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December 20, 2004

Ms. Anne M. Krieg
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Town of Bar Harbor
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Bar Harbor, Maine 04609-1400

Subject: Final Report for Hydrogeologic Consultation, Bar Harbor, Maine

Dear Ms. Krieg,

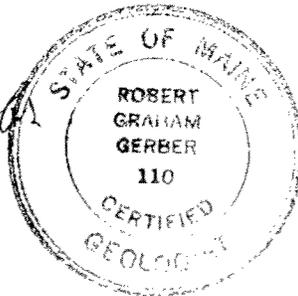
Stratex, LLC, is pleased to present this report summarizing the impact of residential development on sensitive and/or vulnerable hydrogeologic resources in Bar Harbor, Maine. Through goals articulated by the Town of Bar Harbor, Stratex has analyzed available hydrogeologic data and developed a process for protecting resources from the adverse impacts of residential development. This report concludes with recommendations for specific actions steps, should the Town wish to implement resource protection measures.

It has been a pleasure assisting you with this project. Please call if you have any questions.

Sincerely,

STRATEX, LLC

Robert G. Gerber, P.E., & C.G.
President



Hydrogeologic Resource Evaluation

Bar Harbor, Maine

Prepared by,
Stratex, LLC
November 16, 2004

**Hydrogeologic Resource Evaluation
Bar Harbor, Maine**

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Hydrogeologic Resource Evaluation Bar Harbor, Maine

Introduction

A workshop in Bar Harbor, Maine, in November, 2000, revealed citizen concerns regarding the impact of residential development on ground water resources. Increases in the rate of subdivision development, especially in rural areas on sites of marginal development potential, were a primary source of concern. To learn more about potential issues, the Town of Bar Harbor participated in a cooperative study with the United States Geological Survey (U.S.G.S.), and the National Park Service in Acadia National Park. The report prepared by the U.S.G.S (Nielsen, 2002) presented information on ground water use, recharge and nutrient loading from residential wastewater disposal in eleven watersheds located within the municipal boundary of Bar Harbor.

Bar Harbor was interested in extending the findings from the U.S.G.S. report to facilitate an understanding of the issues and to advance the protection of Bar Harbor's hydrogeologic resources. As a result, the Town of Bar Harbor retained Stratex, LLC, (Stratex) to conduct an assessment of the impact of residential development on hydrogeologic resources.

The primary objective of this study by Stratex is to develop a process for protecting sensitive and/or vulnerable hydrogeologic resources from the adverse impacts of residential subdivision development. The Town of Bar Harbor and the Conservation Commission are interested in protecting hydrogeologic resources in the present climate of increasing demand for residential development. A greater understanding of the issues and the options identified will facilitate the development of policy and implementation of strategies to protect the Town's hydrogeologic resources.

Hydrogeologic Resource Evaluation

This report summarizes Stratex's evaluation methods and presents findings through the following steps:

- Identification of water resource values and goals;
- Assessment of water resource conditions;
- Evaluation of resource threats and vulnerability.

Hydrogeologic Resource Evaluation is followed by a section on Process where three fundamental approaches for implementing environmental policy are presented. The Conclusion section of this report introduces action steps for implementing policy recommendations aimed at achieving the hydrogeologic resource goals identified by the town.

Resource Values and Goals

The Bar Harbor Planning Department and Conservation Commission identified hydrogeologic resources as the focus for this evaluation. Interests in ground and surface water sources stem from work performed by the U.S.G.S. in 2002. The Town is interested in the use of the data as well as other available technical data in the development of planning tools to protect vulnerable hydrogeologic resources from the adverse impacts of residential development. This study focuses on hydrogeologic resources outside the areas served by the Bar Harbor public water system (Figure 1).

Bar Harbor values the protection of water quantity and water quality. The goal of hydrogeologic resource protection is to minimize degradation to water quality and quantity from the adverse impacts of residential development. Interests in water resource protection are twofold: First, the Town is interested in maintaining the quantity and quality of water at existing private wells so that future residential development does not degrade existing supplies resulting in, for example, dry or contaminated wells. Second, unspoiled hydrologic resources are an important symbol of the region, with Acadia National Park serving as a national destination for more than 2.4 million visitors annually (Acadia National Park website).

The dominant use of Bar Harbor's hydrogeologic resources is withdrawal of surface and ground water for domestic purposes. Private water supply wells represent a significant percentage of total domestic water use in Bar Harbor. According to the Bar Harbor Tax Assessor, Mr. Steven Weed, approximately 1,114 parcels, or 43.9%, have onsite, private wells for their water supply, and approximately 1,423 parcels, or 56.1%, are served by public water. Assuming the number of residents per parcel is the same for parcels served by public and private water, then about 44% of Bar Harbor residents are served by private wells. Bar Harbor's Population in 2000 was equal to 4820 (U.S. Census website).

The percentage of onsite wells is consistent with private well use in the state of Maine where approximately 43% of all Maine residents obtain their drinking water from private, onsite ground water wells as shown in the following table.

**Ground water withdrawals
Maine, 2000**

STATE	POPULATION (thousands)				PUMPING RATES (million gallons per day)			
	Total	Served by Public Supply	Served by Private Wells		Total	Served by Public System	Served by Private Wells	
			Population (thousands)	Population (%)			Rate (mgd)	Rate (%)
Maine	1,270	726	549	43	65.3	29.6	35.7	54.7

Source: USGS website

In addition to the value as a drinking water source, ground water is also valuable in the dilution of wastewater discharged from residential septic systems. It is estimated that

about 75% of all Maine residents rely on septic systems (Jacobsen, 2004). In Bar Harbor, about half of the parcels in the town, or 49.3%, rely on on-site septic systems with the other half of town parcels served by the public wastewater system (Weed, personal communication). The area served by the Bar Harbor sewer district is shown on Figure 2.

Regulations exist to protect Maine's water resources. However, existing regulations are limited to large projects and susceptible resources like sand and gravel aquifers (which are not present in Bar Harbor). Two primary statutes safeguard Maine's ground and surface water resources. Title 38, Chapter 3, "Protection and Improvement of Waters," controls the discharge of pollutants to surface and ground water and requires the classification of the state's ground water to protect resources such as sand and gravel from contamination by pollutants. Title 22, Chapter 601, "Water for Human Consumption," regulates the quality of drinking water supplies. Appendix A contains additional detail on these statutes, and programs aimed at achieving the goals of the statutes such as the state Plumbing Code, the Subdivision Statute, and the Site Location of Development Law.

Despite the existence of these two primary statutes in Maine, there is no consistent, enforceable, statewide protection strategy for private water supply wells. Instead, homeowners with private wells rely on a patchwork of regulatory mechanisms that include environmental regulation of unique resources, and public health codes developed to address safety issues related to wastewater discharge. A more detailed review of federal, and state water resource protection strategies, included in Appendix A, further reveals the limitations of existing regulatory protection.

The protection of private residential wells tends to fall through the regulatory cracks. This gap in regulations creates rising concern in a climate of increasing residential development. The construction of dwelling units in Bar Harbor continues to increase steadily each year. From 1999 to 2003, the number of permits requested for new dwellings ranged from 40 to 60 dwelling units per year with an average of 55 new dwelling unit permits per year (Chamberlain, personal communication). Figure 3 shows a cumulative plot of new housing permits across the period from 1999 to 2003. Build-out analysis by the College of the Atlantic (Rowan, 2004) extrapolates historic housing trends out to the year 2034 (Figure 4). Rowan estimates the rate of new housing across the 30 year period from 2004 to 2034 to be about 70 new dwelling units per year on average.

To compensate for gaps in the regulation of private water supplies, municipalities like Bar Harbor have elected to protect water resources through local land use management. Based on resource goals established by the Town of Bar Harbor, Stratex presents the following information on the current condition of the resource, and provides implementation strategies to achieve hydrogeologic resource protection. The current condition of Bar Harbor's hydrogeologic resources is provided in the following section. A discussion of fundamental approaches and protection strategies follows in the Process and Conclusion sections of this study.

Resource Condition

This hydrogeologic study focuses on the adverse impacts of residential subdivision development on water resources in Bar Harbor. As part of this section on Resource Condition, Stratex reviewed published reports and compiled available well and water quality data as the foundation for developing a technical opinion on the present condition of Bar Harbor's hydrogeologic resources. First, a review of published reports is provided.

In 1980, the U.S.G.S. developed a study titled, "Ground Water Availability in Acadia National Park and Vicinity, Hancock County and Knox County, Maine" (Hansen, 1980). This work later served as a technical reference for a water-resources management plan for the park (Kahl, 2000) and subsequent work by the U.S.G.S. (Nielsen, 2002). Hansen (1980) found that the well yield from a review of 160 bedrock wells ranged from 0.5 gallons per minute to 100 gallons per minute with a median yield of 10 gallons per minute. Ground water quality evaluated for this study was deemed to be of "suitable" chemical quality for public water supply with a qualifying note of the presence of elevated Radon-222 in water from certain wells. The author found no significant differences in the water yielding properties of different bedrock units. The study did not report on the impacts of residential development on ground water quality, and testing for nitrate-nitrogen, a product of septic system discharge, was not evaluated by the author.

Twenty years later, Kahl et. al. prepared a Water Resources Management Plan for Acadia National Park (2000). The purpose of the report was to guide resource protection and research in Acadia Park over a five to ten year period. Management alternatives were presented for water-related issues that included watershed response to acidic deposition and climatic change, recreational uses on water bodies, wetland and estuarine protection, watershed management for water quality protection, and protection of public health. Objectives and recommendations focused on operations and monitoring within the park boundary. Residential wastewater was identified in Kahl's study as a potential threat to Acadia's water resources. However, objectives and recommendations for mitigating threats from sources outside the park boundary were limited to a statement of interest in developing cooperative watershed strategies with local and state regulatory agencies. In sum, the report did not present any new findings for ground water quantity or quality beyond Hansen's work in 1980. Surface water quality findings were limited to an analysis of impacts from operations and development inside the park boundaries.

More extensive hydrologic work by the U.S.G.S in the vicinity of Bar Harbor was presented in three published reports in 2002 (Nielsen). First, the U.S.G.S. measured flows and collected water quality samples in streams of several watersheds on Mount Desert Island during a period from 1999-2000. From this work the U.S.G.S. performed a second, more in-depth study of water quantity and nitrogen loading in the Northeast Creek/Fresh Meadow estuarine wetland located in Bar Harbor. In response to concerns over increasing residential development, the U.S.G.S. performed a third study in cooperation with the Town of Bar Harbor and the National Park Service. This third study

presents estimates of ground water quantity, an analysis of domestic water use, and an evaluation of recharge and nutrient dilution for several watersheds in Bar Harbor.

Nielsen (2002) evaluated water use and water recharge to assess whether “ground water is used faster than it is recharged to the system.” Nielsen states that, overall, the total estimated ground-water use is about 2.5% of the total amount of estimated recharge with use in some watersheds as high as 18% of recharge. Nielsen based her calculations, in part, on ground water recharge work by Robert Gerber (Gerber and Hebson, 1996) as well as other authors in New England.

Stratex reviewed published reports as background to this study on the impact of residential development on hydrogeologic resources in Bar Harbor. In particular, Stratex reviewed the work of Nielsen (2002) regarding present conditions and future estimates of the quantity and quality of water resources and the potential influence from residential development.

Despite certain similarities in methodology, Stratex’s takes a different approach to the calculation of nitrogen loading and bedrock recharge. Nielsen estimates a single bedrock recharge rate based on literature review to fractured bedrock aquifers in New England. It is Stratex’s opinion that some of the references may not be applicable for estimates of recharge to Maine bedrock. Stratex relies on the work of Gerber and Hebson (1996) which focuses on Maine soils and bedrock. Furthermore, Nielsen calculates a 10% reduction in recharge to bedrock areas overlain by the Presumpscot Formation. Stratex does not use a overlying clay recharge reduction method.

The methodology Stratex uses for calculating nitrate-nitrogen loading is through a review of potential mixing of nitrate-nitrogen in the soil ground water rather than in the bedrock ground water. This approach of calculating nitrate-nitrogen concentrations in soil rather than in bedrock is important for the following reasons:

- Some homeowners in Maine still use dug wells for their drinking water source.
- Analysis of nitrate-nitrogen mixing in bedrock assumes that the bedrock is a homogeneous medium. While this is an acceptable assumption for the regional study of bedrock aquifers and, for example, the impact on the estuarine environment as Nielsen studied (2002), it may not be appropriate on a residential lot-by-lot basis. This is due to the potential for localized features such as bedrock fractures, which can affect ground water flow creating a situation where a hydraulic connection (i.e., between a well and septic systems) is increased or decreased. As a result, bedrock fractures feeding into bedrock wells can exhibit strong local hydraulic connections with soil ground water beneath septic systems, negating the benefit of higher nitrate-nitrogen dilution potential of deeper bedrock units where fractures may carry ground water with lower background concentrations of nitrate-nitrogen.

Stratex performs soil recharge analysis using the Natural Resources Conservation Service Soil Mapping, and assigning recharge rates to individual soil types based on their physical properties and drainage characteristics (Table 1). Figure 10 shows a map of recharge rates for Bar Harbor based on soil types. Soil recharge rates are used to calculate dilution potential of nitrate nitrogen in soil ground water. Stratex calculated an average recharge in soil of 12 percent of precipitation or 6.9 inches per year for the Town of Bar Harbor. Stratex estimates bedrock recharge to be on the order of 10 percent of precipitation or 5.5 inches per year.

Using the domestic water consumption data developed by Nielsen (2002), Stratex prepared a table showing water use as a percentage of recharge to the bedrock aquifer (Table 2). This table provides an illustration of the water balance in the bedrock aquifer based on recharge rates developed by Stratex and water use estimates developed by the U.S.G.S. for the year 2001. The water balance was also extrapolated for future housing predictions. Using the housing build-out by Rowan (2004) at the College of the Atlantic, Stratex calculated ground water use as a percentage of recharge for the year 2034 (Table 3). For the U.S.G.S. basins evaluated, the water use as a percentage of bedrock recharge increases from 4.1% to 8.4% from 2004 to 2034. Figure 11 shows the U.S.G.S. basins included in the calculations.

Applying the principle of mass conservation to the ground water system enables an analysis of water balance where the bedrock aquifer is treated as a whole system with inputs and outputs integrated over that system. Water balance analysis is conceptually appealing to use, and has a long history of application in hydrology. However, there are limitations in the use of this type of analysis.

For example, water balance may be too coarse for small watersheds where a higher degree of resolution is required to account for significant changes in the physical landscape over short distances. Furthermore, it is difficult to accurately estimate the inputs (i.e., precipitation recharge, wastewater discharge) and outputs (i.e., ground water discharge to surface water systems and the ocean, residential pumping, plant uptake) in water systems, although scientific advances in hydrologic monitoring have refined the collection of data.

Issues in the use of water budget calculations arise from the fact that the amount of water that drinking water wells can “capture” is dependent on more than recharge alone, although recharge is a significant component of the budget. In other words, the amount of water a homeowner is able to withdraw from an aquifer depends on the dynamic response of the aquifer system to the given well. It is this very quandary that gave rise to the use of three-dimensional computer models to simulate in space and time, ground water flow, ground water recharge, well pumping, as well as other variables.

However, water budget calculations for Bar Harbor provide us with the indication, in a perfect ground water system where well capture and recharge are systematically similar, that water use is less than total recharge to the ground water system. The estimates

suggest that water use as a percentage of recharge is low (i.e., <10% on average) but it will more than double in 30 years.

Precipitation is an important variable in the calculation of ground water recharge. Changes in precipitation can have a significant impact on ground water availability. A review of precipitation data across the past ten years demonstrates the impact of a drought year. Bar Harbor has an average annual precipitation rate of about 55 inches per year (Nielsen, 2002). Figure 5 shows a plot of average monthly precipitation totals for the period from 1981 to 2004 for one of the recording stations in Acadia National Park. Cumulative plots are shown on Figure 6. The monthly precipitation totals measured during 2001, the drought year, are also shown on these graphs. Recharge to the ground water system occurs as a percentage of precipitation, the rest being lost to runoff and evapo-transpiration. The total precipitation in 2001 was about 25 inches or 45% of the average annual rate of 55 inches per year. With a bedrock recharge rate of about 10% of precipitation, bedrock recharge in 2001 would be on the order of 2.5 inches compared to 5.5 inches for a year with average precipitation.

A review of available well data also provides a window into Bar Harbor's hydrogeologic resource conditions. Well data from more than 370 wells compiled for this study show an average well depth of 234 feet and a median well yield of 5 gallons per minute (Figures 7 and 8, Maine Geological Survey, unpublished data gathered since 1987). While the well yield is significantly less than the median yield of 10 gallons per minute presented by Hansen (1980), it is still well above 0.5 gallons per minute, the minimum amount needed to adequately supply most single family dwellings. It is interesting that only 38% of the 370 wells reviewed for this study were less than 200 feet deep compared to Hansen's results where 78% of wells were less than 200 feet deep. It is likely that the 370 wells reviewed for this study were drilled deeper in search of both higher yields and to provide for larger storage capacity in the borehole. Stratex calculated a median yield for wells less than 200 feet of 8 gallons per minute and a median yield in wells equal to or deeper than 200 feet of 4 gallons per minute.

Based on a review of well data, published reports, geologic maps, and precipitation data, it is Stratex's opinion that Bar Harbor is likely to have enough water to supply the needs of current dwellings as well as the dwellings predicted under the build-out scenario for 2034. Our opinion is based on assumptions that areas presently zoned as unbuildable (i.e., wetlands, steep slopes, etc) will remain undeveloped, annual precipitation rates will continue close to the past average, future pumping rates at residential dwellings will be consistent with current average pumping rates, conserved areas (i.e., park land) will remain undeveloped, and there will be reasonable limits on impervious cover at new developments. There will be exceptions to this general statement of water availability, particularly in areas where well yield is marginal relative to bedrock fractures, soil type, and ground water recharge zones. Also, a well that may provide sufficient water under normal conditions may be compromised during drought conditions by a lower ground water table caused by a reduction in recharge derived from precipitation. Furthermore, new development in close proximity to older wells, increased pumping near existing

wells, or deep excavations such as rock quarries could impact water availability by lowering the ground water table beyond the reach of existing wells.

While Bar Harbor is likely to have enough ground water to meet private well water needs in most of the areas that are zoned for 1-acre lots, the town faces a larger issue with respect to water quality. Bar Harbor faces the potential for contamination from residential activities, such as the storage of chemicals and petroleum, and from onsite septic systems. Septic system contamination of ground water resources is likely to be the greatest issue to hydrogeologic resource protection, especially in local areas where hydrogeologic conditions create a more vulnerable physical setting. For example, thin soils, areas of exposed bedrock, and ground water recharge areas (i.e., topographic highs) represent the vulnerable hydrogeologic settings. Research by Robinson (2004) demonstrated that positioning a residential subdivision near the recharge area of a watershed (versus near the discharge area) increases the potential for well contamination from onsite septic systems.

Contamination from septic systems is one of the most significant issues regarding the potential for adverse impacts to water resources from residential development. The threat derives from two main sources: pathogens (i.e., bacteria and viruses), and elevated nitrate-nitrogen. Methods for alleviating these sources include ensuring sufficient separation distance between a well and septic system to allow die-off of pathogens (i.e., provide a distance in rock or soil that represents 200 days of ground water travel time), and to provide sufficient mixing of wastewater to reduce concentrations of nitrate nitrogen at the wellhead to acceptable levels (i.e., $< 10\text{mg/l NO}_3$). Other factors affecting the potential for well contamination from septic systems includes the potential for salt water intrusion in the coastal setting, and/or drought conditions that reduce the dilution potential of the aquifer.

Nitrate-nitrogen, a product of septic system discharge, has significant health effects at elevated levels. Nitrate-nitrogen is highly mobile in water, and has a low adsorption potential. Nitrate-nitrogen is reduced in concentration in water primarily through dilution. Concentrations of nitrate-nitrogen can also be reduced in the presence of high organic carbon and low oxygen, although the effect of this process on reducing nitrate-nitrogen concentrations in ground water is negligible compared to the effect of dilution. Septic systems release nitrogen in wastewater effluent primarily as inorganic nitrogen at concentrations ranging from 30 to 111 mg/l (Robertson, 1991) with ammonia nitrogen as the dominant nitrogen compound (Hantzsche, 1992). After introduction into the soil at the disposal field, ammonia nitrogen undergoes transformations in the presence of oxygen. Nitrate-nitrogen is the predominant end product of the nitrification process.

To understand current water quality conditions in Bar Harbor, Stratex reviewed 10 years of test data for nitrate-nitrogen concentrations in well water. There were only 236 nitrate-nitrogen tests conducted on private well water (from dug and drilled wells) in Bar Harbor across the period from 1991 to 2000 (Maine Health and Environmental Testing Laboratory, unpublished data, 2004). With about 1,114 parcels in Bar Harbor served by

wells, this represents annual water quality testing for nitrate-nitrogen of only 24 wells or 2% of all wells in the Town. The Maine Department of Human Services guides well owners to perform regular testing (i.e., annual) of private wells. The frequency of nitrate-nitrogen occurrence in Bar Harbor wells is illustrated in Figures 9 and 10.

Records from 200 tests indicate that the concentration of nitrate-nitrogen in private well water from drilled wells in Bar Harbor is 0.6 mg/l on average. The median value was 0.2 mg/l or the detection limit. This concentration is well below the EPA Maximum Contaminant level of 10 mg/l. Precipitation typically has a concentration of nitrate-nitrogen of about 0.25 mg/l. For nutrient loading estimates, 1 mg/l nitrate-nitrogen is often used for the background concentration. The maximum concentration in data reviewed for Bar Harbor was 7.9 mg/l. This elevated concentration, while below the EPA Maximum Contamination Level of 10 mg/l, suggests a contamination source, such as a septic system or manure pile, exists near the well.

Issues relating to septic system contamination can be alleviated by methods that include installing septic system denitrification equipment, decreasing the amount of impervious cover, and increasing lot sizes to allow for more dilution from ground water recharge. An example of recommended lot sizing based on soil type is included in Table 4. Alternatively, residential developments can be served by either public water and/or public sewer.

In Bar Harbor, the gross lot size for houses tallied by Rowan (2004) in watersheds dominated by residential land use (i.e., excluding Breakneck Brook watershed which contains a large area conserved by parkland), ranges from 7 to 36 acres per dwelling unit (Table 5). This gross lot size is anticipated to decrease under the 2034 build-out scenario from 7-36 acres per dwelling unit, down to 4-18 acres per dwelling unit.

While a gross lot size (i.e., septic system density) of 4 to 18 acres appears to be sufficient under the allowable residential density calculations, local well and septic system siting can result in local septic system densities that exceed allowable guidelines, thereby increasing the risk of local well contamination from septic system wastewater. For example, houses that are clustered together can result in a localized net septic system density of less than 1 acre per septic system, greatly increasing the risk of contamination. The relationship between lot size and ground water has been researched by several authors. Robinson (2004) found the following key findings from a review of literature:

- 1) Concentrations of nitrate nitrogen in ground water increase with increasing population/septic system/housing density (Woodard, Ford, Yates, Persky, Clausen, Bicki, Hantzsche, Tuthill).
- 2) Separation distances of 100 feet between wells and septic systems may not be adequate to protect well water quality from nitrate-nitrogen contamination by onsite septic systems (Ford, Robertson).

Inadequate protection at the following separation distances

Ford, 100 feet or less

Robertson, 80-115 feet

- 3) Septic system densities of less than one per ½ acre may not be adequate to protect well water quality from nitrate-nitrogen contamination by onsite septic systems (Woodard, Ford, Perkins, Yates, Persky, Bicki)

The following authors found inadequate protection of water quality at the following septic system or residential lot densities:

Woodard, 1.5 acres per septic system

Ford, 1-acre lot size

Yates, 0.25 to 3-acre lot size

Persky, 1-acre lot size

Septic system impacts can be minimized by requiring developers of new subdivisions to perform hydrogeologic evaluations to demonstrate “no impact,” compared to a standard established by the Town, as part of the application process. Furthermore, good septic system construction, siting, installation and maintenance are key factors in increasing protection from pathogens (Gerber, personal communication 2004).

This section of the report presented information on the current condition of Bar Harbor’s hydrogeologic resources. From this evaluation, Stratex has found that Bar Harbor is likely to have a sufficient quantity of water to serve residential needs under the conditions identified (i.e., average annual precipitation, 1-acre lots, etc.). However Stratex found that water quality could be a local issue in areas where the physical conditions are marginal. Marginal conditions could be compounded by development siting (i.e., in recharge zones) and lot layout, thereby increasing the risk of local well contamination from septic systems. Information on specific resource threats is provided below. Recommendations for mitigating concerns is provided in the Conclusion section of this report.

Resource Threats and Vulnerability

Threats to Bar Harbor’s water resources are derived not only from man’s activities but also from natural sources such as the salt water from the ocean. This study focuses on the threats derived from residential development. Stratex evaluated threats from residential development and performed an assessment of hydrogeologic resources in the Town that are particularly vulnerable. The following list summarizes this evaluation:

Threats

- Impervious surfaces which decrease ground water recharge potential;
- Septic system siting in recharge areas, and areas of thin soil and exposed bedrock;
- Improperly maintained septic systems (incomplete treatment of wastewater, wastewater breakout);

- Aging wells (failing well seals allow for surface water and soil water infiltration);
- The replacement of natural forested and field areas with residential lawns which reduces the natural buffering against surface water contaminant migration, increases surface water runoff, and reduces ground water recharge;
- Salt water intrusion induced by the pumping of wells near the shore which pulls the salt/fresh water interface landward;
- Injection of household chemicals into the aquifers at septic systems;
- Improper storage of household chemicals and petroleum products increases the potential for leaks to ground and surface water systems;
- Disturbance of topsoil during site construction releases metals bound in soils into surface and ground water system and promotes phosphorus migration in surface water.

During a review of published maps and reports, Stratex concludes that the natural conditions most vulnerable to adverse impacts from residential development in Bar Harbor include the following areas:

- ▶ Recharge zones (about the upper third portion of a watershed);
- ▶ Areas of thin soils (<5 feet thick), soils with low recharge rates (5-15%), and exposed bedrock;
- ▶ Coastal areas within about 200 feet of the shoreline.

Process

Bar Harbor is interested in evaluating methods for mitigating the impact of residential development on hydrogeologic resources. There are three fundamental approaches for implementing environmental policy aimed at minimizing activities which are harmful to the environment:

- 1) Voluntary efforts;
- 2) User fees;
- 3) Direct controls

This study focuses on the protection of water resources from the impacts of residential development. Three fundamental water resource protection approaches are described below with particular concentration on direct controls.

Voluntary Efforts

Motivated by social responsibility and advanced by public education, voluntary efforts are a non-mandatory investment in resource protection practices. Voluntary water resource protection practices can vary widely from water conservation at the tap to land conservation at the water resource and can include the following areas:

- Regular well water quality testing (i.e., annually);
- Minimized site alteration to increase ground water recharge (reduced lawn area, impervious coverage, and dwelling size);
- Optimized well siting on lots near the shore to maximize the distance from the shore and minimize the well depth;
- Preservation of large parcels as single residential lots or farmland;
- Infill development in areas served by sewer and water;
- Management of residential composting activities;
- Pet waste management;
- Management of harmful household cleaning chemicals, fertilizers, and pesticides (i.e., storage and use);
- Water conservation equipment (i.e., low-flow showers, toilets, washers);
- Septic system inspection and maintenance (i.e., septic tank pumping once every three years);
- Installation of denitrification equipment in septic systems to reduce the concentration of nitrate-nitrogen in ground water;
- Land conservation.

The voluntary approach to water resource protection relies on individuals and groups to act responsibly. This approach requires the establishment of guiding principles and a strong public communication campaign to inform and guide citizens.

User Fees

Interest in user and impact fees for water resource management is gaining the attention of regulators and non-profit groups in the United States especially in the area of watershed protection and infrastructure improvements. For example, counties in Pennsylvania impart a private well user fee as part of the well permitting process (Chester County website). The well user fee is a flat fee assessed to individual domestic well owners at time of drilling.

Several communities in Maine have considered the use of impact fees to fund expanded infrastructure needs resulting from new development. This allows municipalities to recover costs from those that create the demand. The Maine State Planning Office provides guidance for Towns considering impact fees in their handbook titled "Financing Infrastructure Improvements Through Impact Fees" (2003). Impact fees may finance infrastructure improvements as well as the establishment of parks and open space or recreational areas. However, the establishment of an impact fee program must be based on a qualified need for infrastructure expansion that is a direct result of the new development. It is not clear whether this type of mechanism could be used to manage Bar Harbor's water resources. Stratex recommends consulting with legal counsel if Bar Harbor wishes to explore the use of user fees to fund water resource management.

Direct Controls

Direct controls, derived from goals established by local, state and federal governments, are achieved through the implementation of statutes, laws, rules, standards, and ordinances. In contrast to motivation by social responsibility or intrinsic fiscal impact, this resource protection approach is motivated by legal enforcement, which can carry fiscal consequences in certain cases of non-compliance.

As indicated earlier, two primary statutes safeguard Maine's ground and surface water resources. Title 38, Chapter 3, "Protection and Improvement of Waters," controls the discharge of pollutants to surface and ground water and requires the classification of the state's ground water to protect susceptible resources such as sand and gravel from contamination by pollutants. Title 22, Chapter 601, "Water for Human Consumption," regulates the quality of public drinking water supplies. These state statutes, combined with the Federal Water Pollution Control Act (the Clean Water Act), and the Federal Safe Drinking Water Act, form the foundation of laws aimed at preserving the quality of surface and ground water resources, and protecting water supplies utilized for human consumption in the state.

With no consistent, enforceable, statewide ground water protection strategy for private water supply wells, homeowners with private wells outside subdivisions rely on a patchwork of regulatory mechanisms authorized under two state agencies: The Maine Department of Environmental Protection (DEP) which regulates unique resources, large developments, and separation distances from waste disposal areas, and The Maine Department of Human Resources (DHS) which regulates public health codes for safety related to wastewater discharge. Appendix A contains additional information on existing controls and how they fall short in terms of private well protection.

The state of Maine provides guidance to homeowners in water quality testing in the form of recommended testing frequency (i.e., annual well water testing) and handling protocols (DHS). However, water quality monitoring in private wells is voluntary and non-enforceable, and as a result, participation by homeowners is extremely low. Low testing frequency in Bar Harbor confirms this. Only 236 water quality tests were performed at the state lab for nitrate-nitrogen analysis on water from wells in Bar Harbor during the 10-year period from 1991 to 2000. With about 1,114 parcels in Bar Harbor served by private wells, this represents annual water quality tests for nitrate-nitrogen for only 24 locations or 2% of all parcels with private wells. Note that some homeowners may be sending their water quality samples to private laboratories rather than the Maine State Health and Environmental Testing Laboratory.

As a result of low voluntary monitoring of private water supplies and gaps in regulation of water resources, many municipalities have elected to protect water resources through local land use management (i.e., large lots, deduction of unbuildable areas such as steep slopes, and designation of resource protection areas such as vernal pools). Bar Harbor is interested in land management options to protect water resources from the adverse

impacts of residential development. Stratex offers the following land management goals for new residential development outside the areas served by the public water and public sewer system:

Preserve Ground Water Quantity:

- Minimize adverse impacts on ground water quantity;
- Minimize loss of recharge and enhance infiltration;
- Avoid ground water table lowering beyond the property boundary;
- Stay within the bedrock aquifer safe yield;
- Monitor new well installation;
- Monitor long-term ground water level trends;
- Educate homeowners.

Preserve Ground Water Quality:

- Minimize adverse impacts on ground water quality;
- Prevent degradation of ground water quality from salt water intrusion;
- Prevent degradation of ground water quality from septic systems;
- Prevent ground water contamination from household chemicals, oil products, landscaping, or waste.
- Monitoring water quality in new wells;
- Monitor long-term ground water quality trends;
- Educate homeowners.

Table 6 contains a matrix showing these objectives, along with implementation strategies and proposed ordinance language to achieve resource protection goals. In some cases, developers may work with the Town to have the public water system extended to new developments. Note that the extension of public water to new developments does not release the developer from water quality protection goals. However, where clustered development would be preferable over large lot development, public water supply and/or public sewer system connection may be feasible and desirable.

Conclusion

This study presents a process for protecting sensitive and/or vulnerable hydrogeologic resources from the adverse impacts of residential subdivision development. Stratex begins this report with water resource values and goals articulated by the Town of Bar Harbor. An assessment of hydrogeologic conditions in the Town provides the basis for Stratex's opinion regarding the state of the resource. This analysis suggests there is likely to be sufficient ground water to serve the needs of residents in the Town through the foreseeable future. Stratex presents fundamental approaches for implementing protection measures as means to achieve resource goals. This report concludes with recommendations for specific action steps.

The larger issue facing the Town is potential for degradation of ground water quality from residential onsite septic systems. While water quality data from a limited number of test

results suggest the resource as a whole is not presently in grave danger, future development in certain areas may be at risk based on vulnerable physical conditions and development layout.

Stratex has provided a suggested process for abating the potential for adverse impacts to both water quantity and water quality through a strategy matrix (Table 6). This process involves direct controls in the form of ordinance language. To supplement the goals matrix, Stratex recommends the following action steps for consideration by the Town:

- Set up well data base and register new wells (through the building permit process) and add new wells to GIS system.
- Develop a ground water model to refine water balance calculations, calculate the impact of existing and proposed residential developments on the quantity and quality of ground water in specific areas of Bar Harbor, and to quantify ground water discharge to streams, estuaries and the ocean.
- Educate the public about the value of regular water quality testing at private wells.
- Tabulate water quality test results for new wells.
- Review water quality test data from the Maine Health and Environmental Testing Laboratory on a regular basis (i.e., every 5 years) and for more parameters than nitrate-nitrogen.
- Perform an evaluation of other potential threats to hydrogeologic resources besides residential development (i.e., chemical and petroleum storage).
- Map the public water supply system in GIS.
- Collect additional information from homeowners regarding individual well characteristics and quality/quantity concerns through the distribution of a residential well survey.
- Establish a data base of problem areas (i.e., salt water intrusion, nitrate-nitrogen contamination, dry wells).
- Prevent development on vulnerable areas and develop a map showing where those areas exist.
- Identify and map bedrock aquifer recharge areas.
- Develop a set of procedures for developers to follow to perform a hydrogeologic analysis for subdivisions meeting the criteria for additional investigation.
- Develop a set of procedures for optimizing the location of wells along the shoreline to minimize the potential for saltwater intrusion.
- Refine the build-out analysis and track the rate of residential growth in GIS.

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<http://dsf.chesco.org/health/cwp/view.asp?a=3&q=603830> Chester County Health Department, Pennsylvania, private well permit information

<http://www.ncgc.nrcs.usda.gov/branch/ssb/products/ssurgo/data/me.html> Natural Resources Conservation Service Soil Mapping

Symbol	Soil Type	Description	RECHARGE % of pptn	RECHARGE gpm/acre	RECHARGE inches/year	Total Area square feet	Total Recharge gallons/year
AdB	Adams	loamy fine sand	50%	1.42	27.50	508,528	8,717,022
Bd	Biddeford muck		5%	0.14	2.75	8,182,343	14,025,900
BgB	Brayton	fine sandy loam, very stony	15%	0.43	8.25	35,437,477	182,237,225
BhB	Brayton	fine sandy loam, rubbly	15%	0.43	8.25	2,213,228	11,381,526
BSB	Brayton-colonel association	very stony	15%	0.43	8.25	5,219,451	26,841,029
BTB	Brayton-colonel association	rubbly	15%	0.43	8.25	909,374	4,676,457
BwC	Buxton	silt loam	5%	0.14	2.75	5,490,875	9,412,274
BwD	Buxton	silt loam	5%	0.14	2.75	3,023,739	5,183,192
Ch	Charles	silt loam	15%	0.43	8.25	1,371,503	7,052,955
CoB	Colton	gravelly sandy loam	50%	1.42	27.50	595,025	10,199,722
CoC	Colton	gravelly sandy loam	50%	1.42	27.50	823,890	14,122,847
DaC	Dixfield	fine sandy loam	15%	0.43	8.25	3,755,385	19,312,070
DbC	Dixfield	fine sandy loam, very stony	15%	0.43	8.25	4,467,515	22,974,198
DsB	Dixfield-colonel complex		15%	0.43	8.25	1,595,181	8,203,216
DtB	Dixfield-colonel complex	very stony	15%	0.43	8.25	9,021,614	46,393,648
DWB	Dixfield-colonel-tunbridge complex	very stony	15%	0.43	8.25	1,048,254	5,390,646
Go	Gouldsboro	silt loam	5%	0.14	2.75	3,998,285	6,853,728
Gt	Gouldsboro-beaches complex		5%	0.14	2.75	1,163,733	1,994,832
HcC	Hermon-colton-rock outcrop	very stony	15%	0.43	8.25	61,108,731	314,251,648
HmB	Hermon-monadnock complex		25%	0.71	13.75	2,334,527	20,008,846
HmC	Hermon-monadnock complex		25%	0.71	13.75	765,502	6,560,990
HtB	Hermon-monadnock complex	very stony	25%	0.71	13.75	3,323,875	28,488,381
HtC	Hermon-monadnock complex	very stony	25%	0.71	13.75	10,721,471	91,891,944
HtE	Hermon-monadnock complex	very stony	25%	0.71	13.75	3,982,118	34,130,068
HVC	Hermon-monadnock-dixfield complex	very stony	25%	0.71	13.75	12,691,005	108,772,486
Kn	Kinsman	loamy sand	50%	1.42	27.50	3,084,718	52,877,209
LaB	Lamoine	silt loam	5%	0.14	2.75	15,113,260	25,906,646
LbB	Lamoine-scantic complex		5%	0.14	2.75	9,154,699	15,692,679
LCB	Lamoine-scantic-buxton association		5%	0.14	2.75	7,046,483	12,078,847
LgB	Lyman-brayton complex	very stony	10%	0.28	5.50	13,405,543	45,958,669
LHC	Lyman-brayton-schoodic complex	very stony	10%	0.28	5.50	24,027,417	82,373,996
LsE	Lyman-schoodic complex	very stony	10%	0.28	5.50	35,864,606	122,955,823
LTE	Lyman-schoodic rock outcrop	very stony	10%	0.28	5.50	34,896,106	119,635,483
LuC	Lyman-tunbridge	very stony	10%	0.28	5.50	147,812,997	506,752,223
LWC	Lyman-tunbridge-schoodic complex	very stony	10%	0.28	5.50	63,795,289	218,711,517
MaC	Marlow	fine sandy loam	15%	0.43	8.25	3,391,461	17,440,587
MaD	Marlow	fine sandy loam	15%	0.43	8.25	386,293	1,986,510
MbC	Marlow	fine sandy loam, very stony	15%	0.43	8.25	4,859,571	24,990,342
MbE	Marlow	fine sandy loam, very stony	15%	0.43	8.25	572,372	2,943,424
McE	Marlow	fine sandy loam, very stony	15%	0.43	8.25	1,015,176	5,220,544
MDC	Marlow-dixfield association	very stony	15%	0.43	8.25	3,593,001	18,477,010
MDE	Marlow-dixfield association	very stony	15%	0.43	8.25	961,194	4,942,940
MhC	Monadnock-hermon complex	extremely bouldery	25%	0.71	13.75	3,797,282	32,545,875
MhE	Monadnock-hermon complex	extremely bouldery	25%	0.71	13.75	3,489,994	29,912,155
MXC	Monadnock-hermon-dixfield complex	extremely bouldery	25%	0.71	13.75	1,884,848	16,154,714

Table 1

MXE	Monadnock-hermon-dixfield complex	extremely bouldery	25%	0.71	13.75	12,686,231	108,731,571
NaB	Naskeag-schoodic complex	very stony	15%	0.43	8.25	36,539,663	187,905,218
NBB	Naskeag-schoodic-lyman complex	very stony	15%	0.43	8.25	20,773,794	106,829,238
Ps	Pits	gravel and sand	50%	1.42	27.50	4,872,111	83,516,104
Sa	Scantic	silt loam	5%	0.14	2.75	28,253,518	48,431,239
SdB	Scantic-lamoine complex	very stony	5%	0.14	2.75	19,803,912	33,947,206
SfC	Schoodic-rock outcrop complex		10%	0.28	5.50	46,004,860	157,719,997
SfE	Schoodic-rock outcrop complex		10%	0.28	5.50	50,816,337	174,215,342
SGE	Schoodic-rock outcrop-lyman complex		10%	0.28	5.50	189,658,860	650,213,792
SKC	Schoodic-rock outcrop-naskeag complex		10%	0.28	5.50	81,588,459	279,712,434
SrB	Sheepscot	sandy loam	25%	0.71	13.75	10,824,226	92,772,636
SoB	Sheepscot	sandy loam, very stony	25%	0.71	13.75	8,609,011	73,786,401
SoC	Sheepscot	sandy loam, very stony	25%	0.71	13.75	2,998,865	25,702,778
SrB	Sheepscot-rock outcrop complex		15%	0.43	8.25	1,537,195	7,905,027
TuB	Tunbridge-lyman complex		15%	0.43	8.25	43,677,644	224,612,284
TuC	Tunbridge-lyman complex		15%	0.43	8.25	17,487,704	89,930,520
Ud	Odorthents-urban land complex		5%	0.14	2.75	14,699,614	25,197,588
W	Water		50%	1.42	27.50	32,025,087	548,963,368
WA	Waskish and seabago soils		5%	0.14	2.75	13,084,083	22,428,298
Wo	Wonsqueak muck	flooded	5%	0.14	2.75	20,983,796	35,969,724
Ws	Wonsqueak and bucksport mucks		5%	0.14	2.75	31,194,744	53,472,991
WT	Wonsqueak, bucksport and seabago soils		5%	0.14	2.75	20,048,345	34,366,205

Table 1
Page 2
Soil Types and Recharge Rates

Table 2

2001 Water Use Estimates

Average Soil Recharge Rate 6.86 in/year

Average Bedrock Recharge Rate 5.50 in/year

BASIN	AREA (acres)	SOIL Recharge (gal/yr)	BEDROCK Recharge (gal/yr)	2001 Estimated gw use (Nielsen) (gal/yr)	SOIL Water use as % of recharge (Stratex)	BEDROCK Water use as % of recharge (Stratex)	BEDROCK Water use as % of recharge (Nielsen)
Ground water seepage	1,380	257,131,948	206,155,352	5,800,000	2.3%	2.8%	3.9%
Aunt Betseys Brook	498	92,808,252	74,408,948	4,700,000	5.1%	6.3%	5.3%
French Hill Brook	320	59,693,318	47,859,074	2,900,000	4.9%	6.1%	3.9%
Kitteredge Brook	1,848	344,298,386	276,040,980	8,000,000	2.3%	2.9%	2.2%
Old Mill Brook	1,692	315,191,818	252,704,810	6,900,000	2.2%	2.7%	1.8%
Breakneck Brook	917	170,766,355	136,911,800	411,000	0.2%	0.3%	0.2%
Stony Brook	1,831	340,965,214	273,368,612	8,000,000	2.3%	2.9%	3.2%
Liscomb Brook	69	12,819,087	10,277,693	900,000	7.0%	8.8%	18.0%
Unnamed intermit. tr	249	46,383,184	37,187,684	1,600,000	3.4%	4.3%	3.1%
500-ft buffer	1,377	256,435,581	205,597,040	8,000,000	3.1%	3.9%	2.2%
				Minimum		0.3%	0.2%
				Maximum		7.0%	18.0%
				Average		3.3%	4.4%

Note: The Stratex result of 4.1% differs from the Nielsen result of 4.4% due to differences in assumptions. Stratex assumes a recharge rate for bedrock of 10% of precipitation (5.5 inches/year). Nielsen assumes a rate of 16.4% of precipitation (9 inches/year) with a 10% discount for areas overlain by the Presumpscot Formation.

Table 3

Future Water Use Estimates

Average Soil Recharge Rate = 6.86 in/year

Average Bedrock Recharge Rate = 5.50 in/year

Estimated increase in water use from 2004 to 2034 (based on buildout by Rowan, 2004) = 104.2%

	AREA (acres)	SOIL Recharge (gal/yr)	BEDROCK Recharge (gal/yr)	2001 Estimated gw use (Stratex) (gal/yr)	2034 Estimated gw use (Rowan, Stratex) (gal/yr)	BEDROCK Water use in 2034 as % of recharge (Stratex)
Ground water seepage	1,380	257,131,948	206,155,352	5,800,000	11,845,885	5.7%
Aunt Betseys Brook	498	92,808,252	74,408,948	4,700,000	9,599,252	12.9%
French Hill Brook	320	59,693,318	47,859,074	2,900,000	5,922,943	12.4%
Kitteredge Brook	1,848	344,298,386	276,040,980	8,000,000	16,339,152	5.9%
Old Mill Brook	1,692	315,191,818	252,704,810	6,900,000	14,092,519	5.6%
Breakneck Brook	917	170,766,355	136,911,800	411,000	839,424	0.6%
Stony Brook	1,831	340,965,214	273,368,612	8,000,000	16,339,152	6.0%
Liscomb Brook	69	12,819,087	10,277,693	900,000	1,838,155	17.9%
Unnamed intermit. tr	249	46,383,184	37,187,684	1,600,000	3,267,830	8.8%
500-ft buffer	1,377	256,435,581	205,597,040	8,000,000	16,339,152	7.9%
					Minimum	0.6%
					Maximum	17.9%
					Average	8.4%

Table 4
Allowable Residential Densities
as Limited by Water Quality Impacts

Bar Harbor Average Annual Precipitation (PPTN)= 55 inches/year (Nielsen, 2002)
 Conversion from gpm/acre to inches/yr 19.36

Geologic Soil Type	Average Natural Recharge Rate % of PPTN	Average Natural Recharge Rate gpm/acre	Average Natural Recharge Rate inches/year	A Allowable Acres per Dwelling	1/A Allowable Dwellings per Acre	Drought Recharge Rate gpm/acre	Drought A Allowable Acres per Dwelling	Drought 1/A Allowable Dwellings per Acre
sand and gravel	50%	1.42	27.5	0.5	1.8	0.85	0.9	1.1
thin sandy till	25%	0.71	13.8	1.1	0.9	0.43	1.8	0.6
silty till	15%	0.43	8.3	1.8	0.6	0.26	3.0	0.3
exposed rock and glaciomarine silt	10%	0.28	5.5	2.7	0.4	0.17	4.4	0.2
glaciomarine clay-silt	5%	0.14	2.8	* 5.0	* 0.2	0.09	* 5.0	* 0.2

Notes:

- 1) Glaciomarine clay-silt soils are not only limiting in their ability to treat residential wastewater, but they also have limitations relating to other site engineering issues such as slope stability, drainage and siltation potential. Ongoing research suggest clays may have the capability of denitrifying wastewater more effectively than typically assumed.
- 2) Drought conditions assumes that precipitation is reduced to 60% of the average annual.

Formula: _____

$A = \frac{qs \times Cs}{RR \times (Cn - Cb)}$

Variables:

- A (calculated) acres/dweller recommended residential density in acres per dwelling unit
- Cn = 10 mg/l limiting concentration of nitrate-nitrogen in ground water (equal to the MCL and MEG)
- Cb = 1 mg/l assumed background concentration of nitrate-nitrogen in the uncontaminated ground water
- Cs = 40 mg/l assumed concentration of nitrate-nitrogen reaching the water table from septic discharge
- qs = 250 gpd/dwelling = 0.17 gpm/dweller; average septic discharge rate (for 3 to 5 people)
- RR = (see table) gpm/acre rate of natural ground water recharge in gallons per minute per acre

$Cn = \frac{(qs \times Cs) + (A \times Cb \times RR)}{(A \times RR)}$

Table 5
Gross Residential Density Calculations

BASIN	AREA (acres)	Houses 2004	Houses 2014	Houses 2024	Houses 2034	Houses Total	2004 Gross Density (acres/house)	2034 Build-Out Gross Density (acres/house)
Ground water seepage	1,380	63	69	54	59	245	22	6
Aunt Betseys Brook	498	21	31	21	13	86	24	6
French Hill Brook	320	22	7	13	16	58	15	6
Kitteredge Brook	1,848	46	98	70	78	292	40	6
Old Mill Brook	1,692	47	9	14	22	92	36	18
Breakneck Brook	917	3	0	0	1	4	306	229
Stony Brook	1,831	80	69	56	62	267	23	7
Liscomb Brook	69	10	0	2	4	16	7	4
Unnamed intermit. tr	249	13	7	9	7	36	19	7
500-ft buffer	1,377	123	64	41	46	274	11	5
Totals	10,182	428	354	280	308	308		
Cumulative Houses		428	782	1,062	1,370			
Gross Density (acres/house)		24	13	10	7			

Source for housing projections: Rowan, H. and Longworth, G. 2004. Mount Desert Island: Options for the Future. Presentation by MDI Tomorrow in cooperation with College of the Atlantic.

Table 6
Water Resource Protection Strategy
Hydrogeologic Resource Evaluation, Bar Harbor, Maine

Goal – Preserve Ground Water Quantity by minimizing unnecessary withdrawal from and maximizing recharge to the ground water aquifer such that ground water tables are not significantly lowered and inland migration of salt water interface is kept at bay.

Objective	Implementation Strategy	Proposed ordinance language
No adverse impact on ground water quantity.	<ul style="list-style-type: none"> ▪ Direct new development away from vulnerable areas (i.e., areas with shallow soils, exposed bedrock, steep slopes, wetlands, and ground water recharge zones). ▪ Require hydrogeologic evaluation for new subdivisions with onsite water supply wells. 	<ul style="list-style-type: none"> ▪ The proposed development shall be located outside resource protection areas. ▪ A hydrogeologic assessment prepared and stamped by a Maine Certified Geologist is required when the subdivision has a density of more than one dwelling unit per 40,000 square feet and/or the subdivision is served by a central on-site water supply.
Minimize loss of recharge and enhance infiltration.	<ul style="list-style-type: none"> ▪ Require hydrogeologic evaluation for developments proposing to use ground-source heat pumps 	<ul style="list-style-type: none"> ▪ A hydrogeologic assessment prepared and stamped by a Maine Certified Geologist is required when ground-source heat pumps are proposed for the development.
Avoid water table lowering beyond property boundary.	<ul style="list-style-type: none"> ▪ Limit construction of on-lot impervious area such as roof tops, gravel or asphalt driveways, porches, or roads. 	<ul style="list-style-type: none"> ▪ The proposed development shall not result in a total impervious area coverage increase of more than 20%. Alternatively: Gross housing density shall not exceed 1 house per 2 acres unless active recharge measures are used.
Stay within the bedrock aquifer safe yield	<ul style="list-style-type: none"> ▪ Limit ground water table lowering from excessive pumping or significant excavation and resultant subsurface dewatering at individual lots. ▪ Minimize excessive pumping. ▪ Minimize loss of recharge. 	<ul style="list-style-type: none"> ▪ The proposed development shall not result in lowering the water table more than 10 feet at the subdivision property boundary. ▪ See objective of “minimize loss of recharge” above.
Monitor long-term ground water level trends.	<ul style="list-style-type: none"> ▪ Coordinate volunteer ground water monitoring program for new and existing wells. 	<ul style="list-style-type: none"> ▪ Not applicable to ordinance language.
Educate the public.	<ul style="list-style-type: none"> ▪ Coordinate educational program on water resource protection. 	<ul style="list-style-type: none"> ▪ Not applicable to ordinance language.

Table 6, continued

Goal – Preserve Ground Water Quality by protecting ground water quality so that it will meet the EPA Federal Drinking Water Standards and the State of Maine Maximum Exposure Guidelines and to consider restoring ground water quality where it is now inferior to those standards.

Objective	Implementation Strategy	Proposed Ordinance Language
<p>No adverse impact on ground water quality.</p>	<ul style="list-style-type: none"> ▪ Direct new development away from vulnerable areas (i.e., areas with shallow soils, exposed bedrock, steep slopes, wetlands, and ground water recharge zones). ▪ Require hydrogeologic evaluation. 	<ul style="list-style-type: none"> ▪ The proposed development shall be located outside resource protection areas. ▪ A hydrogeologic assessment prepared and stamped by a Maine Certified Geologist is required when the subdivision has a density of more than one dwelling unit per 40,000 square feet and/or the subdivision is served by a central on-site septic system. ▪ New water supply wells shall be located at least 200 feet from the mean high water line. ▪ Not applicable to ordinance language.
<p>Prevent degradation of ground water quality from salt water intrusion.</p>	<ul style="list-style-type: none"> ▪ Require a 200-foot setback between wells and shoreline to prevent saltwater intrusion. ▪ Drill new wells on shoreline lots as shallow as possible and as far from the shore as possible consistent with obtaining an adequate yield and storage combination. ▪ Prohibit new wells that would cause or increase salt water intrusion in areas with salt water intrusion problems. 	<ul style="list-style-type: none"> ▪ There shall be no additional on-site wells in areas demonstrating existing salt water intrusion with chloride concentrations exceeding 100 mg/l without a hydrogeologic evaluation by a Maine Certified Geologist.
<p>Prevent degradation of ground water quality from septic systems.</p>	<ul style="list-style-type: none"> ▪ Require a 200-foot setback between septic system and any down gradient well to protect against viral contamination. This distance is assumed to provide 200-days of travel time to achieve 99.9% die-off of most viruses. ▪ Utilize recommended lot sizing based on soil recharge capability to minimize nitrate-nitrogen 	<ul style="list-style-type: none"> ▪ New water supply wells shall be located at least 200 feet away from upgradient septic systems including septic systems located outside the subdivision. ▪ The hydrogeologic analysis shall include an analysis and evaluation of the effect of the

Table 6, continued

<p>Prevent degradation of ground water quality from septic systems (Continued).</p>	<p>contamination from residential wastewater.</p> <ul style="list-style-type: none"> ▪ Develop a septic system maintenance program that encourages pumping of septic systems every three to five years, and checking septic system functionality at least every five years. ▪ Prohibit the storage or chemical or petroleum products in vulnerable areas. ▪ Control all types of waste disposal. ▪ Develop an emergency response plan for accidental spills or hazardous releases. ▪ Require water quality testing on all new private water supply wells. ▪ Establish a well data base. ▪ Through public education, encourage all residents to test their water at least once per year (before the water enters any treatment system), usually near the 	<p>subdivision on ground water resources. In the case of residential developments, the evaluation shall, at a minimum, include a prediction of post development steady-state nitrate-nitrogen concentrations at any wells within the subdivision, or at the subdivision boundaries; or at a distance of 1,000 feet from potential contamination sources, whichever is a shortest distance.</p> <ul style="list-style-type: none"> ▪ Private on-site septic systems shall be pumped every three to five years and checked for proper function every five years.
<p>Prevent ground water contamination from chemicals, oil products landscaping processes, or waste.</p>	<ul style="list-style-type: none"> ▪ Develop an emergency response plan for accidental spills or hazardous releases. ▪ Require water quality testing on all new private water supply wells. ▪ Establish a well data base. ▪ Through public education, encourage all residents to test their water at least once per year (before the water enters any treatment system), usually near the 	<ul style="list-style-type: none"> ▪ The Town prohibits the residential storage or use of hazardous materials and/or the onsite storage of greater than 1320 gallons of petroleum. ▪ Garbage, rubbish or other wastes shall be dumped only in areas designated by the Town. ▪ Not applicable to ordinance language.
<p>Monitor long-term ground water quality trends.</p>	<ul style="list-style-type: none"> ▪ Establish a well data base. ▪ Through public education, encourage all residents to test their water at least once per year (before the water enters any treatment system), usually near the 	<ul style="list-style-type: none"> ▪ New water supplies shall be tested for the parameters recommended for "new well evaluation" by the Department of Human Services Public Health and Environmental Testing Laboratory. The test results shall be submitted to the Town prior to receiving a certificate of occupancy ▪ New wells shall be registered with the Town prior to occupancy. ▪ Not applicable to ordinance language.

Table 6, continued

<p>Prevent ground water degradation from non-point source pollution.</p>	<p>end of the summer.</p> <ul style="list-style-type: none"> • Manage non-point source pollution such as those activities associated with residential landscaping practices, pet waste, winter de-icing, and material stockpiles. • Develop a non-point source pollution public education program on the importance of proper management and disposal of household hazardous products, motor oil, and pet and livestock waste. This program should also include information on avoiding use, where possible, or overuse of fertilizers and pesticides, especially prior to rainfall. 	<ul style="list-style-type: none"> • Areas of exposed soil shall be kept to a minimum in accordance with the Maine Erosion & Sediment Control Handbook for Construction: Best Management Practices. Disturbed areas shall be seeded and mulched as soon as possible. (Note that reducing impervious cover, and proper management of septic systems also achieve non-point source pollution goals.) • Not applicable to ordinance language.
<p>Prevent deterioration of ground water quality below State and Federal Standards.</p>	<ul style="list-style-type: none"> • Control housing densities commensurate with available recharge so that upon full build-out to the permitted density, ground water quality can meet Federal and State Standards. • Control residential subdivisions so that ground water impacts to adjacent properties do not result in exceeding one-half of the difference between the ambient ground water quality and the Federal or State drinking water standards, or alternatively, setting an impact limit of one-half the MCL or MEG. 	<ul style="list-style-type: none"> • The hydrogeologic analysis shall include an analysis and evaluation of the effect of the subdivision on ground water resources. In the case of residential developments, the evaluation shall, at a minimum, include a prediction of post development steady-state nitrate-nitrogen concentrations at any wells within the subdivision, or at the subdivision boundaries; or at a distance of 1,000 feet from potential contamination sources, whichever is a shortest distance. • In accordance with the requirements of the hydrogeologic analysis, no subdivision shall increase any contaminant concentration in the ground water at the property line to more than one half of the State of Maine Maximum Contaminant Levels of the Primary Drinking Water Regulations (10-144 CMR 231(7)). No subdivision shall increase any contaminant concentration in the ground water to

Table 6, continued

<p>Remediate contaminated ground water.</p> <p>Educate the public.</p>	<ul style="list-style-type: none"> ▪ Develop a remedial action plan for improving water quality where it is now contaminated; ▪ Provide public education on preserving and improving ground water quality. 	<p>more than the State of Maine Secondary Maximum Contaminant Levels of the Secondary Drinking Water Regulations (10-144 CMR 231(9)).</p> <ul style="list-style-type: none"> ▪ Not applicable to ordinance language. ▪ Not applicable to ordinance language.
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Figure 3
Cumulative Plot
New dwelling unit building permits
Bar Harbor, Maine
(Chamberlain, personal communication, 2004)

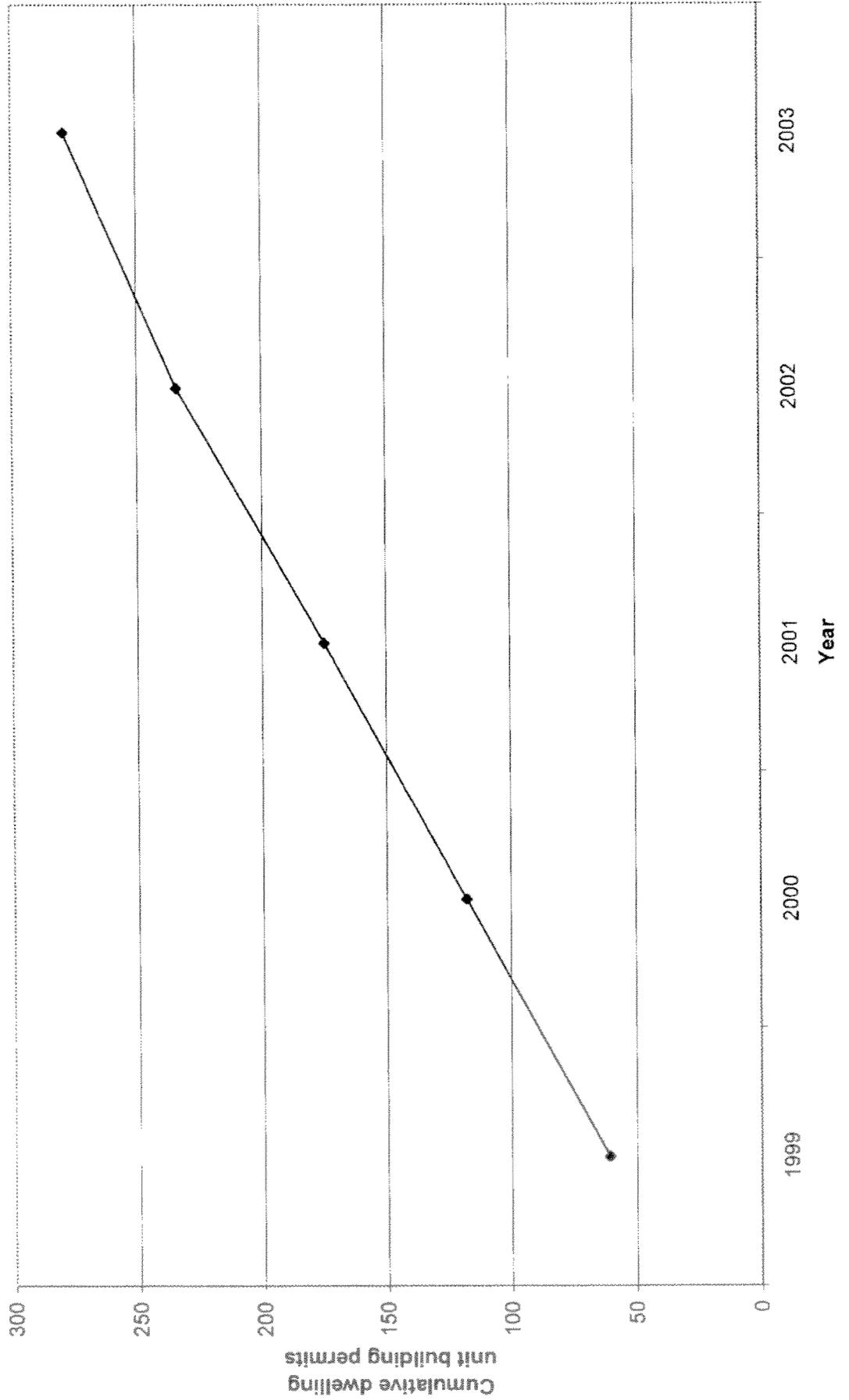


Figure 4
Cumulative Housing Estimates
Bar Harbor, Maine
Source: Buildout by Rowan (2004)

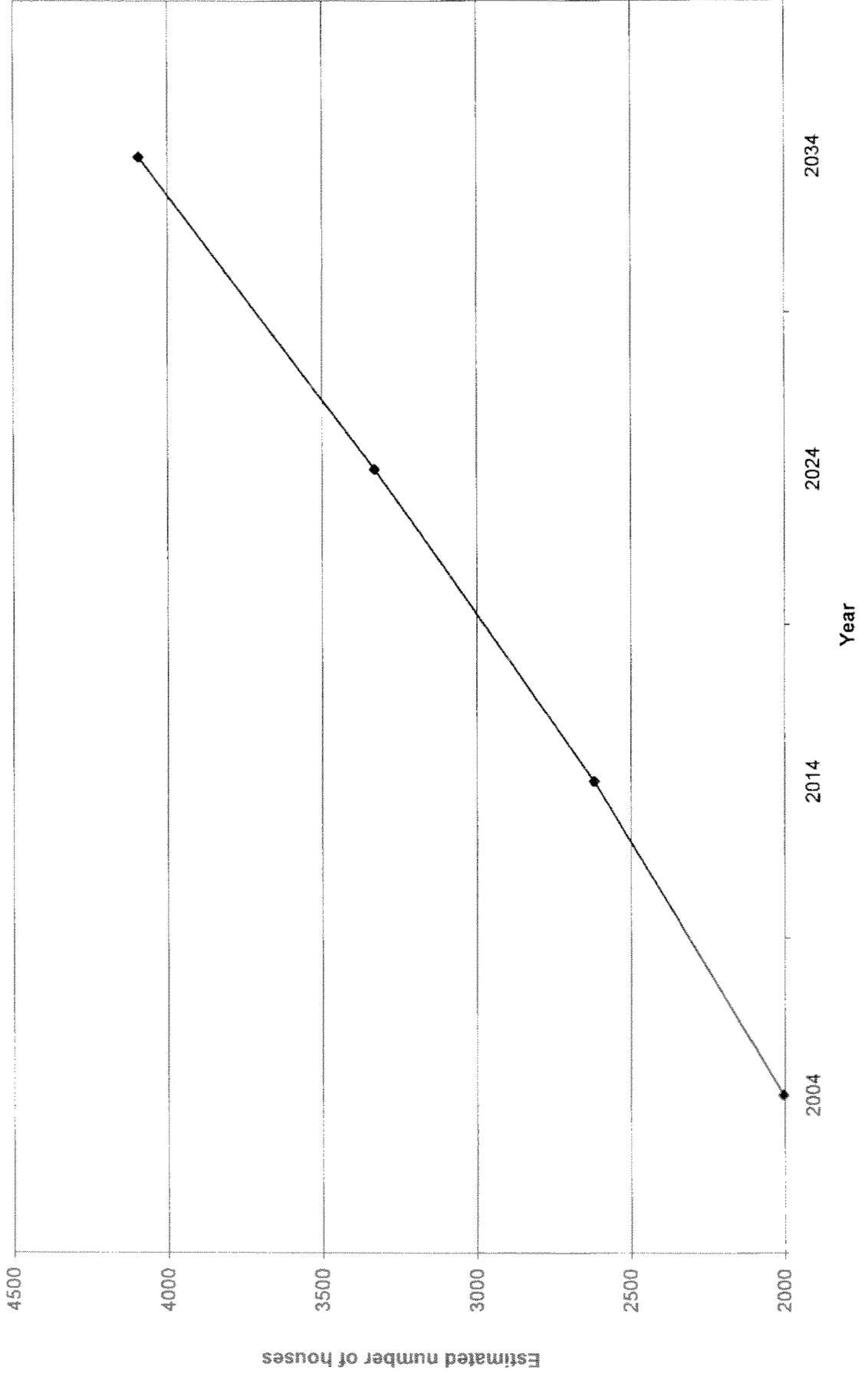


Figure 5
Monthly Precipitation
1981 to 2004
Bar Harbor, Maine

Source: National Atmospheric Deposition Program website

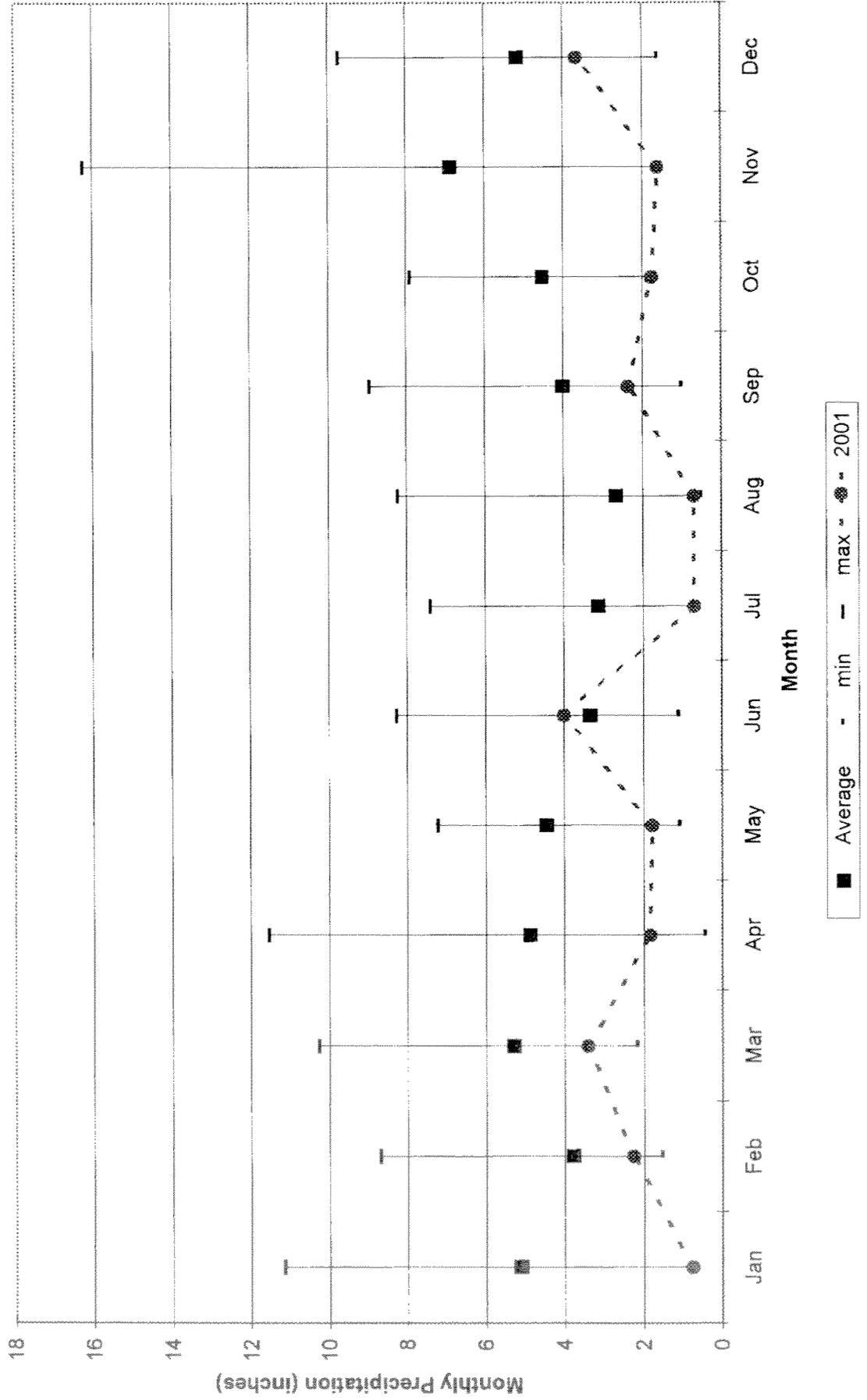


Figure 6
Cumulative Monthly Precipitation
1981 to 2004
Bar Harbor, Maine

Source: National Atmospheric Deposition Program website

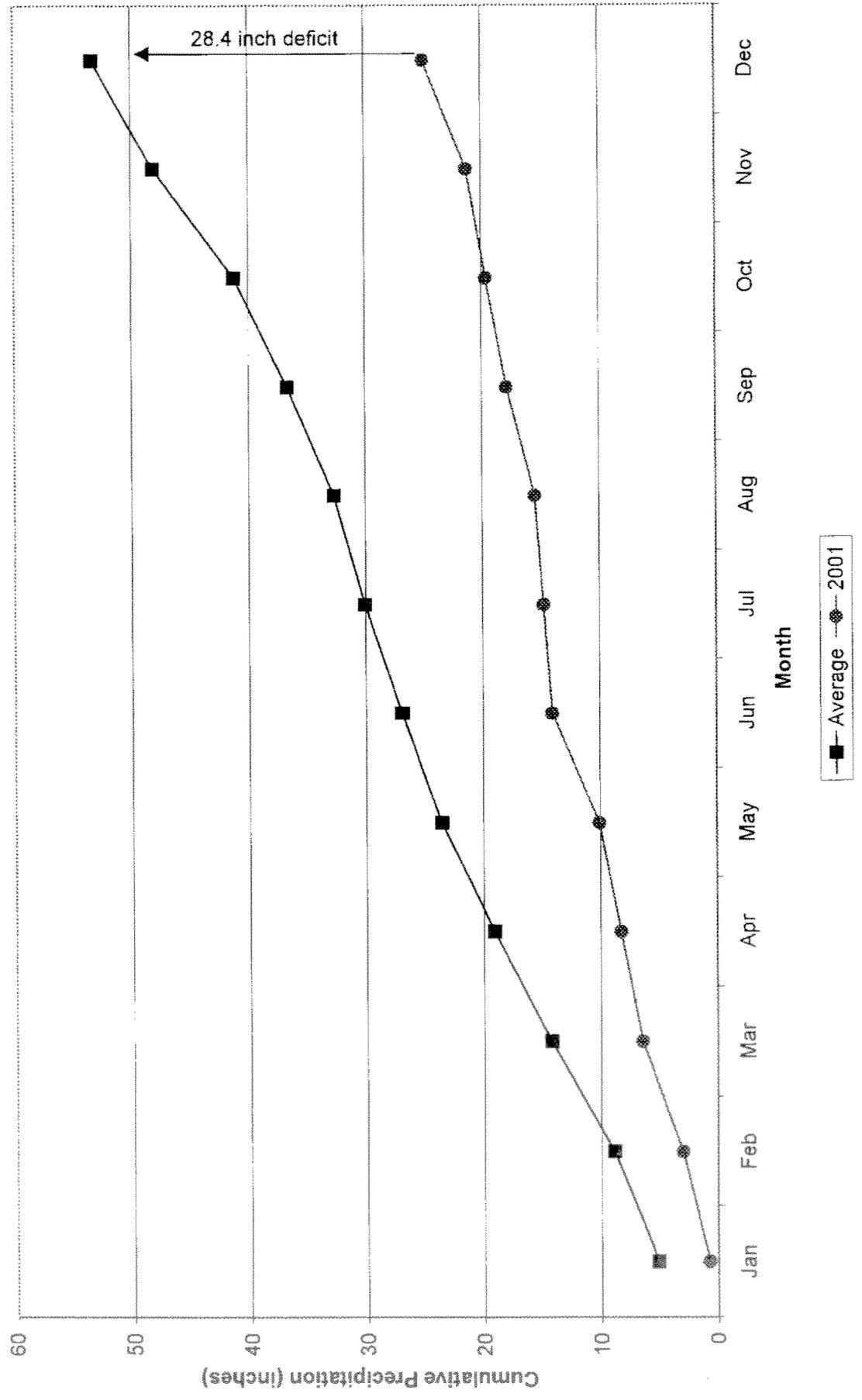


Figure 7
Well Depth
Frequency Distribution
Bar Harbor, Maine

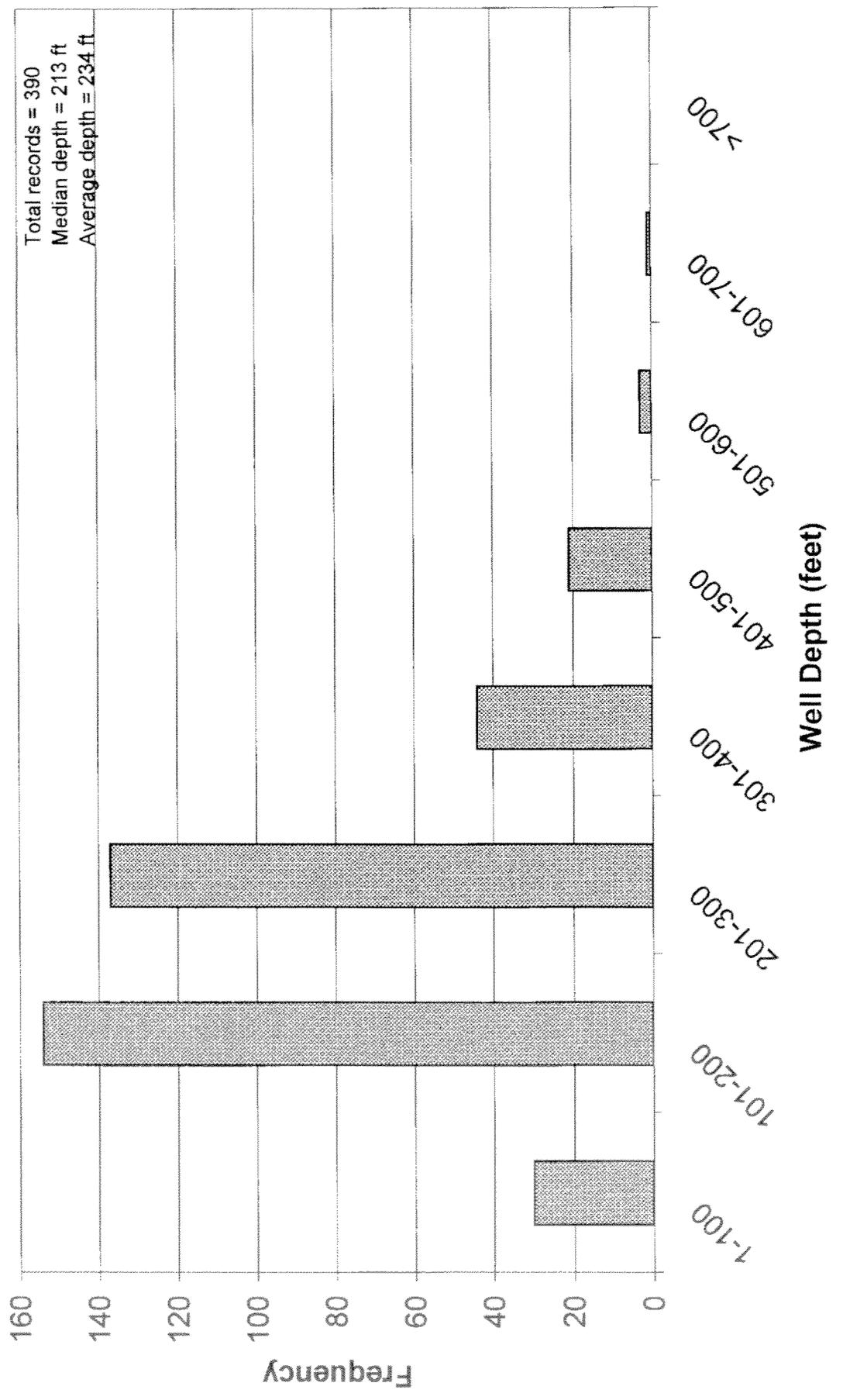


Figure 8
Well Yield
Frequency Distribution
Bar Harbor, Maine

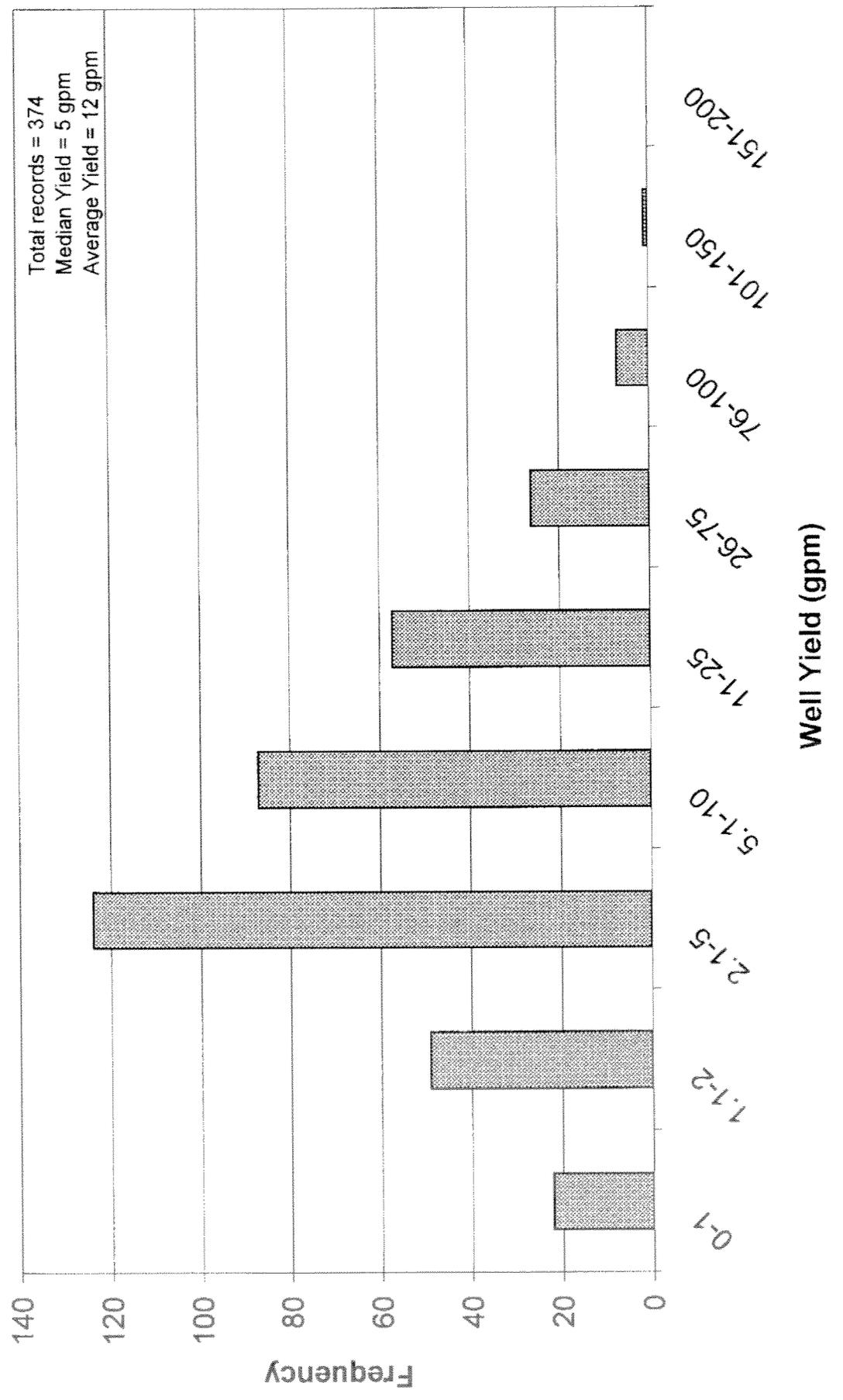
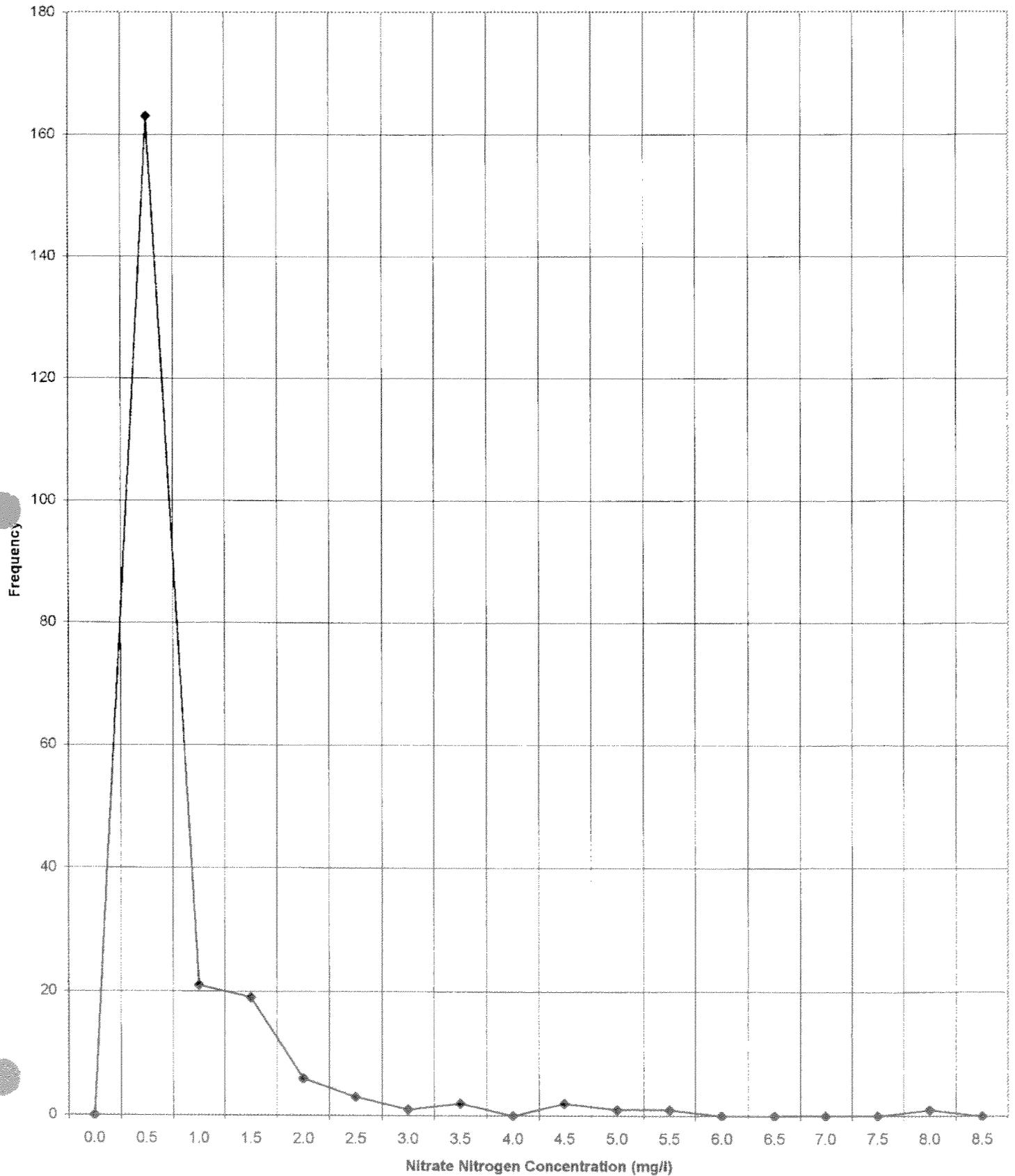


Figure 9
Frequency Distribution of
Nitrate Nitrogen Concentrations in Drilled Wells
Bar Harbor, Maine, 1991 to 2000



Appendix A

Water Resource Regulations

This appendix contains additional information on existing water resource standards, ordinances, rules and laws in Maine. Gaps in these regulations are identified for their limitation in protecting water resources against the adverse impacts of residential development.

At the local level, many municipalities have elected to protect ground water as a drinking water source through local land use management (i.e., large lot zoning, resource protection, subdivision approval process). The following describes existing DEP regulations for ground water and includes information on the limitations of regulatory treatment for the private well.

Through state statute enacted in 1987 (38 MRSA §404), a pre-existing water user (i.e., public water supplier or landowner of 3 years) can take action against ground water withdrawal in “excess of beneficial domestic use for a single-family home and when the withdrawal causes interferences with the preexisting beneficial domestic use of ground water by a landowner or lawful land occupant.” However, this statute does not provide protection against causes of water quality impact.

Regulations under the Maine Site Location of Development Law (38 MRSA §484) require contaminant concentrations in water at the site boundary to be no greater than federal drinking water standards. This law leaves no “headspace” or buffer for the downstream landowner, resulting in a first come, first served approach to ground water use, which is not recommended for long-term land use policy.

The general licensing criteria for solid waste landfills requires that “no unreasonable risk that a discharge to a significant ground water aquifer will occur” (Chapter 400, Maine Solid Waste Management Regulations, DEP). This includes “no unreasonable threat to the quality of an underlying fractured bedrock aquifer.” The Solid Waste Regulations also include limited information regarding water supply wells relative to landfill closure procedures. A landfill must be at least 1000 feet from a water supply well to be eligible for “reduced closure procedures.”

At the local municipal level, the state subdivision statute (30 MRSA §4956), administered by local Planning Boards, requires “no unreasonable adverse impact” to ground water quality or quantity for projects coming under subdivision review. However, the state laws do not provide specific guidance or standards to define “adverse impact” on ground water quality or quantity, leaving the interpretation to local boards and officials. Furthermore, single residential lots escape Maine’s ground water quality protection strategies.

The DEP regulates the discharge of pollutants to Maine waters. In contrast, the DHS takes the approach of controlling the level of pollutants allowed in public drinking water supplies. The DHS strategy for water resource protection occurs through public health code for human consumption rather than environmental regulation of the resource. DHS manages water resource protection through two primary programs: the Wastewater and Plumbing Control Program, and, the Drinking Water Program.

The Maine Wastewater and Plumbing Control Program administers the state's wastewater rules for compliance with public health codes. Wastewater rules related to ground water protection include the Minimum Lot Size Law (12 MRSA §4807) and the Subsurface Waste Water Disposal Rules (22 MRSA §42). The Minimum Lot Size Law provides minimum State requirements for lots utilizing onsite subsurface wastewater disposal. A goal of this law is to "assure environmental sanitation and safety." The minimum lot size for single-family dwellings, with an average wastewater discharge volume of 300 gallons per day, is 20,000 square feet.

The Maine Subsurface Waste Water Disposal Rules (22 MRSA §42) govern the protective separation distance between a septic system and water supply well. Sufficient separation distances between a septic system and drinking water well are required for public water supplies to provide die-off of harmful pathogens (bacteria and viruses). About 200 days of travel time in ground water between a septic system and a well eliminates about 99.9% of most pathogens in residential wastewater (EPA, 1993). Travel time can be calculated for the specific geologic setting. For example, in sand and gravel, and bedrock aquifers, ground water flow rates are on the order of 1 foot per day. The 200-day travel time from an up gradient septic system to a down-gradient well, would be estimated as a distance of about 200-feet. This is not true for ground water flow in till soils due to differences in porosity and hydraulic conductivity. Under the Maine Subsurface Waste Water Disposal Rules (10-144 Chapter 241) a minimum separation distance of 100 feet is required for residential wastewater systems with design flows of 1000 gallons per day or less.

Maine's drinking water rules are derived from the federal Safe Drinking Water Act of 1974 and its 1986 and 1996 amendments. This Act established drinking water standards for public water supplies with the goal of protecting public health by ensuring safe drinking water. In Maine, public drinking water supplies are regulated through Maine Title 22, Chapter 601, "Water for Human Consumption." The Maine Department of Human Services has authority over this Act and the Drinking Water Program administers the state's drinking water rules under this department. The Safe Drinking Water Act has helped to save lives through the establishment of enforceable standards for more than 90 contaminants in public drinking water supplies. For example, the drinking water rules state that new public water supply wells must be at least 300 feet from potential contamination sources such as landfills (Chapter 231, State of Maine Rules Relating to Drinking Water).

However, nearly half of all Maine residents derive their drinking water from private water supplies (Tolman, 2004). Private water supplies are not safeguarded against potential public health threats to the same extent as public water supplies. Furthermore,

there is no prohibition against drinking contaminated water. While the Maine Department of Human Services provides guidelines for private well owners, the guidelines are non-enforceable and do not ensure that water from a given well is safe to drink. For example, the guidelines do not require water quality testing at private wells. In stark contrast, there are strict regulations for water quality testing at public water supplies. The lack of drinking water regulations at private water supplies potentially places consumers of private well water at risk, especially in a climate of increasing interest in dense development.

**Appendix B
GIS Data Sources
Bar Harbor, Maine**

The following data sources are available in digital format and were compiled as part of the Bar Harbor hydrogeologic study.

MAINE OFFICE OF GIS

<http://apollo.ogis.state.me.us/>

MEDOQ Photos

Photodates by Maine GIS TILE_NAME for USGS Digital Orthophoto Quarter Quadrangles appended to create MEDOQs. At this time, the most recent photo date is available in the Data Catalog.

Publication Date: 4/9/2002

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 SW", "Southwest Harbor"

aqfrs24 polygon

File Size: 44Kb Contains the following additional information from Maine Geological Survey on AQFRS24 by 1:24000 USGS quadrangle name: tile, mapping status, series, compiler, mapper, Open File number, associated report number, publication, completion, and begin date. Publication Date: 9/3/2002

"Bar Harbor","bar-harbor","mapped","no aquifers",,,, "0", "0", "0"
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USGS Topographic Quadrangle information

COAST depicts Maine's coastline at mean high water, based on USGS 1:24,000 scale quadrangles. Some New Hampshire and New Brunswick coastlines are also included. Data for this coverage were digitized from the Mean High Water (MHW) line as shown on USGS 1:24,000 scale quadrangle maps. In addition, tidal rivers and ponds are also included in this coverage.

CONTOURS contains contour lines for Maine from USGS 1:24,000 scale quadrangles; in accordance with the source, units may be in feet or meters and intervals may be at 10 to 20 feet, or 3 meters. Additional supplementary contours exist on some of the quads.

PONDS contains pond and lake features in Maine from USGS 1:24,000 scale quadrangles. Data for this coverage were digitized from USGS 1:24,000 scale quadrangle maps by various contractors.

RIVERS depicts double line river features in Maine from USGS 1:24,000 scale quadrangles. Some New Hampshire and New Brunswick features are also included. Codes are included to select river island polygons. Note that tidal portions of the rivers are located on the COAST coverage.

ROADS includes roads and trails in Maine from USGS 1:24,000 scale quadrangles. Some New Hampshire and New Brunswick features are also included.

STREAMS depicts single line streams of Maine from USGS 1:24,000 scale quadrangles. Some New Hampshire and New Brunswick features are also included. Data for this coverage were digitized from USGS . . .

MECNLND contains conservation lands ownership boundaries at 1:24,000 scale for Maine land in federal, state, and non-profit ownership with easements. State, county, town, and coast boundary data were obtained from MEGIS town boundary dataset METWP24. The ownership lines do not represent legal boundaries nor are the ownership lines a survey. MECNLND is an inventory.

WELLS consists of point data, each representing the location of a public water supply well in Maine. The records are current as of June 2003, to the best of Maine Drinking Water Program (MEDWP) record knowledge.

DIRSHED depicts watershed areas of surface waters that are active sources of Maine public water supplies, depicted at 1:24000 scale. For river systems, the watershed is arbitrarily truncated .5 mile (0.8 kilometers) upstream of the intake.

Towns - METWP24 depicts political boundaries, common town names, and geocodes for Maine at 1:24,000 scale. The coverage was created from USGS, 7.5 minute map series, town boundaries.

WBDME6_A is a digital hydrologic unit boundary layer of Level 6 (12-digit) SUBWATERSHEDs for Maine. The source data was developed by delineating the boundary lines on a USGS base of 1:24000 scale

OTHER DIGITAL DATA SOURCES

Tax mapping and sewer infrastructure

bhtax95

taxlines

manholes

sewerlines

districts

Provided by Jim Barker of **GeoSystems, Inc.**, in Yarmouth, Maine. GeoSystems reportedly obtained tax data from the College of the Atlantic. Data are UTM NAV 1927.

Residential Buildout

Provided in digital format by the **College of the Atlantic**, October 2004, Gordon Longworth, GIS Lab Director, Hope Rowan, Research Associate.

Current (2004)

10 years (2014)

20 years (2024)

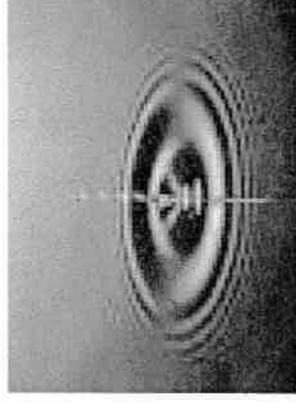
30 years (2034)

Natural Resources Conservation Service Soil Mapping

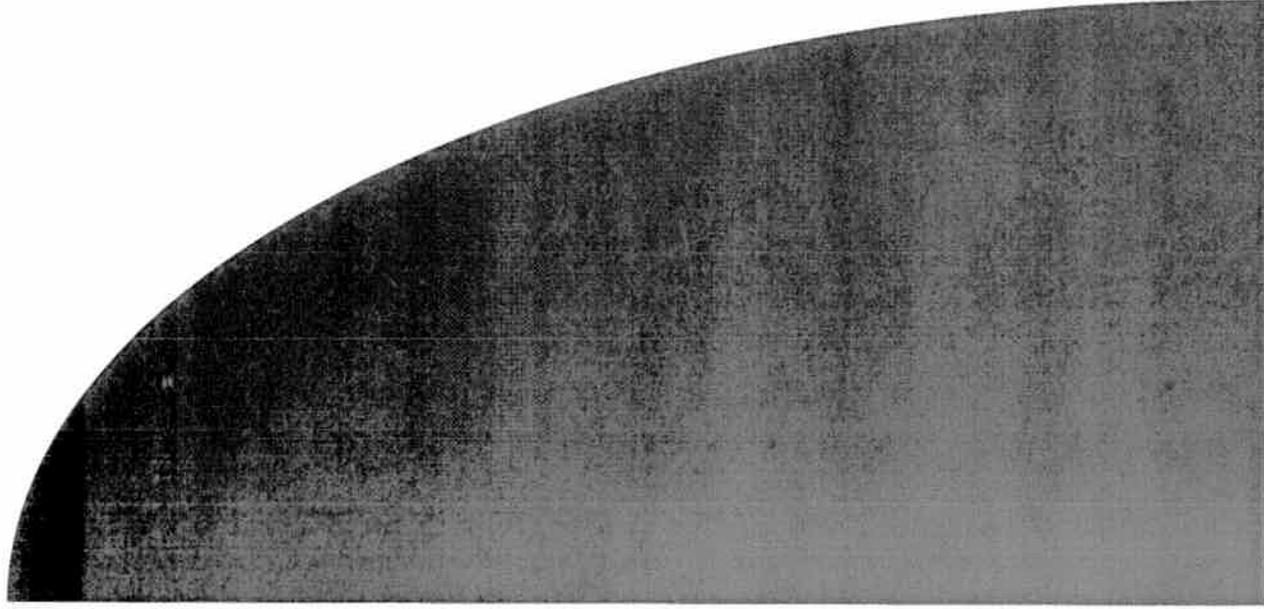
<http://www.ncgc.nrcs.usda.gov/branch/ssb/products/ssurgo/data/me.html>

Soil mapping for Hancock County: Soil Survey Staff 2004, National Soil Survey Characterization Data, Soil Survey Laboratory, National Soil Survey Center, USDA-NRCS - Lincoln, NE., Monday, October 04, 2004

Hydrogeologic Resource Evaluation

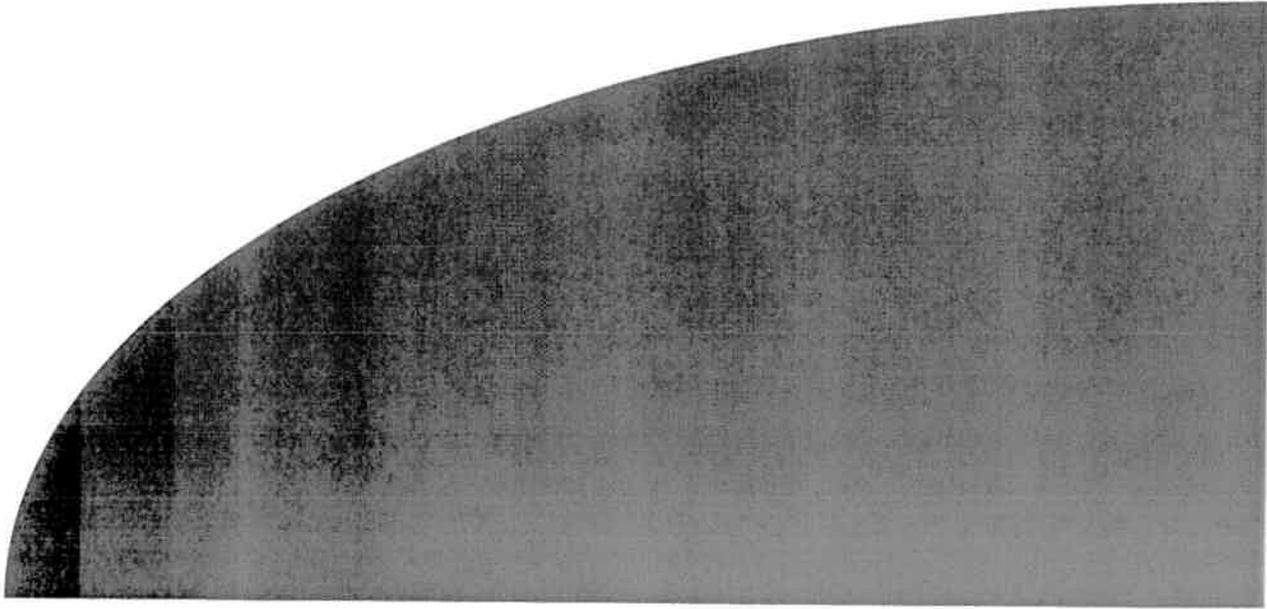


**Bar Harbor,
Maine**



Lissa Robinson, P.E., C.G.

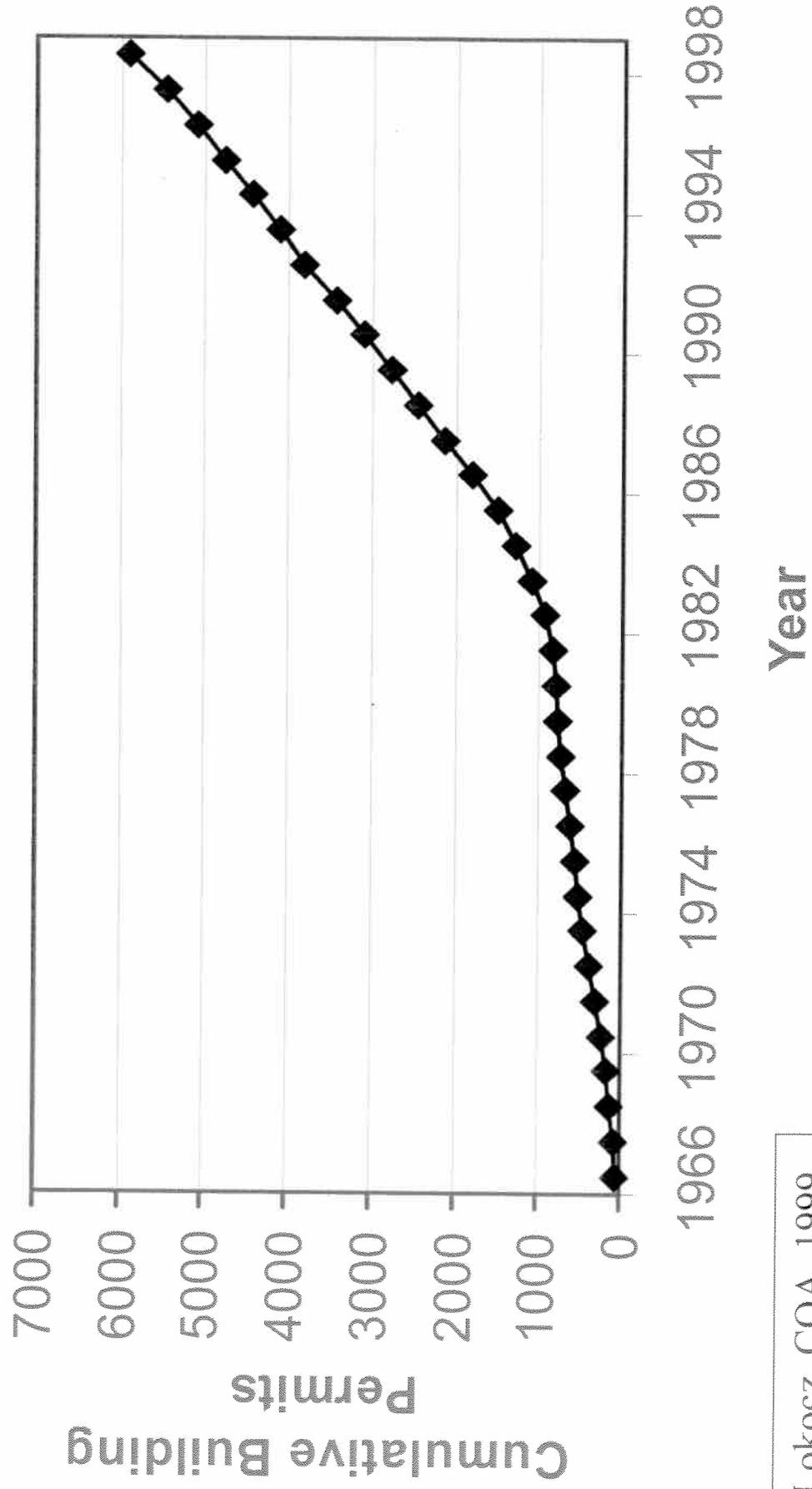
Civil Engineer, Hydrogeologist, and
Land Planner
Stratex, LLC
Portland, Maine



Objective

- Develop a process for protecting hydrogeologic resources from the impacts of residential development.
- ◆ To minimize the impact of new development on existing wells.
- ◆ To preserve an important symbol for the region.

Cumulative Building Permits 1966 to 1998 Bar Harbor, Maine



Lokocz, COA, 1999

Growth risky for Bar Harbor

Study: Water supply could fall short

BY LIZ CHAPMAN
OF THE NEWS STAFF

BAR HARBOR — The underground water supply in the northern area of town is insufficient to serve the number of homes that could be built under existing zoning rules, the Town Council was told Tuesday.

Martha Nielson of the U.S. Geological Survey in Augusta conducted a **Rancock** yearlong analysis of the quantity of underground water in several watersheds in rural Bar Harbor. She made a lengthy report, with two main conclusions:

- If homes were built in the area as allowed under current zoning laws — one home per acre — wells likely would run dry in years of below-average rainfall, as has been the case in recent years throughout Maine.
- The town should be concerned about increased nitrogen levels getting into the groundwater and nearby creeks and bays when there is not enough rainfall to adequately dilute the nitrogen that seeps out of private septic systems.

According to the study, without enough dilution, nitrogen levels can exceed the standards for human health, which is 10 milligrams per liter. However, even less nitrogen is needed to negatively affect fresh and tidal water ecosystems.

Gary Friedmann, chairman of the town's conservation commission, told councilors the study should be used by the planning board and other town officials in making changes to existing zoning laws. The town

also should consider other methods of heading off a serious problem in the future, such as requiring septic systems that would not allow less nitrogen to seep into the surrounding soil and water.

"This is a clear threat to human health and the ecosystems" in the area, Friedmann said.

The council also learned that data and numerous graphs which Nielson had produced as part of her study — which would clearly illustrate the problem — had been removed from her 45-page report.

Specifically, Nielson confirmed that her superiors at the USGS feared that some of her work was too much like the work that private industry could perform. She said the USGS had come under fire in the past for competing with the private sector, and that her bosses thought some of her work would be seen as directly competing with private geology firms.

Therefore, the information was removed from the report and the town must hire a private hydrologist to finish the first phase of the study.

Councilor Valerie Scott noted that the town must pay \$5,000 or more for the private work after already paying about \$53,000 for the USGS study.

"The missing graphs show what anecdotally has been known for years — people are running out of water," said Friedmann, who was clearly frustrated and annoyed that the information had been pulled from the report.

Additional work recommended by Nielson includes monitoring homeowners' wells in the study area to measure fluctuations in water levels and mapping the extent of a clay formation that contributes to the high levels of nitrogen by preventing it from penetrating the ground.

On a lighter note, Nielson noted that the missing USGS information could be considered a new "Watergate."

In other matters Tuesday, the council approved increasing cruise ship port fees from \$1,000 to \$1,250 per ship this year and to \$1,500 per ship next year. The increased fees will raise nearly \$20,000 more annually by 2006, for an estimated total of \$87,000.

The council also approved the language of a form letter that will be sent to nonprofit organizations in town asking them to consider making a payment in lieu of property taxes in recognition of the services they receive from the town.

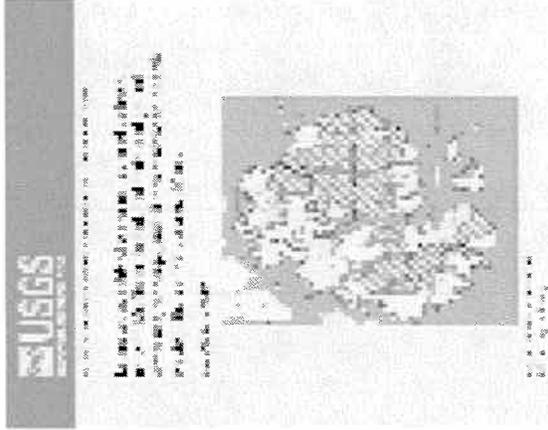
The study was commissioned as part of a larger look at the impact of rural development on the quantity and quality of water on Mount Desert Island and Acadia National Park.

The park has started its own extensive water study, already spending about \$500,000 on the work.

David Manski, a biologist at Acadia, said the park became concerned several years ago about the impact of housing development around the boundaries of the park.

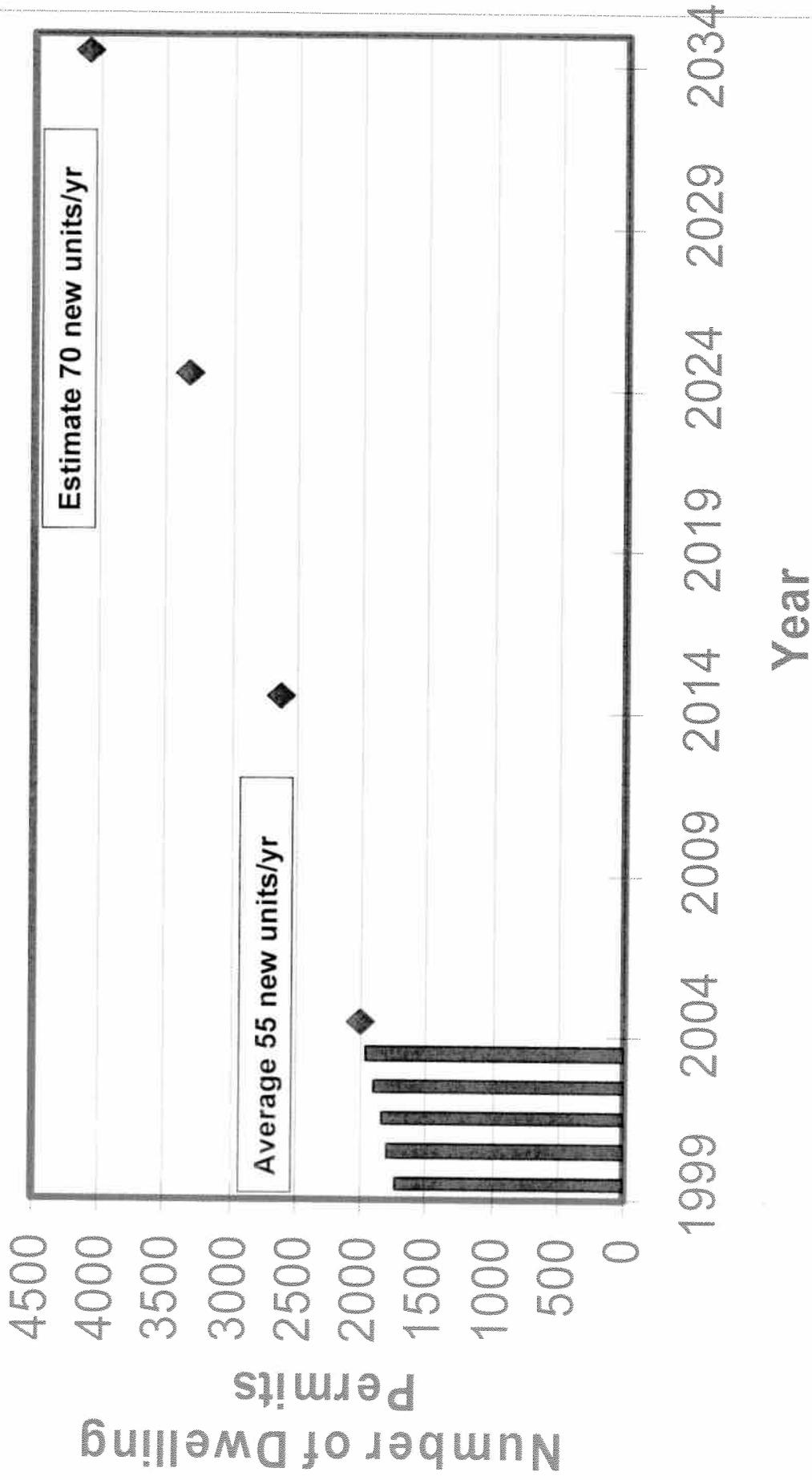
The Northeast Creek watershed was selected for early study because the area has been undergoing rapid subdivision growth in recent years, according to the report.

Friedmann urged the council to have a "build-out model" developed, showing where and how much growth could be realized under existing zoning laws. The town has included money in the proposed budget to hire a private hydrologist to continue the study.



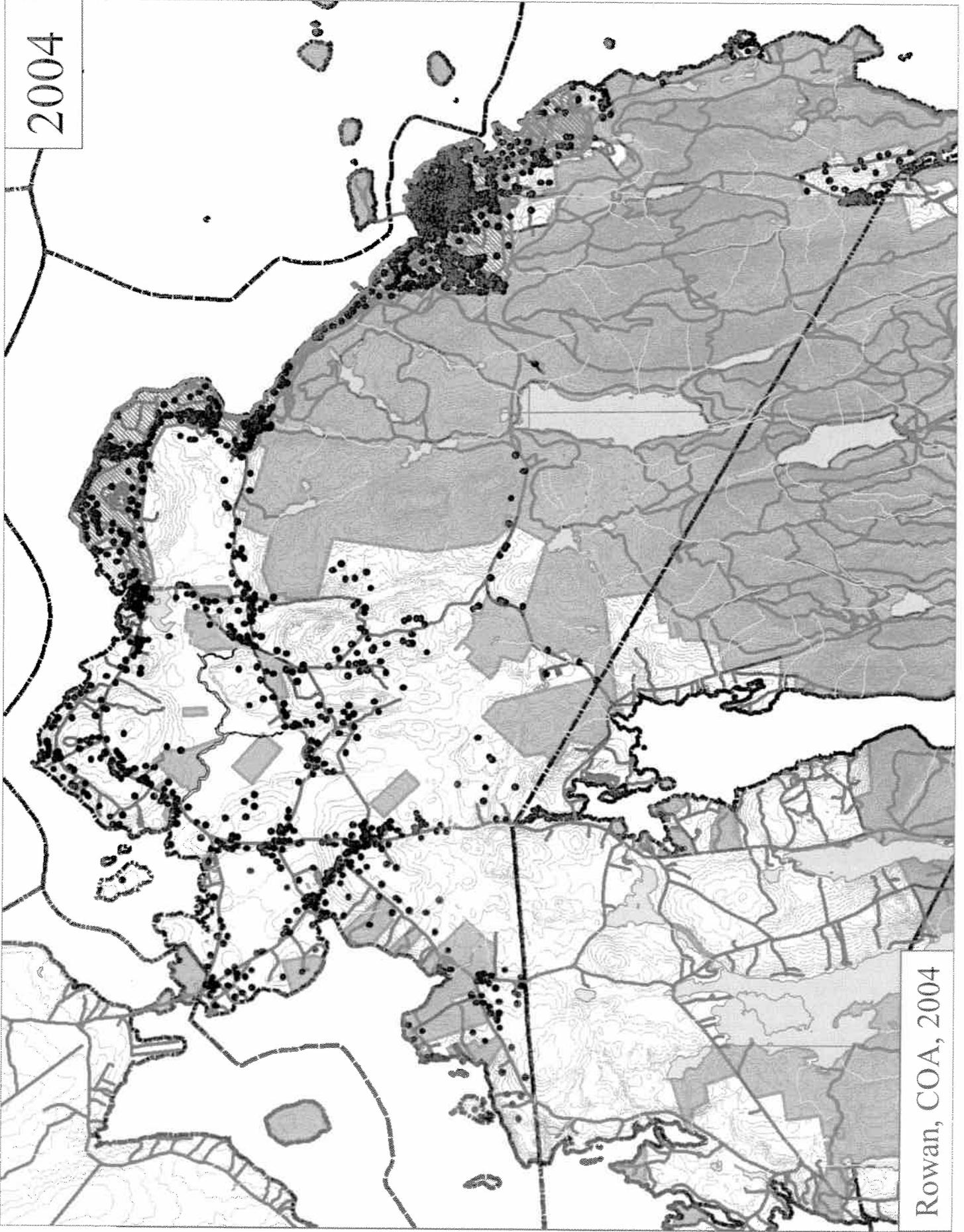
USGS

Residential Housing



Chamberlain, 2004
Rowan, COA, 1999

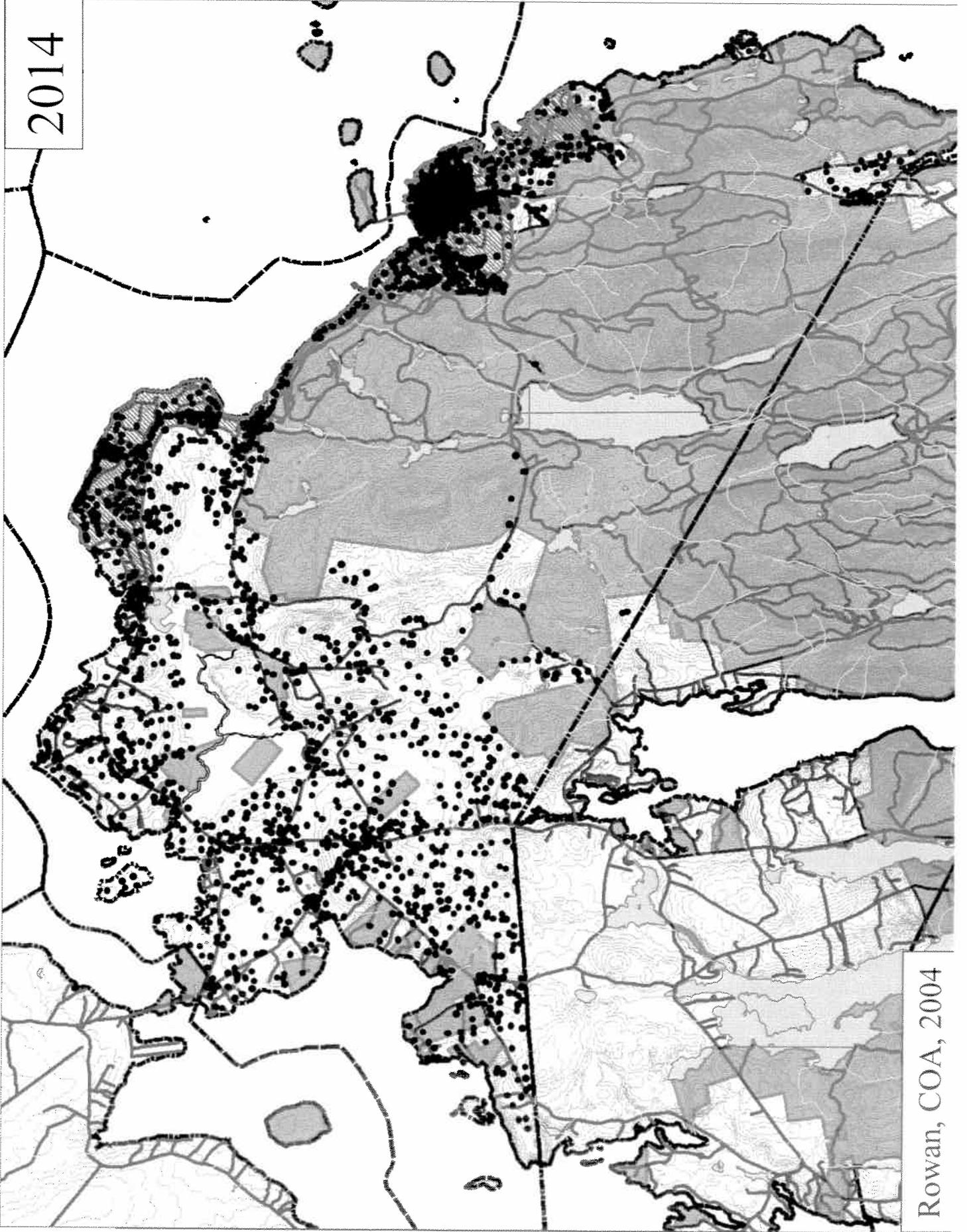
■ New Dwelling Permits —◆— Residential Build-out Estimates



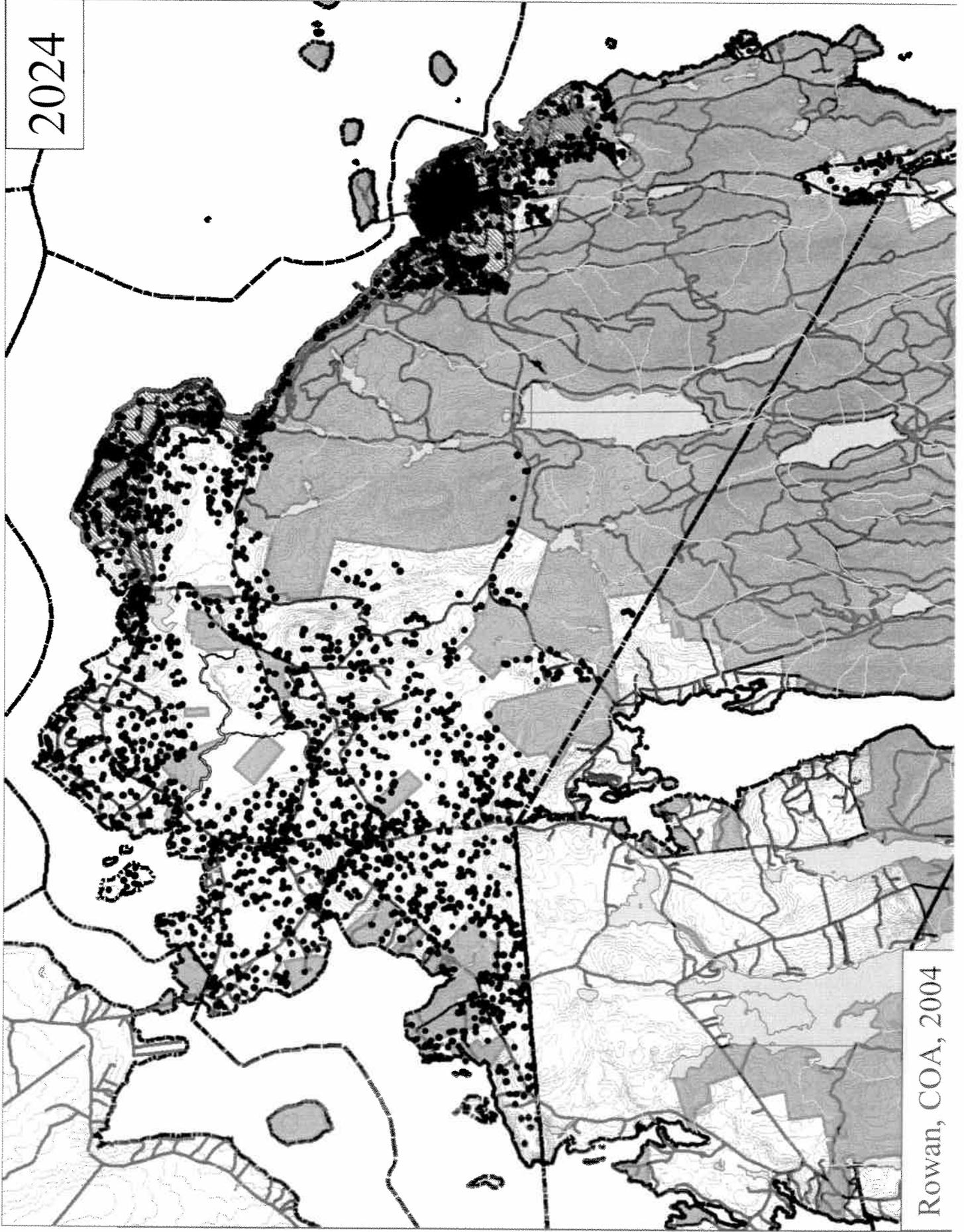
2004

Rowan, COA, 2004

2014



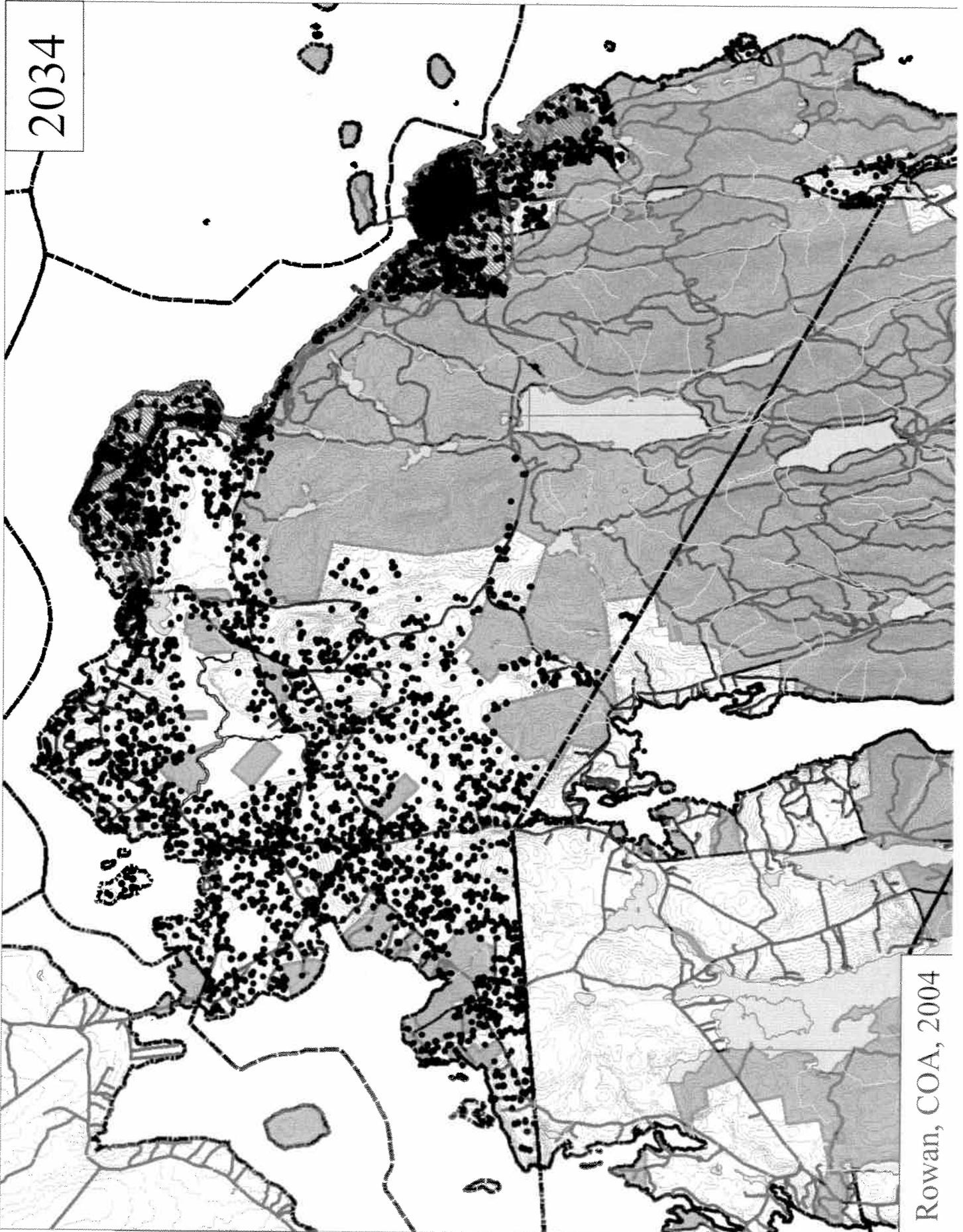
Rowan, COA, 2004



2024

Rowan, COA, 2004

2034



Rowan, COA, 2004

Evaluation Steps

- Evaluate the current conditions;
- Investigate vulnerability and identify threats.
- Develop a process to achieve protection goals.

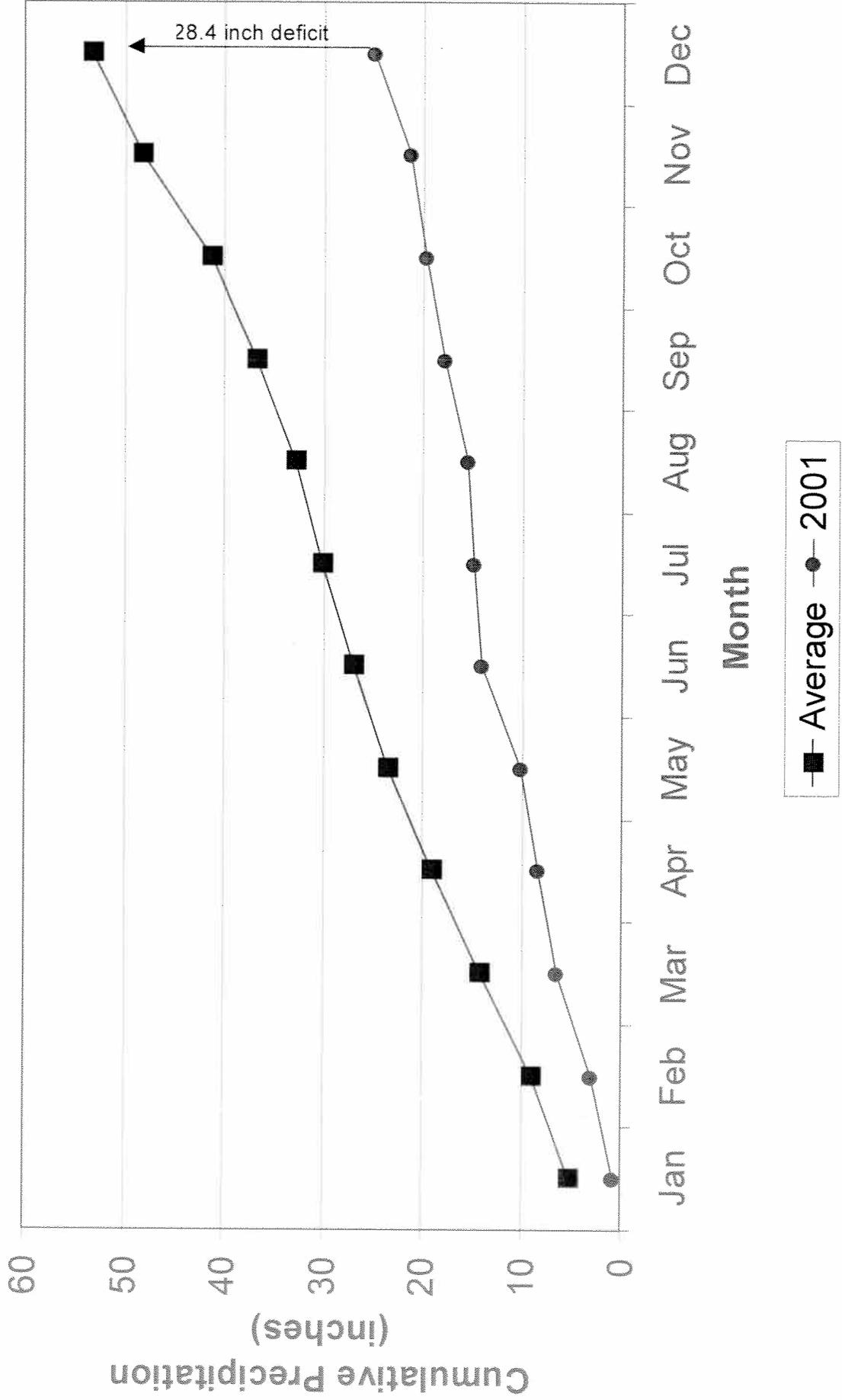
Current Conditions

- Water quantity
Is there enough water?
- Water quality
Is the water safe to drink?

Water Quantity

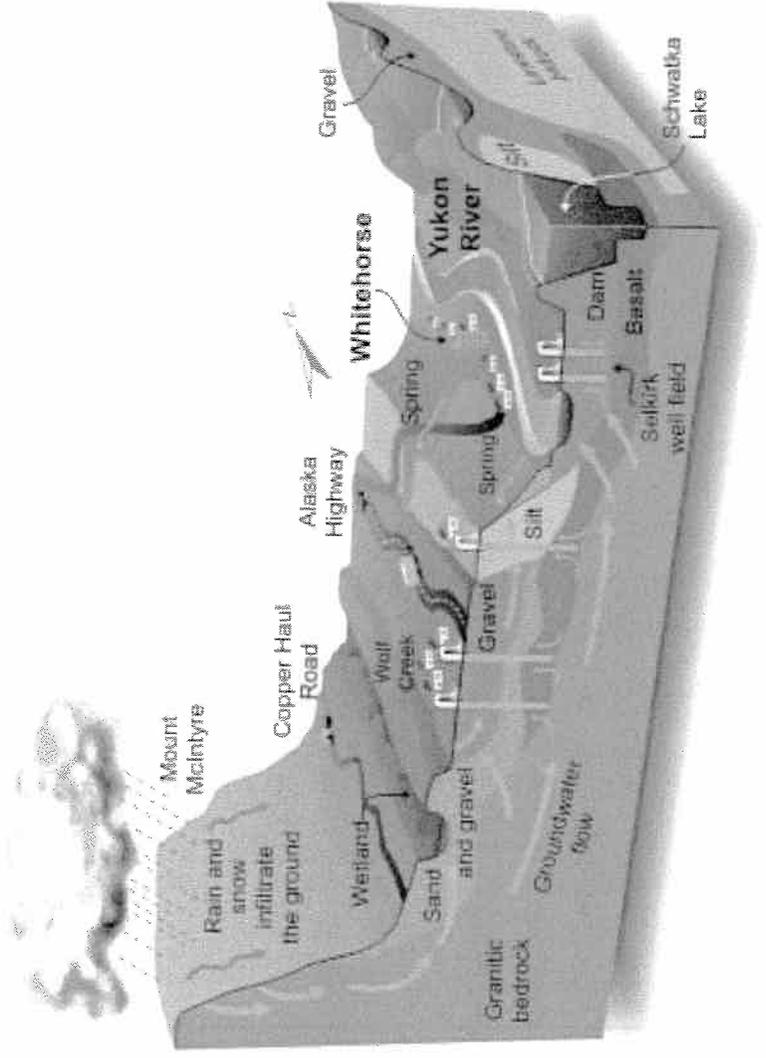
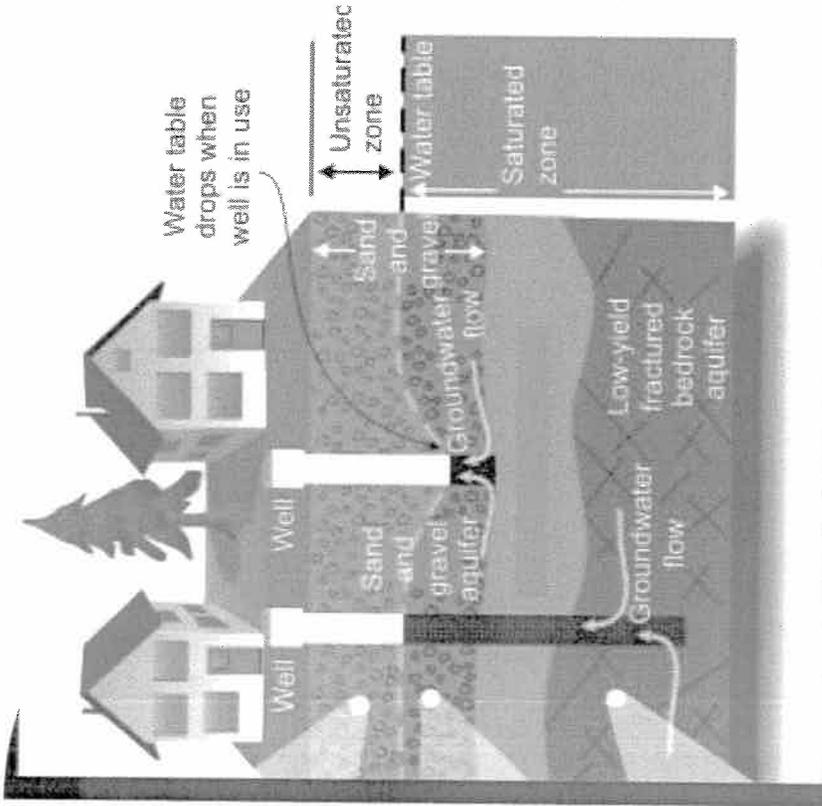
- Water quantity based on precipitation and recharge.
- ◆ Average annual precipitation to ground surface ~55 inches
- ◆ Recharge rate to soil and rock soil ~12.5% of precip (7 in) bedrock ~10% of precip (5.5 in)

Cumulative Monthly Precipitation 1981 to 2004 Bar Harbor, Maine



Private Well

- Precipitation
- Recharge
- Ground water



Current and Future Ground Water Use

- Bedrock recharge ~ 1.5 Bgal/yr
- Water use:
 - ◆ 2001 ~ 47 Mgal/yr
 - ◆ 2034 ~ 96 Mgal/yr
- 2001 -- 4.1% of bedrock recharge was withdrawn for domestic purposes.
- 2034 -- 8.4% of bedrock recharge will be withdrawn for domestic purposes (estimate).

Is there enough water?

In general, there is likely to be enough ground water to provide domestic needs under 2034 build-out estimates.

Conditions:

- ◆ Precipitation reflects past average;
- ◆ Unbuildable areas unchanged;
- ◆ Average pumping rates similar;
- ◆ Conserved park land maintained;
- ◆ Limits on impervious area.

Water Quality

- Contamination of private wells from residential activities:
 - ◆ Petroleum;
 - ◆ Chemicals;
 - ◆ Heavy Metals;
 - ◆ Fertilizers and pesticides;
 - ◆ Salt water intrusion;
 - ◆ Bacteria and nitrates.

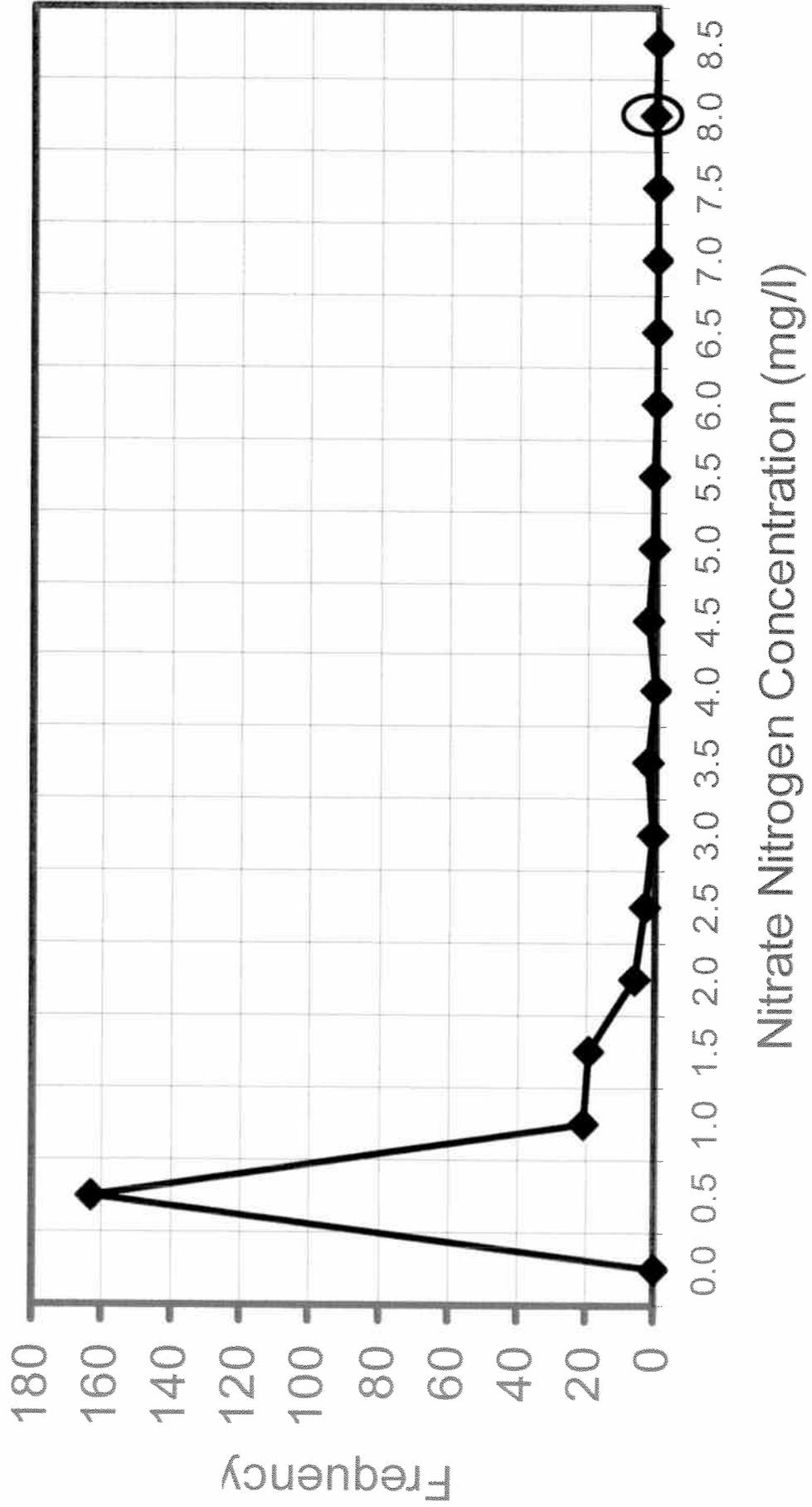
Focus

- Bacteria and Nitrates most significant threat;
- Physical characteristics increase vulnerability.

Test Data

- Ten year period (1991 – 2001):
 - ◆ 200 tests for Nitrate Nitrogen at drilled residential wells (out of a total of about 1,114 wells);
 - ◆ Results below EPA standard of 10 mg/l;
 - ◆ BUT, only 2% of wells were tested (on an annual basis);
 - ◆ EPA and DHS recommend annual private well testing.

Frequency Distribution Nitrate Nitrogen Bar Harbor, Maine, 1991 to 2000



Is water safe to drink?

- Risk of contamination increases with increasing population and decreasing lot size.
- Gross residential lot sizes estimated to decrease from 7 to 4 acres per dwelling by 2034 in certain watersheds.
- Net lot sizes of less than 1 acre call for mitigation measures to protect water quality.
- Homeowners need to test water quality more frequently.

Test Private Well Water Annually

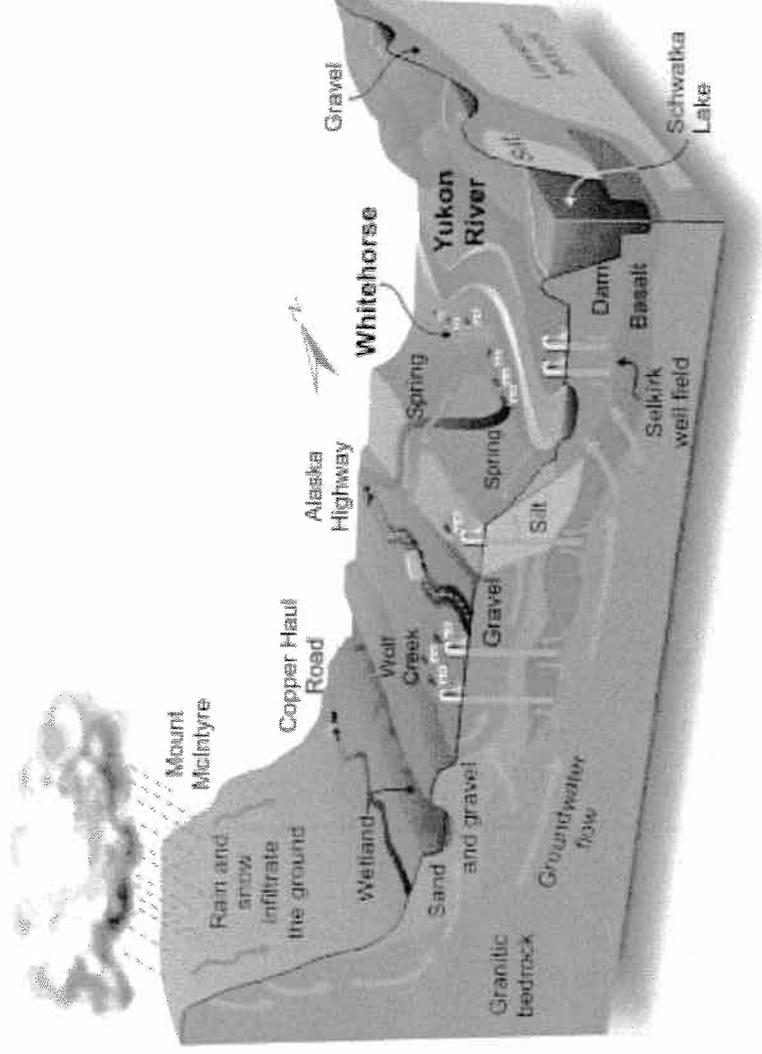
- EPA recommends
 - ◆ Total Coliform Bacteria
 - ◆ Nitrate Nitrogen
 - ◆ Total Dissolved Solids
 - ◆ pH
 - ◆ Other suspected contaminants

Resource Vulnerability

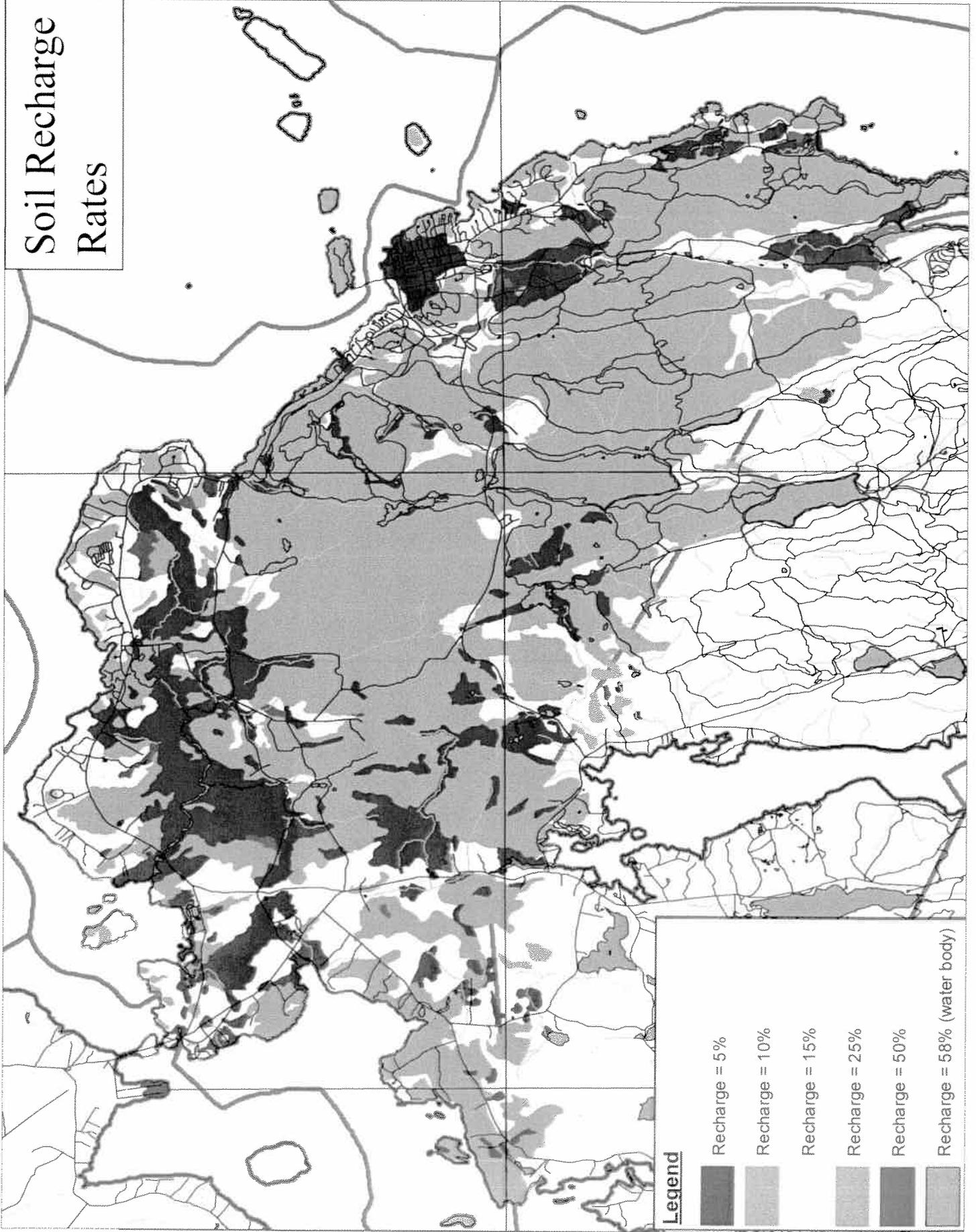
- Recharge zones (about the upper third portion of a watershed);
- Thin soils (<5 feet thick), Low recharge rates (5-15%), and Exposed bedrock;
- Coastal areas (within about 200 feet of the shoreline).

Recharge Zone

- Upper third of watershed



Soil Recharge Rates



Water Resource Protection

- Voluntary efforts;
- User fees;
- Direct controls.

Voluntary Efforts

- Non-mandatory investment in natural resources:
 - ◆ Perform regular well testing;
 - ◆ Reduce impervious coverage;
 - ◆ Install denitrification equipment;
 - ◆ Perform land conservation;
 - ◆ Manage pet waste;
 - ◆ Manage household chemicals;
 - ◆ Manage and maintain septic systems.
 - ◆ Establish partnerships (land trust, public water system, LMF)

User Fees

- Private well user fee;
- Impact fees for infrastructure improvement.

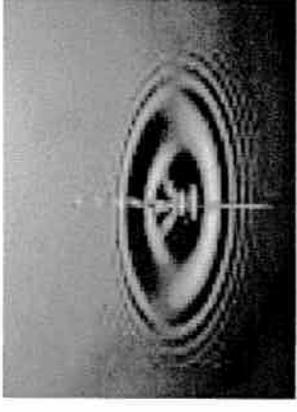
Direct Controls

- To achieve water QUANTITY protection goals:
 - ◆ Minimize loss of recharge and enhance infiltration;
 - ◆ Avoid ground water table lowering beyond the property boundary;
 - ◆ Stay within the bedrock aquifer safe yield;
 - ◆ Monitor new well installation;
 - ◆ Monitor long-term ground water level trends.

Direct Controls, cont'd

- To achieve water QUALITY protection goals:
 - ◆ Prevent degradation from septic systems, salt water intrusion, petroleum, chemicals, etc.
 - ◆ Monitor water quality in new wells;
 - ◆ Monitor long-term ground water quality trends especially in vulnerable areas;
 - ◆ Encourage development that minimizes resource impacts;
 - ◆ Consider extending utilities.

Conclusion



- In general, there is likely to be sufficient quantity of water to 2034 projections;
- Certain areas may be at risk due to the physical setting and site layout;
- Private wells need to be tested more frequently (i.e., once/year);
- Town is justified in implementing protection goals in light of citizen concerns, value of resource, and vulnerability of resources.