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GROUND-WATER MANAGEMENT
BUZZARDS BAY COASTAL STREAMS, MASSACHUSETTS AND RHODE ISLAND
Section 3.03

This report is one input to the Southeastern New England Study. It is a preliminary version and subject to review; comments and criticisms are welcome and will be compiled as an addendum. A new single-purpose report will not be produced. Rather, this report and all recommended revisions will be integrated into a multi-purpose plan which will be produced by the combined efforts of the participating Federal and State agencies and citizens.

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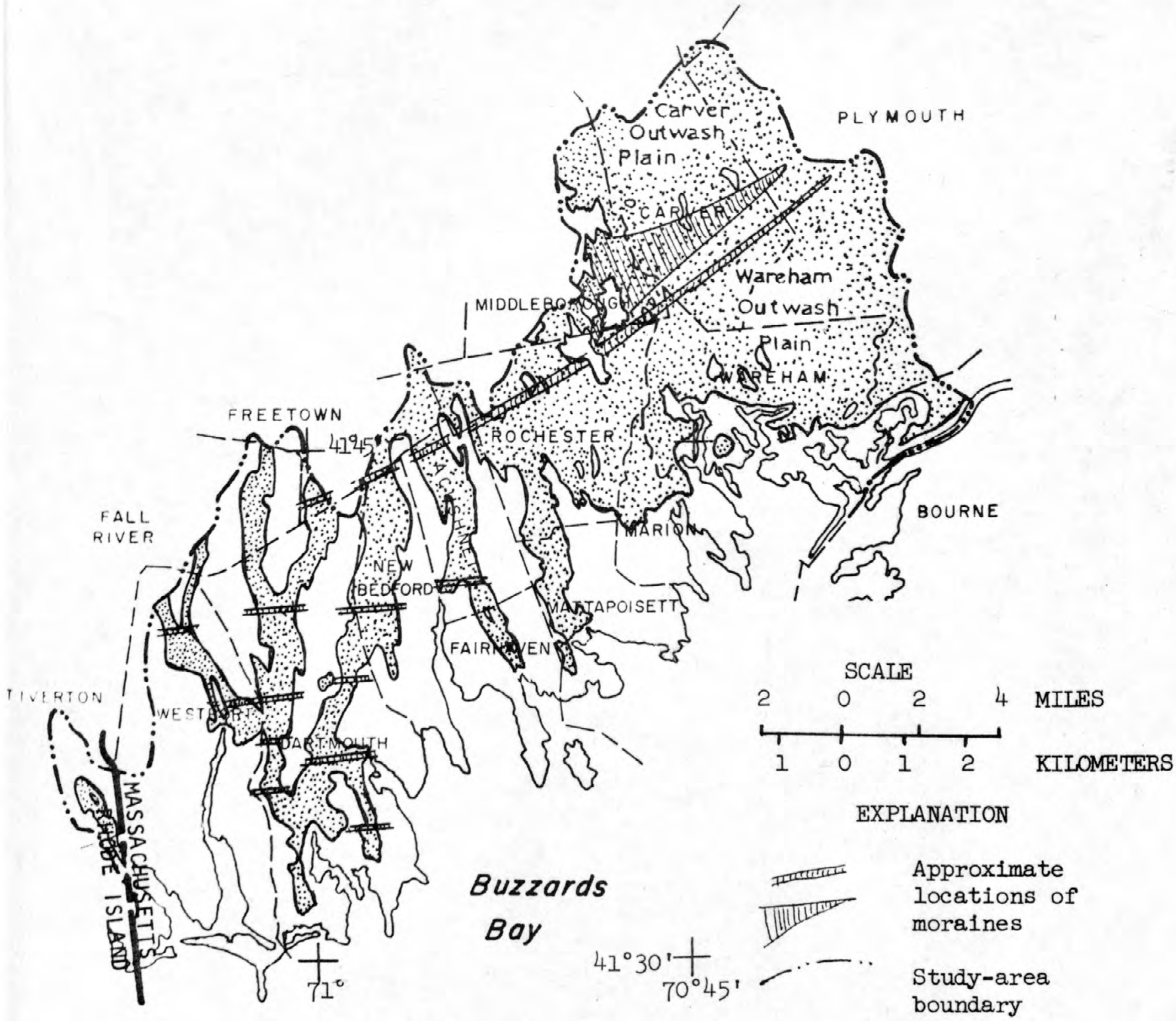
1.0 GEOLOGIC SETTING AND OCCURRENCE OF GROUND WATER

The Buzzards Bay Coastal Streams area lies between Narragansett Bay and Cape Cod on the southeast coast of Massachusetts and Rhode Island. Its drainage is characterized by many short south-flowing streams, which discharge to the narrow estuaries that form indentations in the coastline (figs. 1-1 and 1-2).

The area is characterized by pronounced topographic texture--south-southeast trending ridges and valleys, with low relief of about 100 feet (30.5 m). The topography is the result of preglacial fluvial erosion highly modified by the advancing Buzzards Bay lobe of Wisconsinan Age. The igneous and metamorphic bedrock foundation is overlain nearly everywhere with a thick layer of subglacial till deposited during glacial advance. In the eastern two-thirds of the area, the till forms streamlined elongate hills that are parallel to the direction of glacial ice movement (SSE). In the valleys, stratified lake and stream deposits favorable for ground-water development cover the till and bedrock.



Massachusetts Water Resources Commission, 1960
Williams and Tasker (in press)
J. R. Williams, written commun., 1973

Figure 1-2.--Map of glacial deposits (stippled) favorable for ground-water exploration

Retreat of glacial ice from south to north occurred by steps in which the melting ice formed successive fronts roughly parallel to the Buzzards Bay coast. Wherever the ice front remained stationary, meltwater streams deposited sand and gravel in kame moraines and kame deltas while clay and silt accumulated on the bottoms of temporary proglacial lakes farther south. Near New Bedford, at least six recessional moraines (fig. 1-2) in the form of kames and kame deltas cross the south-southeast trending valleys (J.R. Williams, written commun., Dec. 1973). These moraines are positive relief features in the valleys and are separated by flat swampy areas underlain by silt and clay deposited in the now drained proglacial lakes (figs. 1-2 and 1-3). In addition to the moraines, streams of meltwater flowing on and in the glacial ice formed streambed deposits of sand, gravel, cobbles, and boulders. When the ice melted, these deposits were laid down upon the underlying till in the form of discontinuous sinuous ridges (fig. 1-3) called eskers.

The Cape Cod Bay lobe of Wisconsinan Age had an important influence on the geology of the eastern third of the study area (Williams and Tasker, in press). Meltwater streams discharging from the northeast carried large quantities of sand and gravel to form an outwash plain in Plymouth, Carver, and Wareham. The plain is pitted with kettle holes and kettle-hole ponds formed by melting large remnant blocks of ice. Moraines that mark the melting ice position lie to the north of the outwash plain in the northeastern part of the study area, in Middleborough, Carver, and Plymouth (fig. 1-2).

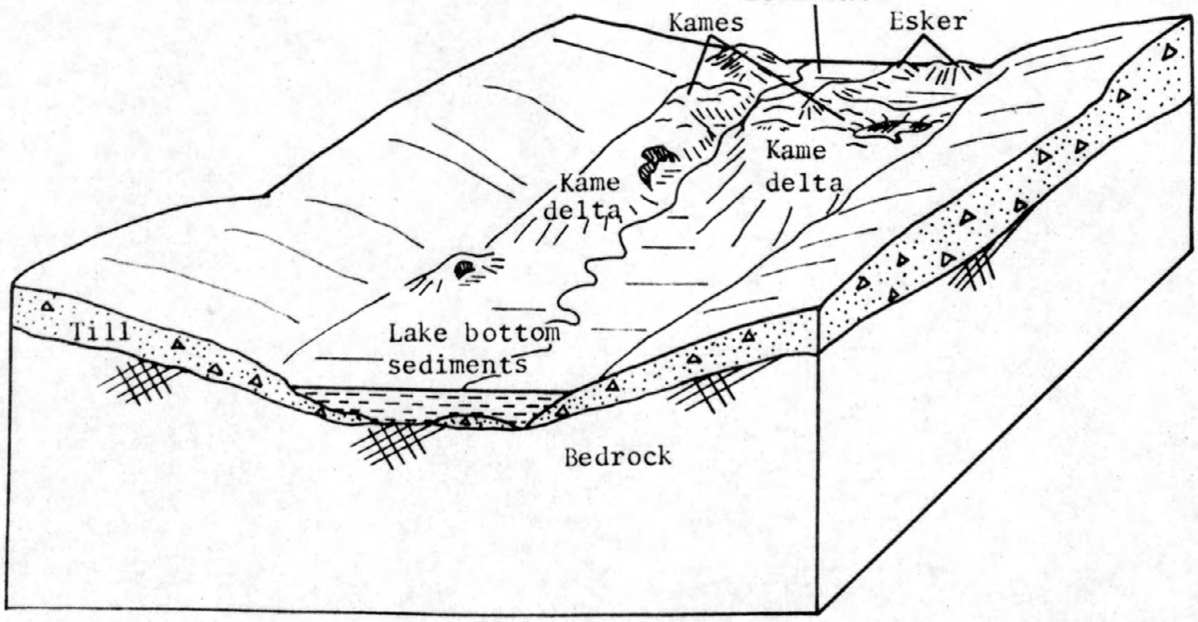


Figure 1-3.--Diagram of glacial deposits and landforms in the valley of East Branch Westport River

In the Buzzards Bay coastal area, ground-water supplies large enough to satisfy municipal and many industrial demands can be found only in the unconsolidated sand and gravel deposits. Although the bedrock aquifer is generally of low permeability, it may supply private homes where municipal water is not available.

The sand and gravel in the eastern part of the study area forms a dependable water-table aquifer (fig. 1-1). Success in developing high yield (300 gpm or 18.9 l/s or more) wells in the eastern third of the study area has been good. Exploration efforts in the kames, kame deltas, and glacial lacustrine deposits of the western two-thirds have been less successful. The complex distribution of sand and gravel in kames and eskers makes location of suitable well sites difficult. Most of these deposits form ground-water reservoirs that have small storage capacity. Although coarse grained at the surface, the kame deltas grade to fine sand and silt at depth, and are, therefore, frequently disappointing areas for ground-water exploration.

Ground water used for public drinking supplies is of good quality, generally low in dissolved mineral content, soft and slightly acidic (table 1-A). Both iron and manganese are troublesome constituents in ground water and locally may be in excess of the recommended limits for public drinking water supplies (U.S. Public Health Service, 1962). For iron the recommended limit is 0.3 mg/l (milligrams per liter), and for manganese it is 0.05 mg/l. The acidity of the water and its free CO_2 make it corrosive to metal pipes, and treatment may be necessary.

Table 1-A.--Water quality of public ground-water supplies

(Range of water quality reported by the Massachusetts Department of Public Health, 1970)

			Milligrams per liter (mg/l)				
Town	Color	pH	Hardness	Iron (Fe)	Manganese (Mn)	Chloride (Cl)	Sodium (Na)
Dartmouth	0-20	6.0-6.7	21-31	0.02-0.08	0.00-0.31	7.5-12.0	5.5- 8.2
Fairhaven	12-38	5.7-5.9	31-43	.10- .48	.05- .20	14.0-15.0	8.2- 8.5
Marion	2-15	6.0-6.3	11-88	.05- .37	.00- .04	13.0-22.0	6.0-13.0
Mattapoisett	0- 5	6.2-6.4	19-22	.02- .10	.00	12.0	6.5- 7.5
Wareham	0- 8	5.8-6.3	8-24	.00- .29	.00- .02	6.1-14.0	5.0- 6.0
Westport	1- 3	6.0-6.2	34-44	.04- .10	.00	16.0-49.0	11.0-28.0

2.0 GROUND-WATER DEMAND AND AVAILABILITY

Ground-water resources in the Buzzards Bay Coastal Streams planning area are being investigated by the U.S. Geological Survey in cooperation with the Massachusetts Water Resources Commission, and much of the information in this report is taken from preliminary results of that investigation. The Massachusetts Water Resources Commission (1960) estimated that 5.5 mgd (240 l/s) of water was available in the Mattapoisett River valley. Sustained withdrawal of 5.5 mgd, however, would deplete the flow of the Mattapoisett River and probably cause flow to cease for some days in the late summer and early fall.

Because of differences in hydrogeologic conditions in this study area, location of ground-water supplies in the central and western parts requires more exploration than in the eastern part. Ground water for municipal supply is generally not available from the few available ground-water reservoirs in the central and western parts of the study area to meet 1990 or 2020 demands.

Table 2-A.--Public ground-water supplies
(All figures in million gallons per day.)

Location of supply by town or city	1970 average daily water consumption (surface and ground water)	1970 average daily ground-water production	Present ground-water production capacity	Estimated 1990 maximum water-supply demand for 1 day	Estimate of adequacy of potential ground-water resources to meet 1990 water demand	Remarks
Acushnet	0.27 (1971)	0.00	0.00	1.9	Adequate	Supplied by New Bedford, test wells indicate that 2 mgd could be developed.
Carver	No public supply except at public buildings				Adequate	Development of public supply by 1990 not anticipated.
Dartmouth	1.28	.79e	1.5	4.9	Inadequate	New Bedford supplements supply.
Fairhaven	1.12	.94	2.0*	3.6	Inadequate	Do.
Marion	.52	.52	1.15**	2.7	Inadequate	Imports ground-water from Rochester.
Mattapoisett	.32	.32	2.0	1.8	Adequate	Eastern half of Assawompset, Great Quittacas, Little Quittacas, and Pocksha Ponds.
New Bedford	20.5	.00	.00	--	Inadequate	
Rochester	No public supply				Adequate	Has right to 50 percent of ground water developed by Marion in Rochester after 1970.
Wareham	1.48	1.08e	3.52	7.3	Adequate	0.4 mgd from Jonathan Pond.
Westport	.01e	.01e	--	1.2	Inadequate	Ground water supplied by Acoaxet Water Works (49 services) and Westport Harbor Aqueduct Co. (53 services).

e, estimate. *0.72 mgd of supply comes from Mattapoisett. **0.86 mgd of supply comes from Rochester.

The availability of ground water for municipal supply is greatest in south Carver, the northeast part of Wareham, and Plymouth at the eastern end of the study area (fig. 1-1). This large ground-water reservoir extends northeastward beyond the Buzzards Bay planning area to Cape Cod Bay and is conservatively estimated to receive 120 mgd (5,260 l/s) average recharge (Williams and Tasker, in press). Not all this water is available for development because ground-water withdrawal would lower pond levels and deplete streamflow.

The northeastern United States water supply study (U.S. Deparement of the Army, 1969) recognized this aquifer as a regional water resource perhaps capable of supplying some of the needs of Boston's south shore area or supplementing the Lakeville Ponds which supply the New Bedford and Taunton systems. The study proposed (pp. 222-227) projects to tap this aquifer for a regional water supply of 24 mgd or 1,050 l/s (south shore area) or 28 mgd or 1,230 l/s (supplement to Lakeville Ponds).

2.1 Acushnet

Acushnet depends wholly on New Bedford for its water supply and in 1971, 0.27 mgd (12 l/s) was purchased. The northern part of the town is supplied by private wells. Test drilling and pumping tests at four sites show that 2 mgd (88 l/s) could be developed.

2.2 Carver

There is no public water-distribution system in the town at present. Many parts of town are well endowed with ground-water resources and future public water supplies could be obtained from wells.

2.3 Dartmouth

Ground water supplemented by water from New Bedford supplied the 1970 demand of 1.28 mgd (56 l/s). Dartmouth presently has four gravel-packed wells at three pumping stations with a maximum combined yield of 1.5 mgd (66 l/s).

The 1990 maximum-day demand is estimated to be 4.9 mgd (215 l/s), which is in excess of the known ground-water resources of the town. An exploration program leading to development of the present wells consisted of seismic investigations and test wells which were drilled only in areas served by the existing distribution system south of Route 6.

2.4 Fairhaven

The 1970 demand of 1.2 mgd (53 l/s) was met by ground water and by a supplement from New Bedford. The town owns two well fields, one in Fairhaven, and the other in Mattapoisett.

The estimated 1990 maximum-day demand of 3.6 mgd (160 l/s) will be in excess of Fairhaven's ground-water resources.

2.5 Marion

In 1970, a demand of 0.52 mgd (23 l/s) was met with ground water. The present public water supply consists of a well field and two gravel-packed wells in Rochester and a well field in Marion. An additional planned gravel-packed well in the Rochester section of the Mattapoisett River valley is expected to yield 0.63 mgd (28 l/s).

The town can probably develop additional ground-water sources in Rochester to meet 1990 maximum-day demands of 2.7 mgd (120 l/s). Marion has agreed to supply to Rochester, if requested, 50 percent of the yield of any well developed after 1970 in that town.

2.6 Mattapoisett

In 1970, ground-water sources in the Mattapoisett River valley were used to provide an average 0.32 mgd (14 l/s) for the public water supply. These sources include two gravel-packed wells and a field of driven wells having a combined capacity of 2.0 mgd (88 l/s) which seems adequate to meet the estimated 1990 maximum-day demand 1.8 mgd (140 l/s).

2.7 New Bedford

New Bedford's water sources include the east half of Assawompsett Pond, Pocksha Pond, Great Quittacas Pond, and Little Quittacas Pond. An aquifer in the northern part of the city is being utilized by the New Bedford Industrial Park.

2.8 Rochester

At present, the town does not have a public water supply. However, public-supply lines of Wareham and Marion extend into Rochester. The town will probably not develop a public water system by 1990 but has an agreement to receive 50 percent of the yield of all new wells developed in Rochester after 1970 by the town of Marion.

2.9 Wareham

In 1970, the Wareham Fire District supplied 0.64 mgd (28 l/s) and the Onset Fire District supplied 0.84 mgd (37 l/s) to the western and eastern parts of the town, respectively. The Wareham Fire District utilized four gravel-packed wells with a combined pumping capacity of 2.1 mgd (92 l/s) and has in reserve another gravel-packed well with a 0.7 mgd (30 l/s) yield. The district has been exploring the western part of town for an additional supply but without success. Recent tests in the Agawam River area near the Plymouth town line located several promising well sites. The Onset Fire District obtains water from a 0.72 mgd (32 l/s) well and from Jonathan Pond which has a sustainable yield of 0.4 mgd (18 l/s) and an emergency yield of 2 mgd (88 l/s). The district has abandoned a well near Jonathan Pond because of high manganese concentration of the water.

Wareham is well endowed with ground-water resources, particularly in the northeastern part of the town on the thick sand and gravel deposits. The estimated 1990 maximum-day demand of 7.3 mgd (320 l/s) could probably be met with ground water, and perhaps supplemented with pond water for peak-demand days. Distribution of new construction in the town may have considerable impact on the availability of ground water of high quality for public supply.

2.10 Westport

The U.S. Environmental Protection Agency (Rojas, 1974) reports that "There are several small water companies in Westport of which the Westport Harbor Aqueduct Company is the largest, supplying primarily to summer residents. In 1970, this system supplied 0.038 mgd to about 347 people in the town". This supply is reported to be obtained from two wells and is located in the southern part of the town.

The water demands of the estimated 1990 population of 17,000 probably cannot be met by ground-water resources. North Westport is a densely populated suburb of Fall River, and quality problems are likely to develop with individual domestic-supply wells now serving that area. The southern part of town is still rural.

The most favorable location for ground-water exploration is the East Branch Westport River valley where the town did some test drilling in 1964-65 and located a potential well site capable of yielding 0.45 mgd (20 l/s) of poor quality water downstream from Noquochoke Lake.

3.0 NEEDS AND STRESSES

Accurate estimates of ground-water availability and understanding of the interrelationships between ground water and surface water are major elements required for the successful management of ground-water resources in southeastern New England.

3.1 Management of Withdrawal

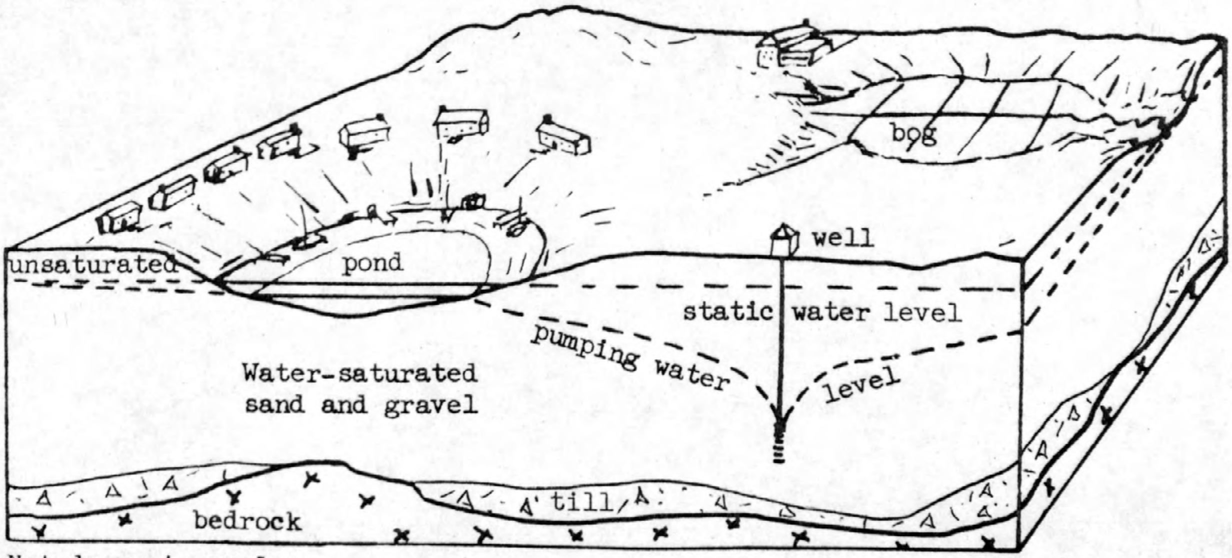
Potential overdevelopment of ground water is a problem in developing additional ground-water supplies. In much of the area, highly permeable aquifer material allows construction of wells with capacities in excess of sustained yield of the ground-water reservoir. In some cases, ground-water resources have been evaluated in terms of pumping capacity of the wells rather than capacity of the ground-water reservoirs. Consequently, overdevelopment is likely as towns seek to satisfy increasing demands. Where ground-water reservoirs lie in two or more towns, competition is likely to arise; for example, the Mattapoisett River valley.

When pumping capacity approaches the sustained yield of aquifers, informed and coordinated management of basin water resources becomes critically important. Ground-water pumping capacity (3.78 mgd or 166 l/s) in the Mattapoisett River basin is approaching the potential 5.5 mgd (240 l/s) yield, and such pumpage rates, if sustained for many months in dry weather, can reduce the low flow of the Mattapoisett River more than 50 percent.

3.2 Ground- and Surface-Water Interrelationships

The interrelationship of ground water and ponds or streams must be clearly understood in order to manage the pumping of ground water with acceptable effect on pond levels, cranberry-bog water levels, and streamflow. Most ground-water reservoirs are in fair to excellent hydraulic connection with ponds, bogs, and streams and some, or even most, of the ground water withdrawn will be replaced through infiltration from these surface-water bodies. Withdrawal from wells adjacent to surface-water bodies will lower water levels in ponds and bogs (figs. 3-1 and 3-2) and generally will decrease streamflow. However, a great advantage of using ground water rather than surface water is that less treatment is required, and, provided surface-water levels are not lowered greatly, the surface-water body may be preserved for recreational use, fisheries, and esthetic values.

Ground-water reservoirs without underground interconnection can influence one another through surface connections (ponds, lakes, swamps, and streams), and such influences can lead to competition between users. In the Mattapoisett River basin, where separate ground-water reservoirs lie in different towns but along the same stream, the users of the downstream reservoirs are at a hydrologic disadvantage during competitive development of water resources. When a stream is in hydrologic contact with two or more ground-water reservoirs, pumpage from upstream reservoirs can, depending on the disposition of the waste waters, diminish the availability of water in downstream reservoirs through the reduction of flow (potential infiltration) in the stream.



Not drawn to scale

Figure 3-1.--Illustration showing the relationship of the water table to ponds and bogs in kettle holes.

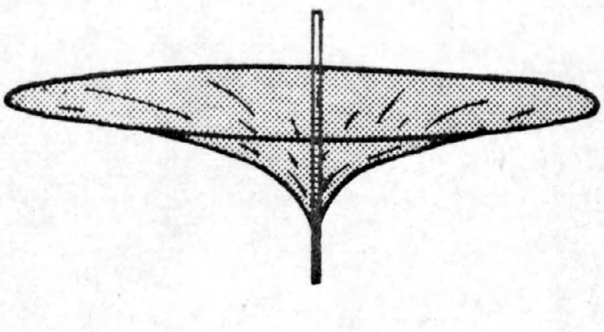


Figure 3-2 .--Illustration showing a cone of depression.

3.3 Salt-Water Encroachment

Salt-water encroachment from Buzzards Bay and brackish-water lagoons, coves, and estuaries is a threat to ground-water quality, and aquifers close to these water bodies are generally avoided as public water-supply sources. Pumping of wells can reverse the natural hydrologic gradient between the well field area and salt- or brackish-water bodies, causing landward encroachment of a salt-water wedge in the lower part of the aquifer. At the well, salt water may be withdrawn along with fresh water, and unless pumping rates are reduced, the salt content will continue to rise, particularly during droughts or dry summer periods when recharge from precipitation is slight.

Salt-water contamination in Fairhaven's well field located in Mattapoisett is a problem. During some exceptionally high tides and storms, salt water from the Mattapoisett River estuary spills over the dam, which is meant to separate fresh and salt water, and floods part of the well field. Sand bags have been used at the dam to prevent such flooding when high tides are expected, but when high water is not anticipated and the sand bags are not used, flooding allows salty water to move upstream and enter the aquifer. After this happens, the wells must be pumped to waste for about 30 days before good quality water is obtained again.

3.4 Recharge

Ground-water recharge results from direct infiltration of precipitation from land surface or, under pumping conditions, infiltration from surface-water bodies overlying aquifers. As urbanization expands, direct infiltration is reduced by paving and roofing on recharge areas, and potential stream infiltration may be nullified by relocating streams in impervious conduits. As paved areas become more extensive, storm runoff increases and increased flooding requires installation of storm sewers, further reducing ground-water recharge. In a gradual manner, recharge to ground-water reservoirs may be sealed off as urbanization proceeds.

Maintenance of recharge can be an objective of land-use planning where depletion of ground-water supplies is to be avoided. Towns choosing ground water for future supply may find such maintenance imperative. A method of compensating for recharge losses as urbanization proceeds is to discharge storm drains to rapid-recharge basins or to wells in recharge areas. Basins are unlined excavations in the permeable sand and gravel deposits of the recharge areas. Basins used for the purpose of storm runoff and recharge on Long Island in New York "...range from 10 to 20 feet in depth and from less than 1 to about 30 acres in area." (Cohen and others, 1968, p. 74).

Water-quality deterioration, however, might become a problem if urban runoff is used as ground-water recharge, especially in shallow aquifers having a high water table. Deicing chemicals applied to roads and parking lots would be carried in solution by the recharging water. Oil and grease would be carried in immiscible liquid suspension, and the water would come in contact with or carry in suspension animal refuse as well as assorted trash and waste materials. Judicious or restricted use of deicing chemicals and traps for grease, oil, and particulate matter would reduce contamination of the recharging water. Also, locating recharge structures at a distance from production wells would allow filtration of suspended and bacterial contaminants.

3.5 Water Quality

Disposal of liquid or solid wastes may be a threat to water quality. Hydrologic conditions at prospective waste-disposal sites are major factors controlling suitability of the sites. Waste-disposal sites in prime ground-water recharge areas may be rejected when water quality is to be protected.

Leachate formed during the percolation of water through refuse in sanitary landfills is particularly noxious. Dissolved solids, chemical oxygen demand, organic acid, and iron rise to high levels in leachate, making it a potent source of water contamination.

Regulations (Massachusetts Department of Public Health, 1971) for sanitary landfills are designed to prevent degradation of major ground-water reservoirs. Regulation 2.3, part (e) states that it is necessary to "... evaluate public importance of ground-water supply to be affected by the operation," and regulation 2.4 states, in part, that "...no area shall be considered or assigned (c) which does not provide for protection of all sources of private and public water supplies." The use of recharge areas for sanitary landfill will result in contamination of ground water unless leachates are prevented from entering the aquifer with recharge. Potential sources of ground water might also be protected by similar landfill site evaluation and regulation of waste-disposal operations on aquifers not yet developed but needed to meet future water demands.

Although good well sites have generally been avoided during siting of sanitary landfills, recharge areas have not always been recognized and avoided. Sand and gravel pits are commonly selected for sanitary landfill operations because of their low value for other uses and availability of cover material. Unfortunately, many of these sites are in recharge areas for present and potential ground-water supplies.

Preliminary evaluation of the possible impact of proposed landfill sites may be made through use of the map (fig. 1-1) which delineates ground-water reservoirs favorable for the exploration for wells capable of supplying municipalities. This map may be used as a guide to landfill site selection, but not as a substitute for onsite investigation and testing. Because of natural ground-water recharge, circulation, and discharge to streams, leaching products of sanitary landfills will eventually be discharged to streams. Generally the concentration of leachate will become attenuated by dilution, adsorption, and chemical reaction with time and travel. The concentration of leaching products could be high in small streams, particularly during periods of low flow when almost all streamflow is derived from ground-water discharge. A fixed horizontal distance or separation requirement (such as 60 ft or 18 m) between a landfill site and a stream may not always be sufficient to prevent deterioration of water quality in small streams. Anticipated leachate loads in ground-water runoff can be compared with dilution potential of local streams to estimate the effect of leachate discharge on stream-water quality.

Contamination of ground water by pesticides may be a threat. A potential ground-water source in the Taunton River basin was rejected because pesticides were detected during a prolonged pumping test. Most bogs are natural ground-water discharge areas; therefore, under normal hydraulic gradients, the likelihood of pesticides from bogs contaminating ground water is minimal. However, hydraulic gradients may be reversed under heavy pumping, and water from bogs may recharge aquifers, greatly increasing the likelihood of contaminating aquifers with pesticides. For this reason, pesticide contamination of water from wells in and near cranberry bogs may gradually increase as water is withdrawn. Thus, periodic monitoring for pesticides in water from wells in agricultural bog areas seems to be indicated. Disposal of pesticides in dumps, by burial, or in sewers or streams is potentially hazardous to ground-water supplies.

3.6 Pond Eutrophication

The many small fresh-water and few salt-water ponds in New England are susceptible to premature eutrophication, as indicated by foul smelling algal blooms, choking pond weeds, and fish kills. Fertilization of ponds with sewage that contains dissolved nitrate, phosphate, and organic nutrients contributes to premature eutrophication. Domestic sewage in cesspools, septic tanks, and leach fields is the major source of nutrients, which seep downward to the water table and then laterally to the ponds (fig. 3-3).

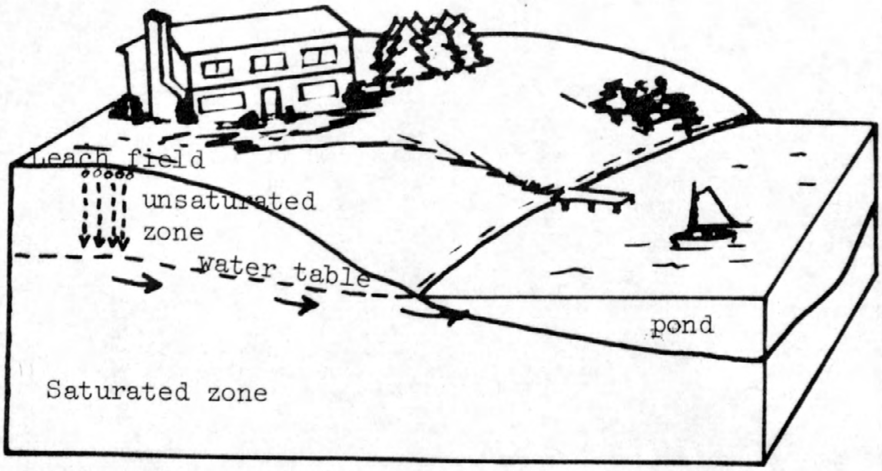


Figure 3-3.--Diagram showing underground path of pond nutrients.

Water drains into ponds over the land surface and through the ground, then evaporates from the pond surface. As a result, dissolved and suspended solids are continually being carried into the ponds and concentrated there. This natural process, after hundreds or thousands of years, fills the ponds, and they become bogs or meadows. Fertilization from sewage hastens the eutrophication process.

Fertilization is virtually irreversible, for the nutrients become incorporated in the pond ecology in the tissues of plants and animals. In order to return a pond to near its original condition, not only must nutrient sources be shut off, but also nutrient concentrations must be drastically reduced. Chemical treatment to retard plant growth has been attempted, but it is expensive, may have undesirable side effects, and may have to be repeated periodically. Bottom dredging and harvesting of plants, although expensive, seems to be effective. However, disposal of dredgings may become a problem, and dredging can stir up additional nutrients from bottom sediments. Prevention of fertilization is economical and effective in maintaining high quality pond environments. Discontinuing subsurface sewage disposal in pond areas would tend to prevent or to reduce pond eutrophication, as would zoning or building regulations that preclude construction of homes with onsite sewage-disposal systems near ponds.

Massachusetts law pertaining to the Great Ponds (natural ponds over 10 acres in area) goes back to the Colony Ordinances of 1641-47, which gave the title to the land under a Great Pond and the water therein to the Commonwealth. Control of Great Ponds has been placed in the Division of Waterways of the Massachusetts Department of Public Works, Massachusetts General Laws, Chapter 91.

4.0 INSTITUTIONAL FRAMEWORK

Hydrologic basins form manageable units of water resources, but they commonly cross political boundaries. Division of management responsibility between political entities usually results in fragmented basin management and leads to competition. Solutions for just apportionment of water and water-related resources are sometimes sought through court adjudication or hearings. Legal proceedings are usually time consuming and are considered only as a last resort. A favored solution for water and water-related problems in hydrologic basins that cross political boundaries is the creation of quasi-judicial bodies that have watershed or basinwide decision-making powers, such as watershed associations or regional water districts. The composition of the association or district is determined by the need for collective action and by hydrologic boundaries, natural or artificial. The Mattapoisett River basin and the outwash plain in Carver, Bourne, Wareham, and Plymouth are manageable hydrologic units.

5.0 CONCLUSIONS

To meet 1990 demands Acushnet, Dartmouth and Fairhaven will probably increase their purchases of water from New Bedford, which depends on Lakeville Ponds for its supply. Wareham contains ground-water resources capable of meeting 1990 demands and Mattapoisett has already developed sufficient ground-water sources to meet its 1990 demand. Marion, through an agreement with Rochester, can develop enough ground water in Rochester to meet the 1990 demand of both towns. Carver and most of Westport have no municipal distribution systems and water is obtained from private wells; Westport will probably not be able to meet its 1990 demand with ground water.

As demand for water increases, the threat of overdevelopment will also increase. Well spacing, location, and yields can be designed to minimize the lowering of pond levels and the water table in bogs. Control of land use on prime recharge areas can prevent uses hazardous or potentially hazardous to ground-water quality, such as highway deicing, salt storage, and sanitary landfills.

Pond eutrophication may be accelerated by seepage of ground water containing nutrients from sewage disposal in cesspools, septic tanks, and leaching fields in pond drainage areas. Regulation of development and waste disposal around ponds can help prevent accelerated eutrophication.

Modeling of the outwash plain aquifer in Wareham, Carver, Bourne, and Plymouth may enable prediction of the effects of various development and management schemes. A model could be used as a management tool to test the design of well fields for impact on pond levels, low streamflow, and well interference.

Management alternatives mentioned above are evaluated in table 5-A.

Table 5-A.--Evaluation of alternatives
(Ground-Water Management, 3.03)

	Alternatives and rating: High, moderate, fair	Environmental evaluation	Economic evaluation	Technical evaluation	Legal and institutional implications	Political implications	Social implications
I.	Include consideration of water table and pond level lowering, both locally and regionally in engineering plans for ground-water development in the outwash plain aquifer in Wareham, Carver, and Plymouth. High.	High value--assessment of future pond level lowering and streamflow depletion may reveal potential environmental degradation and assist in management decisions.	Low value for short term and high value for long term. Increases engineering design cost and construction cost of groud-water supplies. However, investment is returned in maintenance of property values, particularly in recreational and residential pond property areas.	Requires development or subcontracting of additional expertise in ground-water hydrology for many water supply engineering consultants. Could be considerably aided by development of model described under IV below.	Provides data for expansion of environmental responsibility of decision makers and planners. Information would be used by planning groups and state Water Resources Commission to guide ground-water development and by the Department of Public Works, Division of Waterways, to protect Great Ponds.	May tend to increase controversy over marginally acceptable land and water development proposals.	Ground water may be developed with minimal negative environmental impact.
II.	Restriction of land use for highway deicing salt storage, solid-waste disposal, or other activities hazardous or potentially hazardous to ground-water quality on prime recharge areas. High.	High value--prevents contamination of ground water and natural ground-water discharge; conservation of resources.	High value--reduces potential for loss of water resources or present supply because of contamination; a low-cost preventive measure.	Maps of recharge areas and well locations are available; reduces potential for gradual and undetected water-quality deterioration.	Minimal effort in land-use planning; requires zoning or rezoning in some areas and may require detailed hydrologic studies for permits or variances.	May give more power to zoning and planning boards; may be opposed by land developers and other real estate interests.	Restricts developers and landowners but tends to maintain lower public water costs and high public water quality.
III.	Regulation of development of land around ponds to preclude subsurface disposal of sewage that might seep into ponds, fertilize them, and hasten eutrophication. A program of sewering areas around ponds that are already developed could also be undertaken to prevent further deterioration. High.	High value--would slow eutrophication. Reduces possibility of fish kills, algal blooms, and aquatic weed growth. Maintains esthetic quality of pond areas and recreational values.	High value--although initial expense is somewhat greater than without these controls, pond property values are not depressed because of environmental degradation. Recreational values are retained.	Prevention of fertilization is the best method known to slow eutrophication.	Many agencies at many levels of government could integrate these efforts. Town planning and zoning boards may be most effective, but town boards of health have established responsibility for control of waste disposal for health reasons. Authority to establish and enforce regulations may be challenged. Control of Great Ponds has been placed in the Division of Waterways, Department of Public Works.	Such measures may be opposed by some because they will increase development costs.	Increased initial costs may provide environmental and economic benefit for future landowners and citizens.
IV.	Develop a decision-oriented computer model of the outwash plain aquifer in Wareham, Carver, and Plymouth which simulates its hydrology and water supply and disposal operations and allows rapid assessment of various proposed development and management schemes. High.	High value--allows rapid testing of ground-water development proposals and reveals their consequences (particularly those involving pond levels and streamflows).	High value--a tool for the efficient allocation of resources. Can predict long-term trends in well interference, water pollution, and decreases in ground-water availability. Can predict integrated effects of multiple development proposals.	Models developed for similar areas could be adapted to southeastern Plymouth County (Wareham, Carver, and Plymouth). Sufficient hydrologic and geologic data are available from U.S. Geological Survey studies of the region.	Provides a tool for the solution of interdependent ground-water and surface-water conflicts. This tool would be used by the Massachusetts Water Resources Commission, the Southeastern Regional Planning and Economic Development District, and town governments to manage the development of ground water.	Provides more decision-making power for planners and managers.	Simulation model aids decision processes.

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