CONNECTICUT
Ground-Water Quality

Ground water is a major source of supply in Connecticut. Annual withdrawals total about 150 Mgal/d (million gallons per day) (U.S. Geological Survey, 1985, p. 161), and public-supply and private wells provide drinking water to one-third of the State's population (fig. 1). Almost all of the 1,250 public-supply wells currently meet water-quality standards established by the Connecticut Department of Health Services (1985), and ground water beneath more than 90 percent of the land in the State is considered to be suitable for drinking without treatment (Connecticut Department of Environmental Protection, 1986, p. 34).

U.S. Geological Survey data indicated that most ground water in Connecticut is of the calcium-bicarbonate type, with dissolved-solids concentrations being small (fig. 2)—median concentrations for all major aquifers are less than 250 mg/L (milligrams per liter). A few naturally occurring constituents may be present in sufficiently large concentrations to affect the potability of the water and its use for some industrial purposes. Concentrations of iron and (or) manganese larger than 300 and 50 μg/L (micrograms per liter), respectively, are common in all major aquifers, and water from both carbonate- and sedimentary-rock aquifers is commonly hard to very hard (more than 120 mg/L as $CaCO_3$). Large concentrations of sulfate (greater than 250 mg/L), chloride (greater than 250 mg/L), and sodium (greater than 20 mg/L), occur locally in the sedimentary-rock aquifer.

Connecticut's major aquifers, (fig. 2), described in the 1984 National Water Summary (U.S. Geological Survey, 1985, p. 161–166), are shallow and susceptible to contamination. Stratified-drift aquifers are more susceptable to contamination than are bedrock aquifers.

The urbanized and industrialized nature of much of Connecticut has resulted in numerous incidences of ground-water contamination. The most common causes are application of pesticides, improper handling and disposal of solvents, leachate from solid-waste disposal sites, leakage from petroleum storage tanks, and improper storage of road salt. These causes account for 882 of the 928 public- and private-well contamination incidences that have affected about 150,000 people since about 1979 (Connecticut Department of Environmental Protection, 1986, p. 35). The most widespread contamination resulted from the use of the pesticide ethylene dibromide (EDB) in the tobacco-growing areas of north-central Connecticut.

Connecticut contains 70 sites that require monitoring of ground-water quality under the Federal Resource and Conservation Recovery Act (RCRA) and 7 sites that are included on the National Priorities List (NPL) of hazardous-waste sites by the U.S. Environmental Protection Agency (1986a) under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). The State also monitors ground-water quality or supervises such monitoring at more than 80 additional sites where wastes are disposed of, or where discharges to ground water are permitted. Some impairment of ground-water quality has been detected at almost all monitored sites (E.B. Patton, Connecticut Department of Environmental Protection, oral commun., 1986).

Incidences of ground-water contamination detected by State and local agencies increased significantly over the last decade largely because of more comprehensive monitoring and analyses. Practices such as burial of fuel storage tanks and improper waste disposal, the prospect of continued urban growth, the potential for accidental spills of chemicals, the likely strengthening of State drinking-water standards, and the hydrogeologic characteristics of major aquifers suggest that ground-water contamination will continue to be a problem in Connecticut. Furthermore, ground water and surface water are so interrelated in Connecticut that their quality cannot be managed separately. Yields of large public-supply and industrial wells commonly depend on induced recharge from surface-water bodies. Conversely, ground water under natural conditions discharges mainly to streams, lakes, and estuaries. State water-quality management efforts are focused on conjunctive management of ground water and surface water within the framework of major river basins.

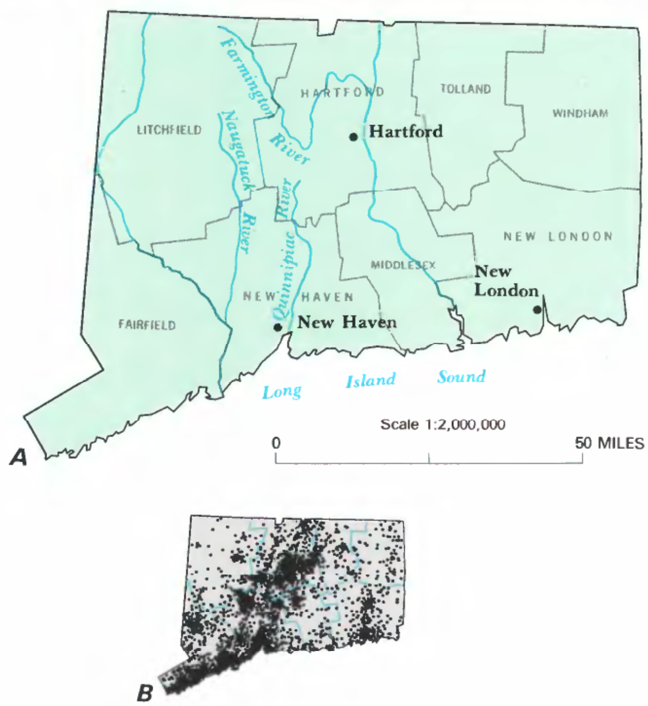


Figure 1. Selected geographic features and 1985 population distribution in Connecticut. *A*, Counties, selected cities, and major drainages. *B*, Population distribution, 1985; each dot on the map represents 1,000 people. (Source: *B*, Data from U.S. Bureau of the Census 1980 decennial census files, adjusted to the 1985 U.S. Bureau of the Census data for county populations.)

WATER QUALITY IN PRINCIPAL AQUIFERS

Connecticut has two types of aquifers (fig. 2*A*)—stratified-drift aquifers composed of unconsolidated sand and gravel of glacial origin, and consolidated bedrock aquifers that are differentiated into sedimentary-, crystalline- (noncarbonate), and carbonate-rock aquifers (U.S. Geological Survey, 1985, p. 161). Stratified-drift aquifers, although unevenly distributed within the State, are the most productive. They are the primary source of ground water for public supply and large industrial or commercial uses. Bedrock aquifers underlie the entire State and are the principal source of water for self-supplied domestic use. The typical relationship between stratified-drift and bedrock aquifers is show in figure 2*B*.

Most of the estimated 225,000 wells in Connecticut tap the upper part of the saturated zone (within 300 feet of land surface) and produce water that may have been in the aquifer only a few months to a few decades. The quality of this water in each major aquifer is generally good to excellent and suitable for most uses. Its chemical composition resembles precipitation that has been slightly altered by contact with aquifer materials. Limited data are available from deeper wells. Therefore, the quality of ground water at depths greater than 300 feet is largely unknown.

Background Water Quality

Selected water-quality variables in the U.S. Geological Survey's National Water Data Storage and Retrieval System (WATSTORE) for 1953–85 have been statistically summarized in figure 2C. The summary is based on dissolved-solids, hardness (as calcium carbonate), nitrate (as nitrogen,), sulfate, and iron analyses of water samples and show the variability of the chemical quality of water from the four principal aquifers in Connecticut. Percentiles of these variables are compared to national standards that specify the maximum concentration or level in a drinking-water supply as established by the U. S. Environmental Protection Agency (1986 b,c). The primary maximum contaminant level standards are health related and are legally enforceable. The secondary maximum contaminant level standards apply to esthetic qualities and are recommended guidelines. The primary drinking-water standards include a maximum concentration of 10 mg/L nitrate (as nitrogen), and the secondary drinking water standards include maximum concentra-

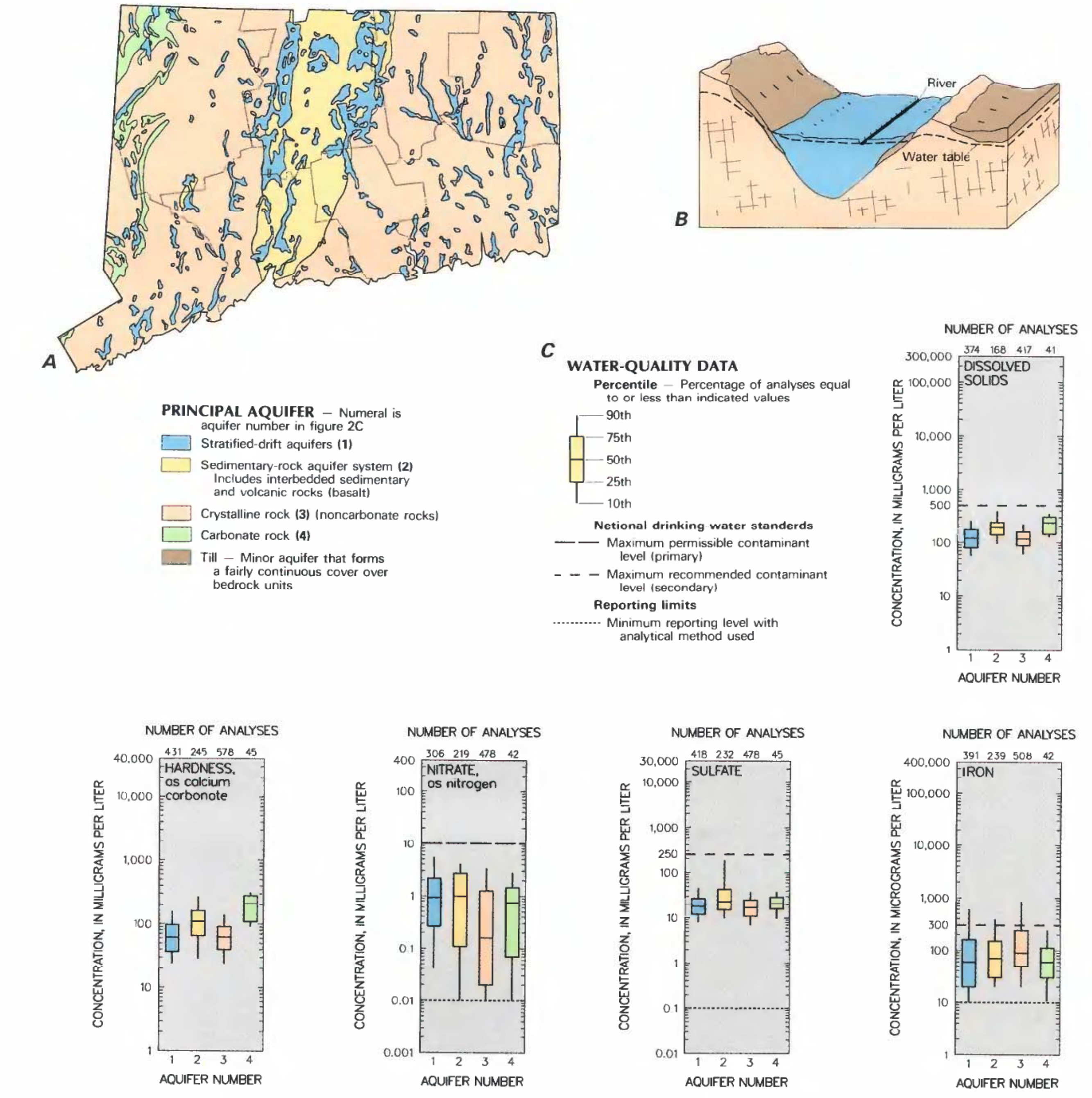


Figure 2. Principal aquifers and related water-quality data in Connecticut. *A*, Principal aquifers. *B*, Generalized block diagram. *C*, Selected water-quality constituents and properties, as of 1953-85. (Sources: *A*, Meade, 1978. *B*, Mazzaferro and others, 1979. *C*, Analyses compiled from U.S. Geological Survey files; national drinking-water standards from U.S. Environmental Protection Agency, 1986 b,c.).

tions of 500 mg/L disssolved solids, 250 mg/L sulfate, and 300 μg/L iron.

The water-quality data were interpreted without considering differences in hydrogeologic setting, well construction, or sampling methods. Data from wells known to be affected by point sources of contamination or saltwater intrusion were excluded. The remaining analyses are believed to represent natural ground-water quality, but a few may be affected by nonpoint sources of contamination. When more than one analysis of water from a well was available, the median concentration of a constituent was used to calculate the summary statistics for the aquifer.

Dissolved Solids

The median concentration of dissolved solids in water from all four aquifers (fig. 2*C*) is smaller than 250 mg/L, which is considerably less than the 500-mg/L standard for potable water supplies. The water from the carbonate-rock aquifer has the largest median dissolved-solids concentration (240 mg/L), but no samples from this aquifer exceeded 500 mg/L. Fewer than 1 percent of the wells in the stratified-drift and crystalline-rock aquifers produced water with more than 500 mg/L dissolved solids. The sedimentary-rock aquifer, however, yielded water with more than 500 mg/L dissolved solids in about 8 percent of the sampled wells, and con-

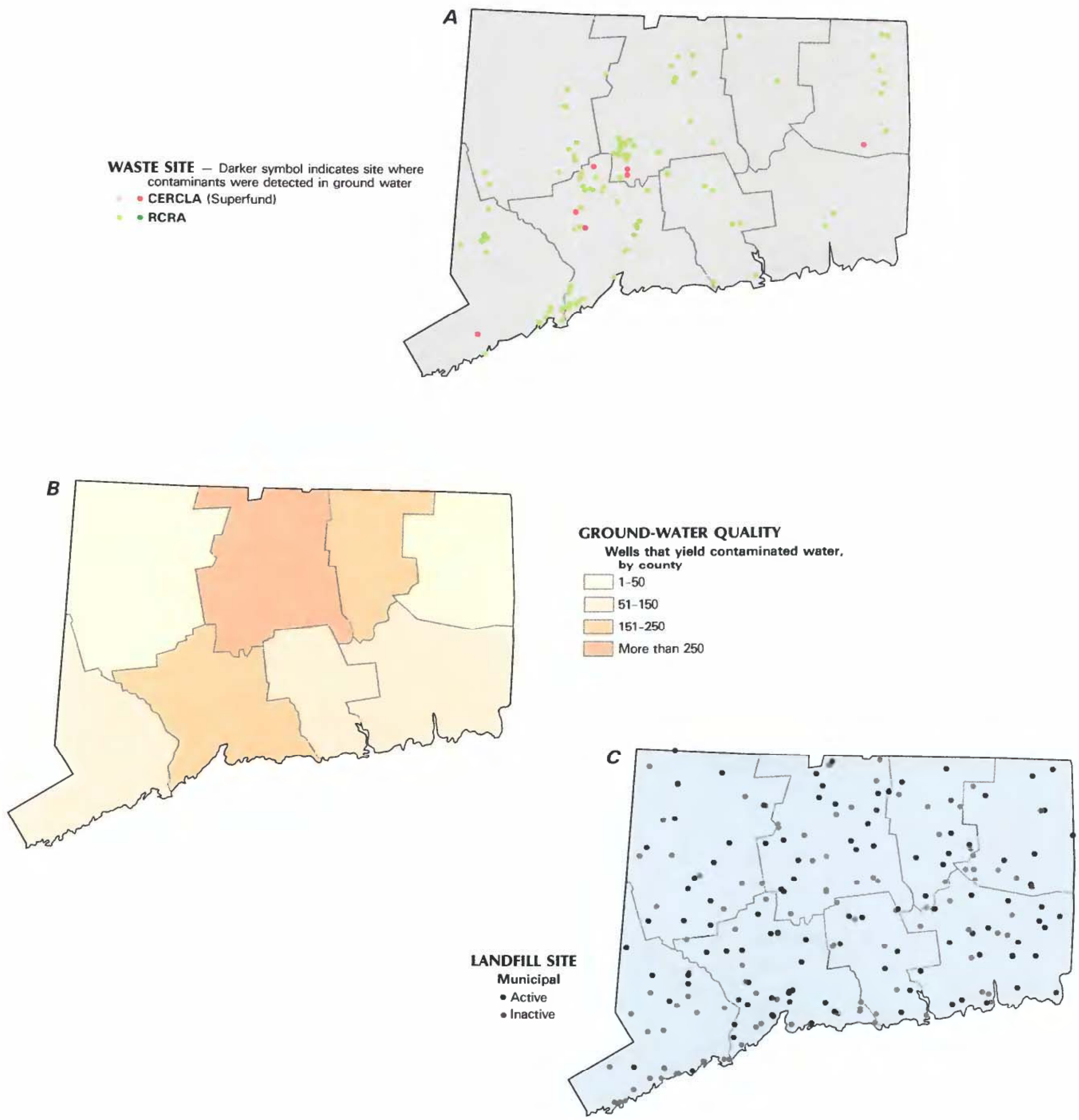


Figure 3. Selected waste sites and ground-water-quality information in Connecticut. *A*, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites, as of January 1987; and Resource Conservation and Recovery Act (RCRA) sites, as of January 1987. *B*, Distribution of wells that yield contaminated water, as of April 1986. *C*, Municipal landfills, as of August 1986. (Sources: *A*, *B*, *C*, Connecticut Department of Environmental Protection files.)

centrations as large as 3,100 mg/L have been reported (Randall, 1964, p. 97).

Large dissolved-solids concentrations also occur locally in some aquifers near the coast. Mazzaferro and others (1979, p. 69) report dissolved-solids concentrations as large as 16,000 mg/L resulting from saltwater intrusion into the sedimentary-rock aquifer near New Haven.

Sulfate

The large dissolved-solids concentrations in water from the sedimentary-rock aquifer primarily result from large sulfate concentrations. The median sulfate concentration of water from the sedimentary-rock aquifer (23 mg/L) is similar to that of the other aquifers. However, in 7 percent of the samples, concentrations ranged from 250 mg/L (the secondary drinking water standard) to as large as 1,600 mg/L. The source of sulfate is thought to be the solution of gypsum (Ryder and others, 1981, p. 62), which is locally abundant (Hubert and others, 1978, p. 25).

Hardness

Calcium and magnesium, which contribute to the hardness of water, are two principal elements that compose the carbonate-rock aquifer. Consequently, water from this aquifer has the largest median hardness (210 mg/L), and nearly 70 percent of the water samples are classified as hard to very hard. About 40 percent of the wells in the sedimentary-rock aquifer yield hard to very hard water, whereas only 15 percent of the wells in the stratified-drift and crystalline-bedrock aquifers produce water of similar hardness.

Nitrate, Chloride, and Sodium

Median nitrate (as nitrogen) concentrations in ground water are small, 1.0 mg/L or less in all aquifers, and only 1 percent of all wells produce water that contains more than 10 mg/L. In north-central Connecticut, Ryder and others (1981, p.63) found the largest nitrate concentrations in the upper 75 feet of stratified-drift aquifers. Median concentrations of chloride and sodium (not shown in fig. 2*C*) are also small, less than 12 mg/L and 10 mg/L, respectively, in all aquifers. However, concentrations as large as 3,000 mg/L of chloride and 410 mg/L of sodium have been measured in water samples from the sedimentary-rock aquifer. Sodium concentrations exceeded the State's drinking-water standard of 20 mg/L (Connecticut Department of Health Services, 1985) in about 12 percent of the water samples from all aquifers.

Iron and Manganese

Large concentrations of iron (as large as 40,000 μg/L) and manganese (as large as 14,000 μg/L) are a common natural ground-water-quality problem in Connecticut. Concentrations of iron and manganese greater than 300 μg/L and 50 μg/L, respectively, may impair the taste of water and stain plumbing fixtures, glassware, and laundry. Although median concentrations of iron (fig. 2*C*) and manganese (not shown in fig. 2*C*) are significantly smaller than these levels in all four aquifers (90 μg/L or less, iron; 24 μg/L or less, manganese), about 17 percent of all samples exceeded the recommended standard for one or both constituents. Large concentrations of iron most commonly occur in the crystalline-rock aquifer, whereas large manganese concentrations are more common in the stratified-drift aquifers.

Radionuclides

Large concentrations of two naturally occurring radionuclides, radon and radium, have been discovered recently in ground water in some parts of the State (Connecticut Department of Health Services, written commun., 1986). Radon concentrations from 100 to 89,400 pCi/L (picocuries per liter) have been measured during reconnaissance sampling of wells in parts of the crystalline-rock aquifer consisting of high-grade metamorphic rocks of granitic composition. Such rocks are likely sources of radon. Although the median radon concentration is smaller than 5,000 pCi/L, 25 percent of the 63 samples exceeded 10,000 pCi/L. Additional ground-water samples in other rock units presently are being analyzed for radon by the Connecticut Department of Health Services (DOHS). Radium concentrations in 5 of 115 samples collected from community-supply wells during 1979 exceeded the primary drinking-water standard of 5 pCi/L.

EFFECTS OF LAND USE ON WATER QUALITY

Ground-water quality has been impaired in some parts of the State and has improved in other parts. The impairment in water quality is primarily because of waste disposal, pesticide application, leaks and spills of fuels and industrial solvents, and storage of road salt. Contaminants generally have been transported through the unsaturated zone to underlying aquifers, although some have been emplaced below the water table or have entered the aquifer by induced infiltration of surface water. Generally, contamination is restricted to an area within a few hundred to a few thousand feet of the source, as well as to shallow depths, because of the limited extent of most ground-water flow systems and the placement of many waste-disposal facilities near areas of ground-water discharge. Where ground-water quality has improved, it is primarily because of improvements in waste-disposal, agricultural, and industrial practices; dilution or natural degradation of contaminants; discharge of contaminated ground water; and decrease or elimination of pumping.

Presently (1986) ground water beneath about 8 percent of the State is known or suspected of being affected by pollution (Connecticut Department of Environmental Protection, 1986, p. 34). The contamination that has occurred can be attributed largely to waste disposal, agriculture, urbanization, and induced recharge.

Waste Disposal

There are 104 RCRA sites, 7 CERCLA sites and 216 known active and inactive municipal mixed-waste landfills in Connecticut (fig. 3). Twenty-six RCRA sites have been cleaned up but are still subject to post-closure permit requirements. The State also contains numerous other waste-disposal facilities not shown in figure 3, including 3 hazardous-waste sites at the U. S. Naval base in New London, an estimated 1,000 or more industrial waste-disposal sites, and more than 350,000 private, domestic sewage-disposal systems. The three hazardous-waste sites at the U. S. Naval base were identified by the U. S. Department of Defense as part of their Installation Restoration Program (IRP) as having potential for contamination (U. S. Department of Defense, 1986). The IRP, established in 1976, parallels the U.S Environmental Protection Agency (EPA) Superfund Program under CERCLA. Other known waste-disposal sites, excluding domestic sewage-disposal systems, have been inventoried by the Connecticut Department of Environmental Protection (DEP). Although all parts of the State contain such sites, they are most common in urbanized and densely populated areas (see figs. 1*B* and 3).

The total effect of waste disposal on ground-water quality is unknown. The DEP has detected contamination in the shallow part of the saturated zone at all CERCLA sites, as well as most RCRA sites and mixed-waste landfills that are monitored (E. B. Patton, Connecticut Department of Environmental Protection, oral commun., 1986). Data on specific RCRA sites and landfills where contamination of ground water has been detected could not be compiled in time for this report, and the information is not shown in figure 3. Leachate from landfills has contaminated 139 wells since about 1979 (Connecticut Department of Environmental Protection, 1986,

p. 35), and a single landfill in southern Connecticut has contaminated several hundred million gallons of ground water (Miller and others, 1974, p. 209).

Improper disposal of industrial solvents, mainly organohalides such as trichloroethylene, is another major cause of contamination. More than 44 public-supply wells have been contaminated by solvents to date (Connecticut Department of Environmental Protection, 1986, p. 35), including at least 20 in the Quinnipiac and Farmington River basins (Connecticut Department of Environmental Protection, 1985a, p. 7; 1985b, p. 10). Domestic and industrial wells in several towns also have been contaminated by solvents. Other industrial-waste contaminants include trace metals, phenol, cyanide, and organic compounds other than solvents (Handman and others, 1979, p. 44–45).

Agriculture

Before 1983 few incidences of ground-water contamination were attributable to agricultural practices. Ground water in some farming areas had nitrate concentrations larger than 10 mg/L as a result of application or storage of chemical fertilizers and manures (Cushman and others, 1964, p. H 66; Connecticut Department of Health Services, written commun., 1976; Handman and others, 1979, p. 48). Few instances of pesticide contamination of ground water had been reported.

During the fall of 1983, contamination of ground water by EDB—a soil fumigant used for tobacco—was detected and subsequently found to affect at least 50 square miles in north-central Connecticut. Through August 1986, water samples from 268 private and 54 public wells have had EDB concentrations that equaled or exceeded the drinking-water standard of 0.10 μg/L established for Connecticut (S. J. Klobukowski, Connecticut Department of Health Services, oral commun., 1986), making this the most significant ground-water-quality problem in the State.

An investigation recently sponsored by the State of the occurrence of pesticides in public-supply wells detected the soil fumigant 1,2-dichloropropane in a well field in south-central Connecticut. No other chlorinated or organophosphate pesticides were detected in samples from 25 utilities supplying an estimated 60 percent of the ground water withdrawn for public supply (Frink and Hankin, 1986, p. 4).

Urbanization

Many areas in Connecticut are extensively urbanized, particularly the coastal parts of Fairfield and New Haven Counties, the Connecticut Valley lowland that extends from New Haven to Hartford, the Naugatuck River valley, and the New London area (see fig. 1*A*). Ground-water contamination in urban areas may be attributed to a readily identifiable cause, such as leakage of fuel from buried tanks, or to less identifiable cumulative effects of human activities. Major causes of contamination in urban parts of Connecticut include leakage from storage tanks containing fuels and other chemicals, accidental spills of fuels and chemicals, uncovered storage of road salt, and use of pesticides.

There are tens of thousands of buried storage tanks, mainly containing fuel oil or gasoline, in the State. Many have leaked because of deterioration, accidental rupture, or improper installation, and a number of incidents of ground-water contamination have been cited (Connecticut Department of Environmental Protection, 1986, p. 35–36). Petroleum and chemical spills are investigated regularly by the DEP. From July 1977 to June 1982, DEP reported spills totaling about 2.7 million gallons (Connecticut Department of Environmental Protection, 1983, p. 73). An estimated 1.8 million gallons were spilled on land, and, where there was neither quick response nor effective clean up, it is likely that a substantial amount reached the saturated zone.

In addition to contamination from readily identifiable sources, recent studies of ground-water quality in two stratified-drift aquifers indicate more subtle changes related to land use. Preliminary findings by Grady and Weaver (1987) indicate that (1) ground water in agricultural areas has the largest median concentrations of sulfate and total ammonia plus organic nitrogen, (2) ground water beneath residential areas contains larger median concentrations of several inorganic constituents, including sodium, chloride, dissolved solids, ammonia, nitrate plus nitrite (as nitrogen), detergents, and nickel, than undeveloped and agricultural areas, and (3) ground water in industrial/commercial areas has the largest median specific conductance, pH, carbon dioxide, calcium, magnesium, chloride, bicarbonate, dissolved solids, boron, and strontium concentrations. These conclusions are tentative and will be evaluated further by the U.S. Geological Survey in ongoing studies relating ground-water quality in stratified-drift aquifers to land use.

Induced Recharge

Most of the stratified-drift aquifers in Connecticut are hydraulically connected to streams, lakes, and estuaries (including Long Island Sound). Where these surface-water bodies are contaminated or salty, intense pumping has resulted in deterioration of ground-water quality. Induced recharge of surface water has been cited as the cause of water contamination in stratified-drift aquifers adjacent to the Naugatuck River (Wilson and others, 1974, p. 63–64). Changes in ground-water quality in aquifers adjacent to the Quinnipiac River also have been attributed to induced recharge (Mazzaferro and others, 1979, p. 64 and 69).

Induced recharge of saline water is a problem in coastal areas. About 100 private wells and 10 public-supply wells have been affected in the Old Lyme area of southwestern New London County (Connecticut Department of Health Services, written commun., 1986), and historical incidences have been described in New Haven and other coastal areas (Brown, 1928; Thomas and others, 1968, p. 72; Ryder and others, 1970, p. 44; Mazzaferro and others, 1979, p. 69).

POTENTIAL FOR WATER-QUALITY CHANGES

Future changes in ground-water quality are uncertain as improvements resulting from more comprehensive water-quality management may, in the aggregate, be greater or lesser than the negative effects resulting from increased population and urbanization. Stratified-drift aquifers are most susceptible to contamination and are likely to be most affected in the future. Land-use decisions will be an important factor in determining future ground-water quality in these aquifers.

State and Federal legislation and regulations have improved management of many sources of pollution, such as solid-waste disposal, underground storage of fuel and chemicals, and industrial use and disposal of toxic and hazardous materials. For example, because of State policy and regulations, few additional landfills are expected, and more communities are turning to resource-recovery methods to solve solid-waste disposal problems. Replacement of old underground storage tanks with modern corrosion-resistant tanks, equipped with leak-detection systems, should alleviate one of the more pervasive sources of ground-water contamination. Management of most hazardous materials generated, stored, treated, or disposed of in the State will decrease the potential for these materials to enter the environment and migrate into aquifers. These factors, together with recent trends toward improved quality of surface water (Connecticut Department of Environmental Protection, 1986), less agricultural acreage, and more stringent controls on waste disposal and land use near public-supply wells have and will continue to improve ground-water quality in some parts of Connecticut.

Other factors, however, indicate that the potential for additional incidences of ground-water contamination is not likely to diminish soon. Connecticut's population increased by 23 percent between 1960 and 1980 (U.S. Bureau of the Census, 1981). Industrial growth, as measured by the number of operating manufacturing establishments, increased by 15 percent between 1967 and 1982 (U.S. Bureau of the Census, 1984). This growth has resulted in advancing urbanization around the principal cities and towns within Hartford, Fairfield, Middlesex, New Haven, and New London Counties. New residential, commercial, and industrial development in rural parts of the State has occurred at the expense of agricultural and undeveloped lands as the total area of farmland decreased by one-half between 1959 and 1982 (U.S. Bureau of the Census, 1985). While farmland is decreasing, the acreage on which commercial fertilizers and pesticides are applied is increasing (U.S. Bureau of the Census, 1985). Conversion of agricultural or undeveloped lands to golf courses, parks, and athletic fields commonly results in additional applications of agricultural chemicals. Increased residential development, with 89 percent of rural and 22 percent of urban households using onsite septic systems (Handman and others, 1979, p. 26), can affect ground-water quality through septic effluents, salting of high-density residential road and sidewalk networks, and application of lawn and garden chemicals.

Expanding industrial and commercial development entails the use and transport of greater volumes of hydrocarbons, industrial chemicals, and other hazardous substances, with proportionately greater opportunities for inadvertent spills, leaks, or discharges of these materials during their storage, handling, and disposal. Over the past 8 years, the number of spills and leaks reported to the DEP has increased from about 600 to over 2,000 (B. D. Coss, Connecticut Department of Environmental Protection, written commun., 1986). This large increase may partly reflect increased compliance with reporting requirements.

Stratified-drift aquifers are the most susceptible to contamination from nonpoint and point sources. The same hydrologic characteristics that cause these aquifers to be favorable sources for large supplies of water, facilitate the entry and migration of contaminants. The combination of relatively large transmissivity, shallow depth to the water table, absence of confining beds, moderate to large hydraulic gradients, thin and pervious soils, the hydraulic connection with surface-water bodies that receive waste discharges, and the generally extensive development of the recharge areas overlying stratified-drift aquifers significantly enhances the potential for their contamination.

Bedrock aquifers are less susceptible to contamination as they are mantled in most areas of the State by unconsolidated deposits of till or stratified drift. However, where bedrock is exposed at the surface or the overlying materials are thin (a common condition in upland areas) contaminants may readily enter along fractures and move rapidly away from their source with little attenuation. The resulting contamination can be difficult to predict or control because knowledge of bedrock flow systems is sparse and such systems commonly are complex.

GROUND-WATER QUALITY MANAGEMENT

Connecticut has a comprehensive program for managing its ground-water resources that originated with passage of the Clean Water Act of 1967 (Connecticut General Statutes, Chap. 446K, Sec. 22a) and the program has been strengthened by subsequent State statutes and Federal clean-water legislation. The program goals are to restore and maintain ground water to a quality consistent with its use for drinking without treatment. Excepted cases are where ground water in a zone of influence of a permitted discharge is suspected of being contaminated and there is no overiding need to improve quality, or the classification goal is GC (areas constituting less than 1 percent of the State that may be suitable for environmentally safe waste disposal).

The DEP, lead agency for ground-water-quality management, administers regulatory programs developed under authority of State and Federal Clean Water Acts (Connecticut General Statutes, Chap. 446K, Sec. 22a and Public Law 92-500 as amended), the Federal Resource Conservation and Recovery Act of 1976 (Public Law 94-580) and Part C (Underground Injection Control Program) of the Safe Drinking Water Act of 1974 (Public Law 93-523 as amended). In 1986, DEP also was designated lead agency for the Wellhead Protection Program authorized by amendment to the Safe Drinking Water Act.

The DOHS implements State and Federal Safe Drinking-Water Act programs for development and enforcement of quality standards for drinking water. DOHS also has responsibility to insure that utilities do adequate planning and facilities construction, and protect public-supply sources.

Connecticut's "Water Quality Standards and Criteria" revised in 1980 (Connecticut Department of Environmental Protection, 1980), establish site-specific water-quality criteria and goals that are the basis of the State's ground-water-quality management program. These criteria and goals, together with the classification system adopted for all ground water in the State, are the bases for the DEP permit-issuance and enforcement policies and determine ground-water-quality management priorities. This overall strategy to protect ground water significantly affected the development of the Federal Ground Water Protection Strategy Program and has been a model for several other states. Because of the broad range of ground-water protection issues and interrelations with surface water, DEP has begun using a basin-planning approach similar to that established by the Federal Clean Water Act to identify specific problems, management priorities, and abatement strategies in different geographic areas.

DEP is required by Connecticut's 1967 Clean Water Act to issue permits for surface-water and ground-water discharges and to take enforcement actions against known or suspected sources of pollution. The permit process for surface-water discharges is coordinated with the National Pollution Discharge Elimination System. The scope of Connecticut's permit program has been expanded since 1967 through subsequent regulatory authorities, while the adoption of quality standards and classifications for ground water provides a strong framework for issuance of permits. The discharge-permit program significantly has improved the State's capability to manage ground-water quality through control of waste placement and treatment, improved construction and maintenance of disposal facilities, and increased monitoring of waste discharges.

Investigations and monitoring of suspected contamination sites are the principal means for detecting contamination. Where responsible parties are identified, enforcement actions to abate or prevent contamination are issued by DEP. Polluters are required to provide alternate sources of drinking water to homes with wells that yield contaminated water. A State grant program provides potable water if the polluter cannot be identified.

State agencies and municipalities have taken other measures to manage ground-water quality. The DEP controls the handling, storage, and disposal of hazardous materials and solid wastes, operates a spill-prevention and response program to minimize contamination from spills and leaks of fuels and chemicals, sets standards for underground tanks, large waste-disposal systems, and road-salt storage and application, and together with DOHS, conducts investigations of known or suspected contamination.

The management of the protection of public-supply sources has high priority. The DOHS has an extensive regulatory program that requires utilities to control land use near public-supply wells, to monitor the quality of water, and to submit long-range plans that will identify aquifers to be protected. Planning has been strengthened by the recently instituted Connecticut Plan for Public Water Supply Coordination—a process to coordinate the planning of public water-supply systems that is overseen by DOHS.

Land use is an important factor in protecting water quality inasmuch as most large withdrawals are from stratified-drift aquifers. The DEP is working directly with municipalities to ensure that future land use is consistent with long-term protection of drinking-water resources and also plans to develop a Wellhead Protection Program under provisions of the Federal Safe Drinking Water Act that will afford further protection to public-supply wells. Several municipalities, under impetus of the State's "208 Program", already have placed controls on land-use activities in areas that recharge stratified-drift aquifers. Presently, the State is moving towards a stronger local/State aquifer-protection program, and DEP is to submit a report to the Legislative Environment Committee in early 1987 on the need for additional controls to improve protection of important stratified-drift aquifers.

The establishment in 1983 of a Diversion Permit Program under authority of the Connecticut Water Policy Diversion Act (Connecticut General Statutes Sec. 22a–365) provides for coordinated management of the State's water resources. The program requires permits for all surface-water diversions and for ground-water withdrawals greater than 50,000 gallons per day. It further requires that ground water and surface water be considered part of a single hydrologic system and that the impacts of diversions and withdrawals on the quantity and quality of water resources be assessed in the context of basin-wide water use and allocation.

Although Connecticut is fortunate in having obtained a large amount of hydrogeologic information for managing ground water during the past 50 years, there are still significant data needs. The least information is on existing water use and future water demands. Information is needed also to define changes in background-water quality, yields of major aquifers and stream-aquifer systems, the effects of induced recharge from waste-receiving streams, the transport of contaminants in aquifers (particularly fractured bedrock aquifers), and the effects of diversions and droughts on surface- and ground-water resources. The adequacy of water-resources information should improve soon through development of water-utility supply plans, the coordinated planning under the Connecticut Plan for Public Water Supply Coordination, the Connecticut Water Use Program conducted in cooperation with the U.S. Geological Survey, and studies of major stratified-drift aquifers by DEP and the U.S. Geological Survey.

SELECTED REFERENCES

Brown, J.S., 1928, Ground water in the New Haven area, Connecticut: U.S. Geological Survey Water-Supply Paper 537, 101 p.

Connecticut Department of Environmental Protection, 1980, Connecticut water quality standards and criteria: Water Compliance Unit Report, 28 p.

_____ 1983, State of Connecticut water-quality management plan: Water Compliance Unit Report, 77 p., 7 appendices.

_____ 1985a, Quinnipiac and central coast west basin plan: Water Compliance Unit Report, 35 p.

_____ 1985b, Farmington River basin plan: Water Compliance Unit Report, 43 p.

_____ 1986, State of Connecticut 1986, water-quality report to Congress: Water Compliance Unit Report, 85 p.

Connecticut Department of Health Services, 1985, Public health code regulation—Standards for quality of public drinking water: Connecticut Public Health Code Section 19–13–B102, 11 p.

Cushman, R.V., Tanski, D., and Thomas, M.P., 1964, Water resources of the Hartford-New Britain area, Connecticut: U.S. Geological Survey Water-Supply Paper 1499–H, 96 p.

Frink, C.R., and Hankin, Lester, 1986, Pesticides in ground water in Connecticut: Connecticut Agricultural Experiment Station Bulletin 839, 10 p.

Grady, S.J., and Weaver, M.F., 1987 [in press], Preliminary appraisal of the effects of land use on water quality in stratified-drift aquifers in Connecticut: U.S. Geological Survey Water-Resources Investigations Report 87–4005.

Handman, E.H., Grossman, I.G., Bingham, J.W., and Rolston, J.L., 1979, Major sources of ground-water contamination in Connecticut: U.S. Geological Survey Water-Resources Investigations, Open-File Report 79–1069, 59 p.

Hubert, J.F., Reed, A.A., Dowdall, W.L., and Gilchrist, J.M., 1978, Guide to the Mesozoic red beds of central Connecticut: Connecticut Geological and Natural History Survey Guidebook 4, 129 p.

Mazzaferro, D.L., Handman, E.H., and Thomas, M.P., 1979, Water resources inventory of Connecticut, part 8, Quinnipiac River basin: Connecticut Water Resources Bulletin 27, 88 p.

Meade, D.B., 1978, Ground-water availability in Connecticut: Connecticut Geological and Natural History Survey, Natural Resources Atlas Series Map, scale 1:125,000, 1 sheet.

Miller, D.W., DeLuca, F.A., and Tessier, T.L., 1974, Ground water contamination in the Northeast States: U.S. Environmental Protection Agency, Environmental Protection Technology Series, EPA–660/2–74–056, 325 p.

Randall, A.D., 1964, Geology and ground water in the Farmington-Granby area, Connecticut: U.S. Geological Survey Water-Supply Paper 1661, 129 p.

Ryder, R.B., Cervione, M.A., Jr., Thomas, C.E., Jr., and Thomas, M.P., 1970, Water resources inventory of Connecticut, part 4, southwest coastal river basins: Connecticut Water Resources Bulletin 17, 54 p.

Ryder, R.B., Thomas, M.P., and Weiss, L.A., 1981, Water resources inventory of Connecticut, part 7, upper Connecticut River basin: Connecticut Water Resources Bulletin 24, 78 p.

Thomas, C.E., Jr., Cervione, M.A., Jr., and Grossman, I.G., 1968, Water resources inventory of Connecticut, part 3, lower Thames and southeastern coastal river basins: Connecticut Water Resources Bulletin 15, 105 p.

U.S. Bureau of the Census, 1981, 1980 Census of population—volume 1, Characteristics of the population; chapter A, number of inhabitants; part 8, Connecticut: U.S. Department of Commerce, Bureau of the Census, PC80–1–A8.

_____ 1984, 1982 Census of manufacturers—Preliminary report, Geographic area series, New England States: U.S. Department of Commerce, Bureau of the Census, MC82–A–1(p), 28 p.

_____ 1985, 1982 Census of agriculture—volume 1, Geographic area series: chapter A, State and county data; part 8, Connecticut: U.S. Department of Commerce, Bureau of the Census, AC82–A–8, 26 p.

U.S. Department of Defense, 1986, Status of the Department of Defense Installation Restoration Program—Information paper: Washington, D. C., U.S. Department of Defense, Office of the Assistant Secretary of Defense (Acquisition and Logistics), Environmental Policy Directorate. Febuary, 35 p.

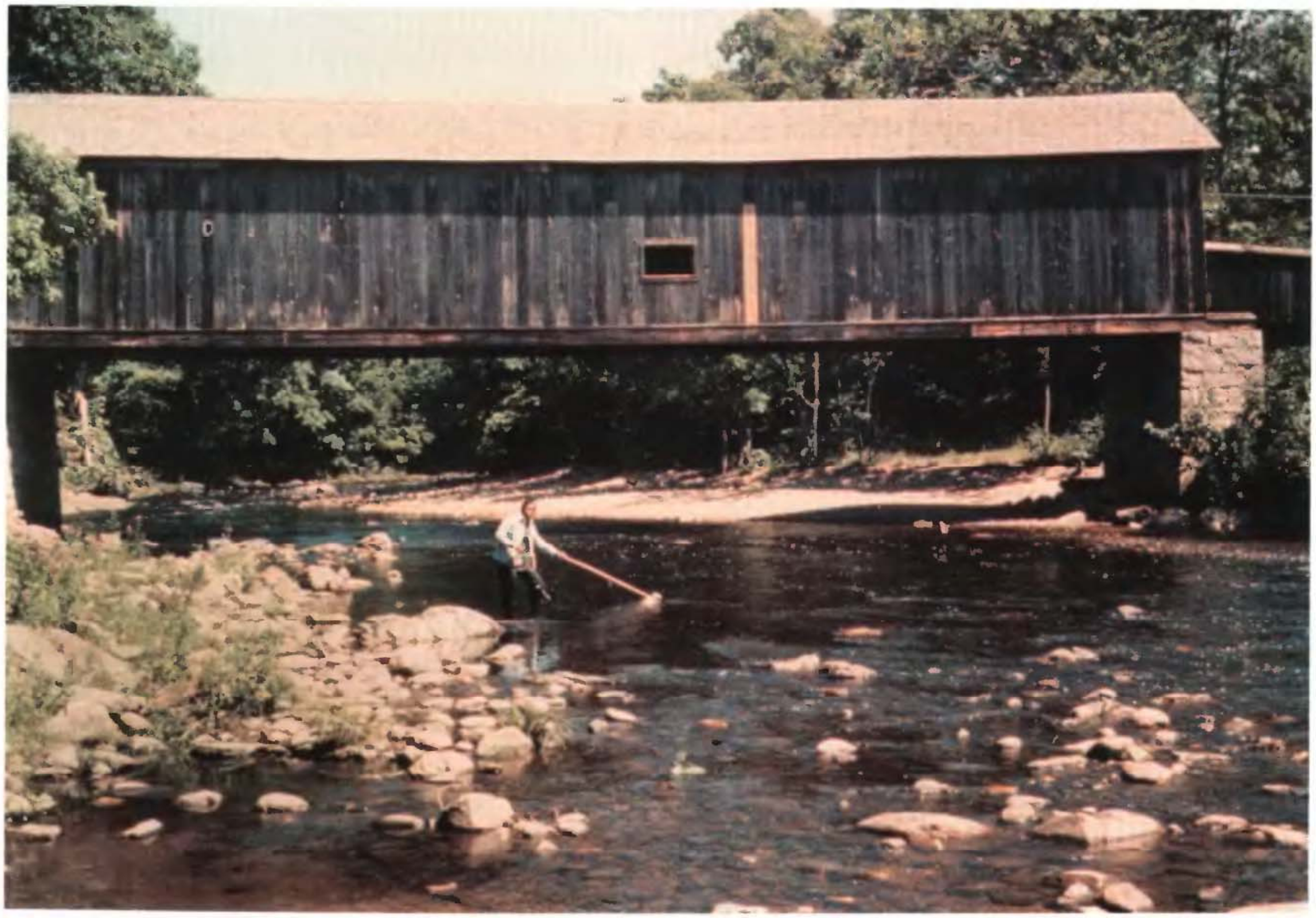
U.S. Environmental Protection Agency, 1986a, Amendment to National Oil and Hazardous Substances Contingency Plan; national priorities list, final rule and proposed rule: Federal Register, v. 51, no. 111, June 10, 1986, p. 21053–21112.

_____ 1986b, Maximum contaminant levels (subpart B of part 141, national interim primary drinking-water regulations): U. S. Code of Federal Regulations, Title 40, Parts 100 to 149, revised as of July 1, 1986, p. 524–528.

_____ 1986c, Secondary maximum contaminant levels (section 143.3 of part 143, national secondary drinking-water regulations): U. S. Code of Federal Regulations, Title 40, Parts 100 to 149, revised as of July 1,1986, p. 587–590.

U.S. Geological Survey, 1985, National water summary 1984—Hydrologic events, selected water-quality trends, and ground-water resources: U.S. Geological Survey Water-Supply Paper 2275, 467 p.

Wilson, W.E., Burke, E.L., and Thomas, C.E., Jr., 1974, Water resources inventory of Connecticut, part 5, lower Housatonic River basin: Connecticut Water Resources Bulletin 19, 79 p.



Water-quality measurement being taken on the Salmon River near East Hampton, Conn. during low flow. Natural low flow in streams is sustained by inflow of ground water. Therefore the quality of the water in most streams at low flow can be used as an indicator of the quality of the ground water in the area. (Photograph by U.S. Geological Survey.)

Prepared by Robert L. Melvin, Stephen J. Grady, and Denis F. Healy, U.S. Geological Survey; "Ground-Water Quality Management" section by Fred Banach, Connecticut Department of Environmental Protection, Water Compliance Unit

FOR ADDITIONAL INFORMATION: Chief, Connecticut Office, U.S. Geological Survey, Abraham A. Ribicoff Federal Building, Room 525, 450 Main Street, Hartford, CT 06103