDED TO THE TOWN FOR REVIEW

3. REQUIRE PREDEVELOPMENT WATER QUALITY TESTING TO DETERMINE AMBIENT WATER QUALITY

4. SET STANDARDS FOR MONITORING WELLS

D. SEPTIC SYSTEMS

The majority of North Kingstown residents rely on the use of individual sewage disposal systems (ISDS) for wastewater treatment. These systems are designed to discharge wastewater to the ground, where contaminants are treated to some degree by the soil. This wastewater contains nitrogen, phosphorus, pathogenic bacteria and viruses, detergents, solvents, and metals.

A properly functioning ISDS retains the settleable and floatable solids in the septic tank where they are aerobically treated and decomposed. The liquid portion of the waste stream is distributed over and through a soil absorption field or leach field which works to purify the water before it enters the groundwater. For proper treatment there must be adequate separation between the leach field and the water table (an unsaturated soil layer).

Many homes in older portions of North Kingstown still utilize cesspools as their means of waste treatment. Unlike a septic system, a cesspool consists of single chamber into which waste is piped and infiltrates into the soil.

Septic system and cesspool maintenance is critical to ensure proper waste treatment. Over time solids (sludge) accumulate in the bottom of the septic tank. These solids, known as septage, should be pumped out of the septic tank approximately once every two years. If too much sludge accumulates no room is left in the septic tank for solids to settle, as a result, the solids flow out of the tank into the leachfield. Solids can clog the leachfield and result in wastes backing up into household plumbing or onto the ground surface.

Improper installation can also result in system failure. If a septic system leachfield is situated too close to the water table, the unsaturated soil zone may not be large enough to adequately treat the wastewater resulting in contamination of the underlying groundwater.

Nitrates which are contributed to groundwater by septic systems represent a health concern. Nitrates are persistent in groundwater and have the potential to move great distances. Dilution is the only means of reducing the nitrate level in

groundwater. Even a properly functioning system contributes in the range of 30-80 mg/l of nitrate to groundwater. The nitrate nitrogen drinking water standard established by the USEPA is 10 mg/l.

Research has shown that in order to ensure adequate dilution, overall density levels for ISDS must not be allowed to exceed an amount that allows for dilution below the 10 mg/l. Around the country a number of places have established density levels designed to insure the dilution and mitigation of the nitrate and maintain acceptable levels in public wells. The USEPA will require the closure of any well that exceeds 10 mg/l.

In 1988, the Town adopted an interim amendment to the zoning ordinance requiring an average density of one unit per two acres. In so doing , the Town relied on research conducted on Long Island, Cape Cod, the Pinelands in New Jersey, for the state 208 Plan, and other places that assessed the impact of nitrate from septic systems on groundwater. Such research indicated that to maintain a nitrate level below the Safe Drinking Water standard of 10 mg/l would require sufficient land to allow for dilution of the nitrate in the septic system effluent and as a component of a fertilized lawn. Density requirements to meet that standard varied from 1 acre to 16 acres with the difference attributable to soils, depth to groundwater, and other localized attributes such as expected lawn size.

Deciding on an appropriate density is grounded fundamentally in public policy that establishes an acceptable level of nitrate for a community's drinking water supply. Thus, while Cape Cod established an acceptable goal of no greater than 5 mg/l of nitrate, in New Jersey 2.3 mg/l of nitrate is considered the planning goal. The decision to reduce the density in North Kingstown's recharge areas is based on 5 mg/l as an acceptable nitrate level, recognizing the levels of development already existing in each recharge area. Existing and build-out levels of development were documented in a report prepared by the North Kingstown Department of Planning and Development in May, 1989.

An extensive study was conducted in 1989 by the state of Connecticut Department of Environmental Protection, Water Compliance Unit on the land required to support residential development. The study concludes that based on nitrogen dilution and other factors the densities required for the protection of public health and the environment is 1 unit per 2 acres exclusive of wetlands.

To appropriately assess the impacts on the long-term quality of the Town's groundwater several nitrate load models were used. Models in use for Cape Cod and from Cornell University were run using the basic model formula with modification to inputs to allow for variables particular to North Kingstown. For example,

the Cape Cod model assumes that lawn size will average 4000 square feet; a study conducted by the North Kingstown Planning Department (Whalen, 1989) showed that the average lawn size in North Kingstown was 8,000 square feet. Such variation as well as that for household size, rainfall, etc. will become inputs to personalize the models for North Kingstown use. The result of inputting North Kingstown assumptions to simulate local conditions in accepted models resulted in approximately a one unit per two acres density requirement to maintain the 5 mg/l nitrate load.

Consideration was given to judging development strictly on a nitrate load model but the Groundwater Committee determined that this approach provided a development review methodology that could be easily manipulated. In addition, it was recognized that the nitrate load represented averages and does not reflect changes in household characteristics. It seemed that strict use of nitrate load modeling might preclude future homeowners from making additions to homes, adding apartments for accessory use and similar activities that could intensify use. Built into the 2 acre zone recommendation is the flexibility to deal with such situations. However, the Groundwater Committee recognized that some types of development such as commercial, industrial, and multifamily were best reviewed using a nitrate load model. In these situations the Committee recommends that these development proposals be reviewed based on an assesment of nitrate load.

Finally, after review of available literature and nitrate analyses studies, the Groundwater Committee accepted for recommendation the use of 5 mg/l of nitrate as an appropriate planning goal for North Kingstown. Inherent in this goal is a recognition that depending upon development density, precipitation, and similar factors, the long term nitrate level is anticipated to reach a range that may stretch from above 5 mg/l to below it. The Groundwater Committee recognizes that a full nitrate load analysis should be accomplished following the completion of each wellhead study.

Septic tank cleaners and additives pose an additional threat to groundwater. Generally, these additives will not improve the systems performance, and may actually harm the beneficial bacterial action in the tank.

There are three basic categories of septic system cleaners: Organic solvents (often chlorinated); inorganic (acid, base, flocculating agents); and biological (bacteria, yeast, enzymes). The major issues relative to groundwater pollution from septic system cleaners include: Acids and bases may cause sludge bulking and disrupt normal biological activity; Bases can be severely detrimental to soil structure; Organic solvents work well to remove grease from piping but pose a high risk of contaminating groundwater with chlorinated hydrocarbons;

Inorganics (root killers) have the potential to pollute groundwater with metals.

POLICIES/OBJECTIVES

* MAINTAIN AN ACCEPTABLE LEVEL OF NITRATE-NITROGEN CONCENTRATION IN GROUNDWATER BY APPROPRIATELY MANAGING THE DENSITY OF DEVELOPMENT

* ENSURE SUFFICIENT SETBACKS TO PREVENT CONTAMINATION OF SURFACE WATER AND DRINKING WATER WELLS

* DISCOURAGE USE OF SEPTIC SYSTEM CLEANERS AND ADDITIVES

RECOMMENDED ACTION:

1. MAP AQUIFER AREAS AS A TWO (2) ACRE ZONE

2. ESTABLISH A WASTEWATER MANAGEMENT ORDINANCE TO ENSURE PROPER MAINTENANCE OF SEPTIC SYSTEMS.

3. EDUCATE THE PUBLIC ABOUT THE NEED FOR WASTEWATER MANAGEMENT, SEPTIC SYSTEM MAINTENANCE, AND THREATS POSED BY THE USE OF SEPTIC SYSTEM CLEANERS AND ADDITIVES. THIS EFFORT MUST INCLUDE THE EDUCATION OF THOSE IN THE BUSINESS OF SELLING AND INSTALLING SEPTIC SYSTEMS AND SEPTIC SYSTEM PRODUCTS

4. AMEND SUBDIVISION AND ZONING REGULATIONS TO REQUIRE THAT DENSITY BE CALCULATED ON LAND EXCLUSIVE OF WETLANDS

5. REQUIRE THAT SEPTIC SYSTEMS BE SET BACK 150 FEET FROM SURFACE WATER BODIES AND WETLANDS

6. PROHIBIT LARGE (OVER 5000 GALLONS) SEPTIC SYSTEMS OR THE CLUSTERING OF SEPTIC SYSTEMS WITHIN WELLHEAD AREAS

7. IN NEW SUBDIVISIONS IN AQUIFER AREAS, PROHIBIT FILLED OR MOUNDED SEPTIC SYSTEMS ON LOTS OF LESS THAN 40,000 SQUARE FEET WHERE THE DEPTH TO THE WATER TABLE IS LESS THAN FIVE (5) FEET

8. ADOPT STANDARDS FOR A NITRATE LOADING MODEL USING EXISTING AND ACCEPTED RESEARCH FINDING

9. USE NITRATE LOADING ANALYSIS FOR ANY COMMERCIAL OR MULTI-UNIT RESIDENTIAL DEVELOPMENT TO ENSURE THAT NITRATE CONTRIBUTION DOES NOT EXCEED THE PLANNING GOAL OF 5 MG/L

10. PREPARE A NITRATE LOAD ANALYSIS BASED ON BUILD-OUT FOR EACH WELLHEAD FOLLOWING DELINEATION

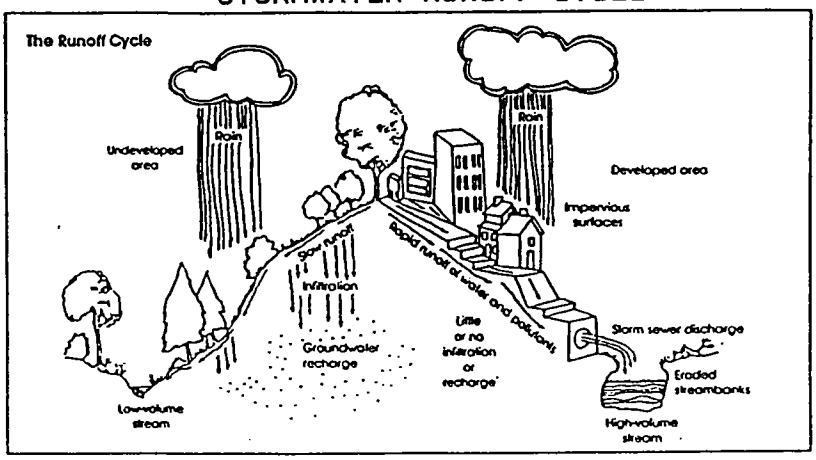
11. INVESTIGATE CREATING INDIVIDUAL SEWAGE DISPOSAL SYSTEM REGULATIONS THAT ARE MORE STRINGENT THAN EXISTING STATE

E. STORMWATER RUNOFF AND MANAGEMENT

Stormwater runoff is simply precipitation running over the land during or following a storm. Precipitation infiltrates downward through the ground to replenish groundwater supplies (groundwater recharge). As land is developed and natural vegetative cover is replaced by impervious groundcover such as asphalt, changes in the quality and quantity of stormwater runoff may occur. Impervious groundcover prevents rainfall from seeping into the ground where it is purified as it is filtered through vegetation and soil. Instead rainwater runs rapidly over the impervious land surface where it may pick up materials such as pesticides, fertilizers, oil, grease, heavy metals, and animal wastes. These pollutants are then washed off with stormwater runoff, adding to the pollutant load carried to receiving waters.

In addition, soil left unprotected during construction may erode away with stormwater contributing sediments to water bodies. Because surface and groundwaters are hydrologically connected, the pollutant load carried to ponds, rivers, and other surface water bodies may reach drinking water. Figure 6 illustrates the stormwater runoff cycle.

FIGURE 6
STORMWATER RUNOFF CYCLE



The runoff cycle (Metropolitan Washington Council of Governments).

Techniques have been developed to minimize the impact that stormwater runoff may have on ground and surface water bodies. An exhaustive study of such techniques was prepared by the RIDEM and the Stormwater Management and Erosion Control Committee which discussed preferred water quality control measures and recommended design guidelines for stormwater management.

The committee identified the wet detention basin as the technique that produced the most desirable results to achieve

water quality enhancement of stormwater runoff. Wet detention basins provide the opportunity for the contaminants in runoff to settle prior to being discharged. Vegetated wet detention basins provide pollutant removal benefits through biological uptake.

Other techniques for water quality enhancement such as the extended detention dry basins and infiltration devices were recommended for use in conjunction with wet basins or in areas where the installation of wet basins is not possible.

Computer modelling techniques have been developed that allow the estimation of pollutant load into groundwater or surface water bodies based on the stormwater management techniques chosen. Such techniques allow systems to be designed to meet a preselected water quality goal. Stormwater management systems can be designed such that the water discharged from the system meets drinking water standards.

Maintenance is critical to the proper functioning and operation of stormwater management facilities. Maintenance includes street sweeping to prevent sedimentation, cleaning of catch basins, and cleaning and sediment removal from detention basins.

POLICIES/OBJECTIVES

* CONSIDER WATER QUALITY IMPACTS OF STORMWATER CONTROLS IN REGULATORY REVIEW PROCESS

* USE BEST MANAGEMENT PRACTICES (BMPS) FOR WATER QUALITY AND QUANTITY MANAGEMENT WHEN IMPLEMENTING TOWN STORMWATER CONTROL PROJECTS

RECOMMENDED ACTION:

1. ADOPT A SOIL EROSION AND SEDIMENT CONTROL ORDINANCE TO PREVENT SEDIMENTATION OF SURFACE WATER BODIES

2. INCORPORATE STORMWATER BEST MANAGEMENT PRACTICES (BMPS) (NONSTRUCTURAL AND LOW STRUCTURAL) INTO DEVELOPMENT REGULATIONS AS A MEANS OF REDUCING POLLUTANT LOADINGS AND MAINTAINING GROUNDWATER RECHARGE

3. INCORPORATE COMPUTER MODELLING TECHNIQUES INTO DEVELOPMENT REVIEW PROCEDURES FOR ASSESSING IMPACT OF STORMWATER

4. AMEND DEVELOPMENT REGULATIONS TO INCLUDE REDUCED IMPERVIOUS SURFACES AND USE OF NATURALLY VEGETATED BUFFERS

5. MAP THE EXISTING STORMWATER DRAINAGE SYSTEM AND ANALYZE THE WATER QUALITY IMPACTS OF THE EXISTING DRAINAGE SYSTEMS

6. ESTABLISH A PRIORITIZED MAINTENANCE SCHEDULE FOR TOWN OWNED STORM DRAINS AND OTHER STORMWATER CONTROL STRUCTURES

7. DEVELOP ENFORCEABLE MAINTENANCE SCHEDULES FOR PRIVATE STORMWATER CONTROL STRUCTURES

8. DEVELOP AN EDUCATION PROGRAM TO INCLUDE EDUCATION OF TOWN DEPARTMENT OF PUBLIC WORKS EMPLOYEES

9. THE TOWN WILL WORK WITH THE RIDOT TO:

A. DIRECT DISCHARGES INCLUDING ROAD RUNOFF AWAY FROM THE ZONES OF CONTRIBUTION TO THE AQUIFERS

B. CHANGE EXISTING DRAINAGE PATTERNS ON STATE ROADS THAT DISCHARGE TO THE AQUIFER

10. THE GROUNDWATER COMMITTEE WILL WORK WITH THE NORTH KINGSTOWN DEPARTMENT OF PUBLIC WORKS TO DIRECT DISCHARGES INCLUDING ROAD RUNOFF AWAY FROM THE ZONES OF CONTRIBUTION TO THE AQUIFERS

F. HAZARDOUS MATERIALS

Hazardous materials are defined as chemicals or substances which are harmful to human health and the environment. Such substances may be used in industry, agriculture, medicine, research and household products. Uncontrolled releases and spills of hazardous materials by improper use, storage, and disposal can have a serious impact on groundwater supplies. The proper storage and handling of such materials is the most important means to prevent them from becoming groundwater contaminants.

The federal government under the Superfund Amendments and Reauthorization Act (SARA) has classified materials into categories of chemical hazards. Reporting standards have been established for these chemicals depending on the type of chemicals, amount stored, and risk posed. For example, the storage of some hazardous materials (those defined as extremely hazardous) requires the preparation of an emergency response plan that must be submitted to the town and the state. For others depending on the quantity stored the reporting consists of completing Right to Know Material Safety Data Sheets for submission to the Local Emergency Planning Committee, the State Emergency Response Commission and the local Fire Department. The North Kingstown Fire Department has the authority to enter any commercial or industrial facility to determine how such materials are stored and the type of hazard posed.

The Resource Conservation and Recovery Act (RCRA) is federal legislation that established a national program to protect human health and the environment from improper handling of solid waste

and to encourage conservation of natural resources. Subtitle C of this act imposes controls over the management of hazardous waste throughout its life cycle by tracking currently active hazardous waste treatment, storage, and disposal facilities.

The Town is presently working on a Hazardous Materials Emergency Plan which outlines emergency response procedures should such an incident happen in North Kingstown. In addition the Hazardous Materials Emergency Plan will identify those facilities in North Kingstown that store extremely hazardous materials on site and provide site specific emergency response plans for accidental releases at these facilities.

The Hazardous Materials Response Plan provides an opportunity to identify critical spill event locations or locations in which spill events would seriously jeopardize the Town's wellfields. The plan should include proposed mitigative measures to minimize the risks posed by such spills.

POLICIES/OBJECTIVES

* THE TOWN SHOULD WORK WITH THE BUSINESS COMMUNITY TO FOSTER THE USE OF BEST MANAGEMENT PRACTICES FOR THE STORAGE, USE, AND DISPOSAL OF HAZARDOUS MATERIALS

RECOMMENDED ACTION:

1. DEVELOP A HAZARDOUS MATERIALS ORDINANCE WHICH SETS MINIMUM STANDARDS REGARDING THE STORAGE OF HAZARDOUS MATERIALS. INVESTIGATE ESTABLISHING AN INSPECTION PROGRAM TO BE CARRIED OUT IN CONJUNCTION WITH THE ORDINANCE

2. COMPLETE AND IMPLEMENT THE TOWN HAZARDOUS MATERIALS EMERGENCY RESPONSE PLAN. THE PLAN SHOULD INCLUDE IDENTIFICATION OF CRITICAL SPILL EVENT LOCATIONS AND ASSOCIATED CONTINGENCY PLANS

3. REVIEW, AND ENHANCE WHERE NECESSARY, SPILL RESPONSE MATERIALS AND PROCEDURES USED AT TOWN FACILITIES POTENTIALLY SUBJECT TO SPILL EVENTS

4. WORK WITH THE NORTH KINGSTOWN FIRE DEPARTMENT TO IDENTIFY ALL FACILITIES USING HAZARDOUS MATERIALS WITHIN THE AQUIFER

5. PREPARE EDUCATIONAL MATERIALS AND SPONSOR INFORMATIONAL WORKSHOPS FOR THE BUSINESS COMMUNITY REGARDING HAZARDOUS MATERIALS AND GROUNDWATER PROTECTION. TOPICS COVERED SHOULD INCLUDE GUIDANCE OR BEST MANAGEMENT PRACTICES FOR STORAGE AND HANDLING, SUCH AS USE OF CONTAINMENT STRUCTURES, PROPER DESIGN OF DRAINAGE SYSTEMS, APPROPRIATE WASTE MINIMIZATION AS WELL AS TREATMENT AND DISPOSAL OPTIONS

G. HOUSEHOLD HAZARDOUS MATERIALS/WASTE

Many commonly used household products are hazardous and pose a threat to human health and the environment. Because many of these products contain dangerous synthetic chemicals that are not removed by the soil, improper disposal of these substances by pouring them down the drain, into the toilet, or onto the ground could potentially contaminate the groundwater. Some of these chemicals can be harmful in very small amounts. A quart of motor oil can contaminate thousands of gallons of drinking water. Table 5 lists the hazardous components of some common household products.

The RIDEM sponsors household hazardous waste cleanup days several times a year at locations throughout the state. Citizens may dispose of their hazardous wastes at these locations free of charge. In addition, used motor oil can be recycled at the North Kingstown Transfer Station.

POLICIES/OBJECTIVES

* IDENTIFY A SET OF APPROPRIATE TECHNIQUES THAT FACILITATES PROPER DISPOSAL OF HOUSEHOLD HAZARDOUS MATERIALS

* EXPLORE A REGIONAL EFFORT TO IMPLEMENT A FULL PROGRAM OF DISPOSAL ALTERNATIVES

RECOMMENDED ACTION:

1. PUBLICIZE STATE SPONSORED HAZARDOUS WASTE CLEAN UP DAYS

2. SPONSOR LOCAL HAZARDOUS WASTE CLEAN UP DAYS

3. ENCOURAGE THE STATE TO ESTABLISH PERMANENT HAZARDOUS WASTE COLLECTION SITES

4. DEVELOP EDUCATIONAL PROGRAMS AND MATERIALS ABOUT PROPER WASTE DISPOSAL AND NON TOXIC ALTERNATIVES FOR USE IN SCHOOLS AND THE LIBRARY

TABLE 5
TOXIC AND HAZARDOUS COMPONENTS OF COMMON HOUSEHOLD PRODUCTS

Product	Toxic or hazardous components
Antifreeze (gasoline or coolant systems)	methanol, ethylene glycol
Automatic transmission fluid	petroleum distillates, xylene
Battery acid (electrolyte)	sulfuric acid
Degreasers for driveways and garages	petroleum solvents, alcohols, glycol ether
Degreasers for engines and metal	chlorinated hydrocarbons, toluene, phenols, dichloroperchloroethylene
Engine and radiator flushes	petroleum solvents, ketones, butanol, glycol ether
Hydraulic fluid (brake fluide)	hydrocarbons, fluorocarbons
Motor oils and waste oils	hydrocarbons
Gasoline and jet fuel	hydrocarbons
Diesel fuel, kerosene, #2 heating oil	hydrocarbons
Grease, lubes	hydrocarbons
Rustproofers	phenols, heavy metals
Car wash detergents	alkyl benzene sulfonates
Car waxes and polishes	petroleum distillates, hydrocarbons
Asphalt and roofing tar	hydrocarbons
Paints, varnishes, stains, dyes	heavy metals, toluene
Paint and lacquer thinner	acetone, benzene, toluene, butyl, acetate, methyl ketones
Paint and varnish removers, deglossers	methylene chloride, toluene, acetone, xylene, ethanol, benzene, methanol
Paint brush cleaners	hydrocarbons, toluene, acetone, methanol, glycol ethers, methyl ethyl ketones
Floor and furniture strippers	xylene
Metal polishes	petroleum distillates, isopropanol, petroleum naptha
Laundry soil and stain removers	petroleum distillates, tetrachloroethylene
Spot removers and dry cleaning fluid	hydrocarbons, benzene, trichloroethylene, 1, 1, 1 trichloroethane
Other solvents	acetone, benzene
Rock salt (Halite)	sodium concentration
Refrigerants	1, 1, 2 trichloro - 1, 2, 2 trifluoroethane
Bug and tar removers	xylene, petroleum distillates
Household cleansers, oven cleaners	xylenols, glycol ethers, isopropanol
Drain cleaners	1, 1, 1 trichloroethane
Toilet cleaners	xylene, sulfonates, chlorinated phenols
Cesspool cleaners	tetrachloroethylene, dichlorobenzene, methylene chloride
Disinfectants	cresol, xylenols
Pesticides (all types)	napthalene, phosphorus, xylene, chloroform, heavy metals, chlorinated hydrocarbons
Photochemicals	phenols, sodium sulfite, cyanine, silver halide, potassium bromide
Printing ink	heavy metals, phenol-formaldehyde
Wood preservatives (creosote)	pentachlorophenols
Swimming pool chlorine	sodium hypochlorite
Lye or caustic soda	sodium hydroxide
Jewelry cleaners	sodium cyanide

* Courtesy, Barnstable (MA) Board of Health

H. STORAGE AND HANDLING OF ROAD SALT

Improper storage of salt piles and heavy salt applications on state and local roads for winter maintenance has caused water quality problems in many areas. The primary concern with road salt application is the potential of elevating sodium levels to unhealthy levels in drinking water supplies. In addition, chloride while not a health concern may effect taste of water and cause corrosion of piping.

While sodium levels in North Kingstown's public wells have been impacted by road salt, sodium and chloride levels are still well below suggested standards. The roads within the aquifer region which are likely to have the most significant impact on Town wells are state maintained.

The location of uncovered salt storage piles within the aquifer has the potential to contaminate groundwater supplies and other freshwater resources. The State is presently in the process of developing a salt storage policy.

POLICIES/OBJECTIVES

* TO ELIMINATE SALT STORAGE WITHIN THE AQUIFER AREAS

* TO REDUCE SALT APPLICATION RATES WITHIN THE AQUIFER AREAS

RECOMMENDED ACTION:

1. ADOPT REGULATIONS WHICH:

A. PROHIBIT THE LOCATION OF BOTH PUBLIC AND PRIVATE SALT STORAGE PILES WITHIN THE AQUIFER AREAS

B. REQUIRE THAT ALL SALT STORAGE PILES BE LOCATED ON IMPERVIOUS, CURBED SURFACES, AND ARE COVERED

2. THE GROUNDWATER COMMITTEE WILL WORK WITH THE NORTH KINGSTOWN DEPARTMENT OF PUBLIC WORKS TO:

A. MAINTAIN AND CALIBRATE EQUIPMENT TO AVOID EXCESSIVE USE OF ROAD SALT

B. EDUCATE TOWN PERSONNEL ABOUT SALT APPLICATION AND STORAGE

C. ENCOURAGE USE OF 2-7 RATIO OF SALT TO SAND, AND POSSIBLY CHANGE TO THE USE OF CALCIUM CHLORIDE

I. PESTICIDES AND FERTILIZERS

The application of excessive amounts of fertilizers and pesticides on home lawns and gardens may contribute significant

amounts of nutrients to surface waters and groundwater.

Fertilizers contain nitrates and phosphates which are the contaminants of concern. Runoff from fertilized lawns that are near or adjacent to surface water bodies may carry fertilizers to the water body and promote algal growth and eutrophication. Appropriate vegetated buffers from water bodies reduces the potential for such contamination. In addition, overfertilizing along with overwatering lawns may cause fertilizers to leach down into the groundwater. Land development techniques such as clustering which have the potential to reduce the amount of land committed to lawns also tend to reduce demand for fertilizers.

Although pesticides are a considered a known contamination source, tests performed by the RIDEM indicate that very few pesticides are getting into the groundwater. Some pesticides may however, be being used in North Kingstown for which the state is not testing at present.

POLICIES/OBJECTIVES

* ENCOURAGE THE PROPER USE (BEST MANAGEMENT PRACTICES-BMPs) OF PESTICIDES AND FERTILIZERS FOR WATER QUALITY PROTECTION

RECOMMENDED ACTION:

1. EDUCATE RESIDENTS ABOUT THE PROPER USE OF FERTILIZERS AND PESTICIDES AND ALTERNATIVES

2. IDENTIFY MAJOR USERS OF FERTILIZERS AND PESTICIDES IN THE AQUIFER REGIONS

3. ENCOURAGE CLUSTERING OF DEVELOPMENT TO RETAIN VEGETATED AND FORESTED AREAS

4. ENCOURAGE XERISCAPING AND OTHER LOW MAINTENANCE ALTERNATIVE LANDSCAPING TECHNIQUES

5. REQUIRE VEGETATED BUFFERS (150 FEET RECOMMENDED) AROUND SURFACE WATER BODIES

J. JUNKYARDS/SALVAGE YARDS

Automobile junkyards and salvage yards have the potential to contaminate groundwater. Historically junk and salvage yards have been repositories for varied waste for reuse (such as vehicles which are disassembled for parts) and vehicle storage which may introduce substances into groundwater, surface waters, and soils such as oil, gas, antifreeze, brake fluid, transmission fluid, battery acids, and solvents.

POLICIES/OBJECTIVES

* CONTINUE PROHIBITION OF JUNK AND SALVAGE OPERATIONS IN AQUIFER AREAS

* REGULATE ALL OTHER PROPOSED JUNK AND SALVAGE OPERATIONS BY SPECIAL EXCEPTION

RECOMMENDED ACTION:

1. INSTITUTE AN INSPECTION PROGRAM FOR ALL JUNK AND SALVAGE YARDS IN THE AQUIFER

2. SET STANDARDS FOR OPERATION OR BEST MANAGEMENT PRACTICES AS A CONDITION OF LICENSE RENEWALS

K. SAND AND GRAVEL OPERATIONS

Sand and gravel serves as an important resource in North Kingstown. In many parts of the Town's aquifers, it is the primary protective covering over the groundwater. It is equally important not only as a Town natural resource but statewide as a resource that is a vital component in development. Septic systems and construction projects are but two development activities that require the types of sand and gravel that are found in North Kingstown.

Because of its abundance in stratified drift sand and gravel aquifers, North Kingstown continues to be the host of sand and gravel extraction operations. Some aquifer areas contain approximately 75 feet of sand and gravel between the land surface and the water table.

A properly run sand and gravel operation can minimize contamination risks to groundwater. As is the case with other land use activities, when improper management and storage of materials and equipment occurs the risk of contamination increases. For example, associated with sand and gravel operations is the use of heavy equipment. At some sites, fuel and repair equipment are also stored; gasoline, oil, and similar products pose a distinct threat to the groundwater.

The sands and gravel that comprise the saturated soils of the groundwater can be of equal quality as the sands and gravel that overlay the groundwater. As such, plans that include excavation into the watertable have been proposed in the past.

Such excavation raises serious concerns. The major concern of which is that it removes a layer of protection against contamination of the aquifer since the soil overlying the aquifer has the capacity to retain and attenuate contaminants. Any leakage or discharge of fuel inadvertently could enter the

groundwater without any attenuation by soils. In addition the creation of such surface water bodies may represent tempting sites for illegal disposal of unwanted possibly hazardous materials by unrelated parties. In fact these areas continue to be a part of the groundwater system with the potentially degraded water eventually moving towards a public well.

Finally, the final development of the land following gravel extraction/earth removal activities may also pose risks to the groundwater. Where a sufficient separation has been provided to the water table, land may be developed using an ISDS, which is the predominant form of sanitary waste disposal in North Kingstown. Research has shown that a minimum of 8 feet is required in sand and gravel soils to allow for sufficient filtration and attenuation of the waste.

Alternatively, some consideration may be warranted to reduce a required separation to the water table where the operators of sand and gravel activities are prepared to dedicate the site to an open space conservation easement. Such dedication would not remove any other requirements associated with the proper revegetation and reclamation of the site.

All of these issues raise questions about the proper regulation of gravel extraction activities such that the integrity of the groundwater is protected.

POLICIES/OBJECTIVES

* REGULATE SAND AND GRAVEL OPERATIONS TO MINIMIZE RISKS TO GROUNDWATER RESOURCES

RECOMMENDED ACTION:

1. CONTINUE TO REGULATE SAND AND GRAVEL EXTRACTION AS A SPECIAL EXCEPTION

2. DEVELOP ADDITIONAL REVIEW CRITERIA FOR MONITORING AND ENFORCING SAND AND GRAVEL OPERATIONS

3. SET UP INSPECTION SCHEDULES FOR MONITORING SAND AND GRAVEL ACTIVITIES

4. REQUIRE A RESTORATION AND STABILIZATION PLAN AS PART OF SAND AND GRAVEL EXTRACTION OPERATORS PERMIT

5. PROHIBIT EXTRACTION INTO THE WATER TABLE

6. MAINTAIN 8 FOOT SEPARATION BETWEEN GROUNDWATER TABLE AND LOWEST LEVEL OF EXTRACTION ACTIVITIES

7. PROHIBIT FUEL STORAGE AND EQUIPMENT REPAIR ON SITE

8. ENCOURAGE THE USE OF BEST MANAGEMENT PRACTICES FOR STORAGE OF EQUIPMENT

9. REVIEW EARTH REMOVAL ORDINANCE AND BRING INTO CONFORMANCE WITH THE ABOVE RECOMMENDATIONS

IX. OTHER AQUIFER PROTECTION METHODS

A. ZONING REGULATIONS

Zoning is the primary tool used to regulate land use. As mentioned earlier the Town of North Kingstown has had a Groundwater Reservoir and Groundwater Recharge Overlay Districts Ordinances to protect the Hunt, Annaquatucket, and Pettaquamscutt Aquifers in place since 1974 (as amended in 1988 and 1990). This revised ordinance prohibits many threatening land uses and activities and provides that some uses are permitted by special exception of the Zoning Board of Review after site plan approval by the Planning Commission. In examining the potential threats to the Town's groundwater resources the Groundwater Committee suggests many strategies outlined in this document will require additional changes to the zoning ordinance.

1. GROUNDWATER DISTRICTS ORDINANCE

Although the 1990 amendments to this existing Groundwater Districts Overlay Ordinance address the siting of high density development and other land uses with the potential to contaminate groundwater resources, the current regulations lack sufficient criteria upon which zoning board decisions can be based regarding development in aquifer areas.

a. ZONING BOARD CRITERIA

Criteria such as performance and design standards should be a part of the ordinance. This approach allows the development community to better understand the expectations of the Town and clarifies the findings that the zoning board must reach in their decision making. Performance and design criteria should include but not be limited to:

*adequacy of the site for proposed use;
*suitability of the site for the proposed use;
*adequacy of sewage disposal method, water source, and stormwater management;
*adequacy of utilities and other public services;
*impact on public or private water supplies;
*storage of any potentially hazardous material and hazardous materials contingency plans for these materials;
*soil erosion and sediment control plans;
*proposed groundwater withdrawals;

*provision of appropriate butters for surface water bodies.
*nitrate-nitrogen loading.

b. SITE PLAN SUBMISSION REQUIREMENTS

In addition to current site plan review requirements, sufficient information must be provided for the Planning Commission and Zoning Board that allows for an adequate assessment of the full impact of the proposed use on the Town's groundwater resources. Submission requirements should include but not be limited to:

*existing and proposed water sources and volumes of water use;
*any proposed facilities for refuse storage and disposal;
*sewage disposal methods, other waste disposal methods, proposed stormwater management methods;
*existing vegetation, topographic features and water bodies /wetlands;
*public and private water supply wells on adjacent properties, and
*limits of groundwater overlay districts or wellhead areas

c. GUARANTEE OF PERFORMANCE

The adoption of appropriate regulations is not sufficient to protect groundwater unless those regulations are fully enforced. The Town zoning official has the authority to enforce the zoning regulations as well as any conditions imposed by the zoning board of planning commission as a result of their findings during the review process.

B. DEVELOP A TOWN GROUNDWATER MONITORING PROGRAM

The development of a Town groundwater monitoring program would provide a means of detecting pollution plumes so that mitigation can be instituted before reaching a public water supply well. At present the Town relies primarily on the testing of the Town's municipal wells performed by the RIDOH as the means of monitoring the drinking water quality. The establishment of wellhead protection areas and the mapping of potential contamination sources allows for the targeting of areas where contaminants if discharged might be located. This would involve locating observation wells in the vicinity of pollutant sources so that pollutants (if present) may be detected early. Additionally, the wellhead studies could be used to decide where monitoring wells should be located such that they provide a level of information to the Water Department about the quality of water approaching the wells.

In recognition of the importance of groundwater monitoring as a protection measure, the North Kingstown Water Department has

instituted beginning fiscal year 1992 a program to install groundwater monitoring wells. $50,000 has been budgeted for this purpose. The number of wells has not yet been set.

Specifically, monitoring wells would be appropriately be located to monitor contamination sources such as UICs, landfills, and USTS.

It would also be beneficial to the Town to work with businesses to develop a monitoring well program for those business facilities located in sensitive areas. The costs associated with laboratory testing could be shared.

All groundwater quality monitoring information should be centralized and checked on a regular basis.

C. GROUNDWATER EDUCATION PROGRAM

Educating people about the importance of the Town's groundwater resources is one of the keys to a successful groundwater protection program. A groundwater education program should be designed to reach all levels of the community, including business people, town staff, schools, and the general public.

Business Community. Different facets of the business community must be educated about how they can work with the Town to protect groundwater resources. Businesses that sell products that pose a threat to groundwater should be made aware of the potential impacts of product misuse as well as proper handling and storage techniques. Other businesses that utilize materials that are hazardous to groundwater must also be educated about proper handling, storage, and disposal of these materials. In addition the Town should work with business people to ensure that they meet federal, state, and local regulatory requirements.

Town Staff. Department of Public Works employees are involved in activities which may impact the Town's groundwater resources. These activities include road salting, stormwater management, and handling other hazardous materials such as petroleum products. Staff education about the hazards posed to groundwater by such activities and proper use of these materials would set an example for the rest of the community.

Other Town staff who would benefit from educational programs on groundwater protection include the Building Official since he is the Town's zoning enforcement officer and therefore needs to understand the various regulatory requirements controlling the groundwater areas; the Engineering Department which inspects approved developments; and the Fire Department which deals with legislation related to hazardous materials.

Schools. An overall environmental education program should be instituted at the North Kingstown schools. An environmental education program could begin with a survey of schools by sending a questionnaire to school principals regarding the current environmental education programs.

The Town could work with the school department to include environmental education as part of the in-service teacher education. A given number of in-service sessions per year could be devoted to environmental issues. The program should be designed to be used by all teachers at different levels in different ways.

General Public. The Groundwater Committee has already created a basic educational flyer about the groundwater resources in North Kingstown which was mailed to Town residents. The Committee may decide to publish additional educational materials (pamphlets, flyers, etc.) which could be mailed to homeowners with tax or water bills or perhaps distributed by septage haulers and oil distributors. This could be a joint effort with other agencies or private groups interested in groundwater protection. In addition periodic workshops on groundwater issues could be developed and presented to the general public, or displays could be created for showing in the library, schools, or banks.

Accomplishing a full education program would be best achieved by creating a public body charged with implementation of these recommendations. One solution might be the establishment of a working environmental education committee. Such a committee would be composed of citizens with the various skills necessary to implement the Town's environmental education goals.

D. LAND ACQUISITION

The acquisition of land in the aquifer areas although one of the most expensive protection options offers the most protection, since certainly one of the most effective means of protecting the aquifers is to own and control the land above it. Land may be acquired by outright purchase or controlled by purchase of development rights. Still another means of obtaining aquifer lands might be through receiving land donations for tax credits. The ability of the Town to purchase land will vary over time depending on the economic conditions in the Town as well as in the state.

Since watershed management is critical to preserving and restoring the quality of the groundwater, the Town of North Kingstown Conservation Commission has established groundwater and wellhead protection as the Town's highest priority for land acquisition, and a list of open space sites within the aquifer regions has been compiled. In addition, the Groundwater Committee believes that future well sites must be identified and

purchased.

At least two funding programs exist that can support the Town's efforts at acquiring land in aquifer areas. The first, the RI Natural Heritage Program, has already been used by the Town to provide matching funds for the acquisition of land in the Annaquatucket Aquifer. The second source of funding assistance is the Water Quality Protection Fund, an element of the Water Quality Protection Act; this Act requires water suppliers to charge a 2.5 cent surcharge for each 1000 gallon of water used by a customer. The surcharge, in turn is to be used by the Water Resources Board to finance sufficient bonding for land acquisition.

The Town may also wish to consider seeking authorization for the institution of a real estate transfer tax the proceeds of which would be dedicated to open space preservation efforts. Finally, as the Town brings to review and consideration the water rate study, consideration should be given to including within the rate structure, funding for water quality protection. Such funding could be used for acquisition as well as monitoring.

X. CONTINGENCY PLANNING

A community such as Town of North Kingstown which is completely dependent on groundwater for its drinking water supply needs to not only plan for protection of this resource but also for response to unforseen emergencies. Such emergencies may include leaking underground storage tanks and unanticipated spills or discharges of hazardous materials while in transport or from fixed facilities.

A. EMERGENCY RESPONSE PLAN

The Town is presently in the process of preparing a Hazardous Materials Emergency Plan. This plan outlines the procedures to be followed should a hazardous materials release or spill occur and serves to prepare Town departments for an emergency response. In addition this plan will contain specific response plans for those facilities in North Kingstown which store extremely hazardous materials on site.

The preceding Groundwater Protection Plan describes contamination sources of concern. In addition. the Hazardous Materials Emergency Plan notes the transportation network over which hazardous materials likely travel. This plan documents response procedures including proper notification to Town Water Department employees and other water suppliers that may be effected.

B. CONNECTIONS TO OTHER SOURCES/SYSTEMS

As mentioned previously the North Kingstown water system has an emergency connection with the KCWA and the water system operated by the RIPA. While the North Kingstown water system is connected to the Narragansett Water system, the flow is directional to Narragansett only, and therefore cannot be considered an emergency connection. Although other connections have been discussed with surrounding water suppliers and as part of a possible statewide system, there are no formal plans for construction.

In order to assure full protection for emergency situations a full range of connections must be explored.

C. FUTURE WELL SITES

A number of reports and plans have been prepared by and for the Town which have recommended potential well sites for future use. The following sites have been suggested:

1. Kettle Hole Pond - in conjunction with the preparation of the Annaquatucket Wellhead study, a site was identified adjacent to Kettle Hole Pond (personal communication, D. Heath, USEPA). Use of this site would allow the Town to expand the use of the Annaquatucket Aquifer with out jeopardizing the safe yield. Such expansion would be appropriate in an emergency situation to replace a well or expand the Town's water supply capacity.

2. The Butcher Site - a report by Lee Pare & Associates, Inc. (March, 1980) suggested two possible schemes for development of the Butcher site. This is a tested and proven potential well site.

3. Hunt River Drive Site (Dyer Avenue) - this site in the Hunt Aquifer was suggested in the Palmer-Donovan Study.

The use of computerized models for the preparation of wellhead delineation studies will provide the Town with the flexibility to identify other well sites and their wellheads with a view to the potential impact from existing land uses. A true investigation into the development of additional well sites will involve the expenditure of funds for testing of the site to determine the potential for development of high yielding wells.

XI. OTHER IMPLEMENTATION ISSUES

A. COORDINATION WITH THE STATE AND OTHER MUNICIPALITIES

As with most natural resources, groundwater knows no

municipal boundaries. Groundwater protection and water supply management are responsibilities shared by federal, state, and local government. The recommendations of the Groundwater Protection plan are meant to supplement existing state and federal regulations and to strengthen the Town's role in protecting its vital groundwater resources. The need for coordinated action is noted throughout this plan.

Beginning in 1988 the Town has worked with the towns of East Greenwich, Warwick, the KCWA and RIPA on protection of the Hunt Aquifer. To that end and as described above, the Town anticipates accomplishing a wellhead study and protection program. The results of this effort may show the need for a regional body. This regional body could be instrumental in ensuring the implementation of a Hunt Aquifer protection plan.

North Kingstown is also working with the towns of South Kingstown, Exeter, the Kingstown Water District, the Wakefield Water Company, and the University of Rhode Island on a study of water quality and quantity issues in the Chipuxet Aquifer. The University is coordinating this effort.

A final regional effort which the Town of North Kingstown is now participating in is the Narrow River Stormwater Management Study. North Kingstown along with the towns of Narragansett and South Kingstown have been awarded a $275,000 Aquafund grant to develop a stormwater management plan for the Narrow River. A portion of this project falls within the Pettaquamscutt Aquifer.

The state of Rhode Island has available data regarding state permitted activities such as UICs, USTs, and solid waste. Because these activities have the potential to impact groundwater, it is important that information regarding these activities be shared with the Town. All state permits and conditions of approval should be forwarded to the Town, as well as monitoring results and investigation reports.

Because of the sensitive nature of the aquifers some consideration should be given to a coordinated review of development proposals in these areas. This would involve bringing together all parties involved and may include RIDEM, CRMC, RIDOT and abutting communities.

B. FUNDING MECHANISMS

The exploration of funding methods will be necessary in order to fully implement this Groundwater Protection Plan. One possible funding mechanism that should be considered is the inclusion of funds for water quality protection within the water rate structure. The Town is presently conducting a water rate study, making the investigation of the feasibility of this funding source particularly timely.

Table 6 compares local revenue sources for wellhead protection.

TABLE 6

POTENTIAL LOCAL REVENUE SOURCES

REVENUE SOURCE	WHO PAYS[1]	REVENUE YIELD[2]	PREDICT-ABILITY[3]	COST[4]	INCENTIVE EFFECTS[5]
TAXES	TAXPAYERS	HIGH	HIGH	LOW	WEAK
IMPACT FEES	POLLUTERS	HIGH	LOW	HIGH	STRONG
PERMIT FEES	POLLUTERS	LOW	LOW	MOD.	STRONG
FINES/PENALTIES	POLLUTERS	MOD.	LOW	HIGH	STRONG
EXCISE TAXES	VARIES	MOD.	MOD.	MOD.	MOD.
UNIT CHARGES	BENEFICIARY	HIGH	HIGH	LOW	MOD.
ACCESS FEES	BENEFICIARY	HIGH	MOD.	LOW	STRONG
SERVICE FEES	BENEFICIARY	HIGH	HIGH	LOW	MOD.

(1) Indicates whether the funding burden falls primarily on polluters, beneficiaries of wellhead protection activities, or general taxpayers.

(2) Indicates whether the revenue yield from a particular funding source will be high, medium, or low relative to other sources.

(3) Indicates the relative stability and predictability of revenues from a particular funding source from year to year.

(4) Indicates the relative administrative costs of a particular funding source.

(5) Indicates whether the incentives for changing behavior (e.g., water conservation) are relatively strong or weak for a particular funding source.

Source: USEPA

C. FUTURE ROLE OF THE GROUNDWATER COMMITTEE

The Groundwater Committee does not believe that their job is over with the completion and acceptance of the Groundwater Protection Plan. The Committee sees a role for itself in moving the yet to be completed wellhead studies forward. Other tasks could include monitoring the implementation of the proposed groundwater protection recommendations and public education regarding such initiatives.

The Town Council should draft a new charge for the Committee and revitalize it with the appointment of additional members or replacement of those who no longer wish to serve.

XII. SPECIFIC RECOMMENDATIONS BASED ON WELLHEAD STUDIES (RESERVED)

XIII. GLOSSARY

Analytical model	A model that provides approximate or exact solutions to simplified forms of the differential equations for water movement and solute transport. Analytical models can generally be solved with calculations or computers.
Aquifer	Water bearing formations, bedrock, sand, or gravel that yield useable supplies of water to wells.
Aquifer system	A body of permeable and relatively impermeable materials that functions regionally as a water-yielding unit. It comprises two or more permeable units separated at least locally by confining units that impede groundwater movement but do not greatly affect the regional hydraulic continuity of the system. The permeable materials can include both saturated and unsaturated sections.
Attenuation	The process by which a compound is reduced in concentration over time, through adsorption, degradation, dilution, and/or transformation.
Drainage Basin	The land area from which surface runoff drains into a stream system, pond, or other waterbody
Effluent	Treated wastewater that flows from a septic system or any other treatment process.
Filtration	The physical removal of suspended particles from effluent by soil or sand particles.
Geology	The structure of the earth in a given region or area, including soil, rocks, and water.
Groundwater	The portion of water contained in interconnected pores of fractures located beneath the surface of the earth

Groundwater Flow	The movement of water through openings in sediment and rock that occurs in the zone of saturation
Groundwater model	A simplified conceptual or mathematical image of a groundwater system, describing the feature essential to the purpose for which the model was developed and including various assumptions pertinent to the system. Mathematical groundwater models can include numerical and analytical models
Groundwater Recharge	The process in which precipitation infiltrates beneath the surface of the earth to the saturated or unsaturated zones, or when an aquifer receives seepage from a surface water body
Groundwater Reservoir	Stratified drift deposits having a saturated thickness greater than or equal to 40 feet and a transmissivity greater than or equal to 4000 feet squared per day. These are areas are the high yielding portions of the aquifer.
Hydrogeology	A study that encompasses the interrelationships of geologic materials and processes with water
Hydrology	The study of the occurrence, distribution, movement and chemistry of all waters
Hydrologic Cycle	A cyclical process in which water undergoes endless circulation from ocean to atmosphere to the earth and back to the ocean, the water is stored temporarily in lakes, streams, the soil, or ground
Hazardous materials	Chemicals or substances which are harmful to human health and the environment. These substances are used in industry, agriculture, medicine, research and consumer goods. The present a hazard when they are released into the environment (air, water, or ground)

Hazardous waste	Waste materials that are dangerous to handle or dispose of; often characterized as being flammable, corrosive, toxic reactive, volatile, or water soluble
Hydraulic conductivity	A physical property that reflects the ability of bedrock, sand, or gravel to transmit water at a specific rate.
Induced infiltration	When the cone of depression from a pumping well extends to a nearby stream or lake, lowering the adjacent water table below the stream or lake level the result is that the stream or lake begins to lose water to the adjacent groundwater aquifer.
Infiltration	The process in which water seeps down into the groundwater
Interbasin transfer	Water from one watershed that is discharged into another watershed.
Leachate	Water that carries away nutrient chemicals or dissolved contaminants as it seeps from sources of contamination (i.e., solid waste disposal sites, septic systems, road salt piles, etc.)
Leaching	The process by which nutrient chemicals or contaminants are dissolved and carried away by water.
Monitoring Well	A well that is used for periodic or continuous sampling of groundwater to determine changes in water level, water quality, or the extent of groundwater contamination
Maximum Contaminant Level (MCL)	The mandatory maximum level of a contaminant established by the USEPA as close to the MCLG as feasible based on technological and economic considerations. The MCLs set the quality of water that is acceptable for distribution by a public water system.
Maximum Contaminant Level Goal (MCLG)	Nonmandatory standard or maximum level of a substance that the USEPA has established in consultation with the National Academy of Sciences and has

	deemed acceptable based on reviews of the human and animal health effects data for a given substance.
Mound System	Also called a filled system. An alternative system design in which fill material, generally sand, is laid on top of plowed soils that are unsuitable for waste treatment. These systems are generally used where there is an inadequate thickness of acceptable soil to support a conventional system.
Percolation	Downward movement of water through the unsaturated zone; the act of water seeping or filtering through the soil without a definite channel
Permeability	Ability of a porous medium to transmit fluids under a hydraulic gradient. The property or capacity of a porous rock, sediment, or soil for transmitting a fluid; it is a measure of the relative ease of fluid flow under unequal pressure
pH	A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity. Originally stood for "potential of hydrogen"
Pollutant	Any solute or cause of change in physical properties that renders water unfit for a given use
Potable water	Suitable for human consumption as drinking water
Primary Drinking Water Standards	A regulation which applies to public water systems specifying contaminants which, in the judgement of the USEPA administrator may have an adverse effect on the health of persons.
Public water supply system	System for provision to the public of piped water for human consumption, if such system has at least 15 service connection or regularly serves at least 25 individuals daily or at least 60 days out of the year. The term includes any

	collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with the system, and any collection or pretreatment storage facilities not under such control that are used primarily in connection with the system.
Recharge	The addition of water to the zone of saturation; also, the amount of water added. Can be expressed as a rate.
Recharge area	Area in which water reaches the zone of saturation by surface infiltration. An area in which there are downward components of hydraulic head in the aquifer. Infiltration moves downward into the deeper parts of an aquifer in a recharge area.
Recharge boundary	An aquifer system boundary that adds water to the aquifer.
Safe yield	The rate at which groundwater can be withdrawn from an aquifer without causing a long term decline of the water table.
Saltwater Intrusion	Movement (due to human activity) of saline groundwater into an aquifer formerly occupied by freshwater.
Saturated zone	Portion of the subsurface environment in which all voids are ideally filled with water under pressure greater than atmospheric. The zone in which the voids in the rock or soil are filled with water at a pressure greater than atmospheric.
Septage	An anaerobic slurry of solid wastes, including the scum, sludge, and liquid contents of a septic tank at the time of pumping. The septage must be periodically pumped from the septic tank.
Septic System	An on-site waste disposal system.
Sole Source Aquifer (SSA)	An aquifer that is the sole or principal source of drinking water, as established

	under Section 1424(e) of the Safe Drinking Water Act (SDWA)
State Wellhead Protection Program	Program to protect wellhead protection areas within a State's jurisdiction from contaminants that may have any adverse effects on the health of persons
Time of Travel (TOT)	The time required for a contaminant to move in the saturated zone from a specific point to a well.
Transmissivity	The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient.
Unsaturated Zone	The area above the water table where the soil pores are not fully saturated, although some water may be present.
Watershed	Any sloping land surface that sheds water. Usually used synonymously with drainage basin.
Water table	Upper surface of a zone of saturation, where that surface is not formed by a confining unit.
Wellfield	An area containing two or more wells supplying a public water supply system.
Wellhead	The physical structure, facility, or device at the land surface from or through which groundwater flows or is pumped from subsurface, water bearing formations.
Wellhead Protection Area	The surface and subsurface area surrounding a water well or well field, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or well field.
Zone of Contribution	The area surrounding a pumping well that encompasses all areas or features that supply groundwater recharge to the well.

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