DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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COMMONWEALTH OF MASSACHUSETTS, WATER RESOURCES COMMISSION,
BARNSTABLE COUNTY, and the NATIONAL PARK SERVICE

HYDROLOGIC INVESTIGATIONS
ATLAS HA-692 (SHEET 3 OF 4)

FRESHWATER-SALTWATER BOUNDARY

Seawater, which contains approximately 18,000 milligrams per liter of chloride, completely surrounds the Cape and bounds the freshwater-flow system. The inland extent of saline surface water in late fall 1976, delineated by specific conductance greater than 1,000 microsiemens per centimeter, is shown in figures 14 and 18. For mixtures of freshwater and seawater, a specific conductance of 1,000 microsiemens per centimeter is approximately equivalent to a chloride concentration of 250 milligrams per liter, which is the concentration limit recommended for drinking water (U.S. Environmental Protection Agency, 1979). Freshwater on Cape Cod generally contains less than 20 milligrams per liter of chloride.

Freshwater and saline water in the aquifer are separated by a transition zone where mixing occurs (fig. 15). In this zone, freshwater flowing to the ocean mixes by hydrodynamic dispersion and diffusion with seawater flowing inland into the aquifer from the ocean. Freshwater and saline water remain separated by the transition zone partly because there is no turbulent mixing of saline water with the fresh ground water and partly because saline water is denser than freshwater.

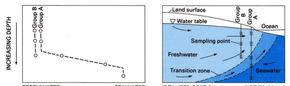
The general position of the transition zone on the inner, mid-, and outer Cape (fig. 6) was estimated from (1) electric borehole-geophysical logs for three test holes, (2) chloride profiles from groups of wells at 29 sites, and (3) digital-model analyses (Guswa and LeBlanc, 1985). The electric logs show lower electrical resistivity in sediments saturated with saltwater than in sediments saturated with freshwater (wells MIW 26, TSW 234, and TSW 200 in figs. 17, 20, and 21).

Groups of wells were installed at 29 sites (figs. 14 and 18) to sample ground water for chloride content at different depths. At 24 of these sites, the deepest sampling point is 100 feet or less below land surface. The transition zone was fully penetrated at seven sites (fig. 15A) and is 20 to 80 feet thick. At the other sites, the profiles of chloride concentration show freshwater to the deepest sampling point (fig. 15B), brackish water near the water table underlain by freshwater (fig. 15C), or saline water at all sampling points (fig. 15D).

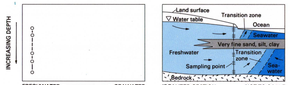
The position of the transition zone, commonly referred to as the freshwater-saltwater boundary, is determined by a dynamic balance in which the seaward-flowing freshwater prevents saline water from intruding landward. Changes in natural or artificial recharge rates and pumping rates of wells can change the flow to the ocean. When the seaward flow rate changes, the freshwater-saltwater boundary gradually moves to a new position that is again in balance with the new flow rate. Decreased freshwater outflow causes landward movement of the boundary; increased freshwater outflow causes seaward movement of the boundary. This movement is not instantaneous, and several years may elapse before a new stable boundary position is attained.

ZONE OF TRANSITION MONITORING WELL SITES

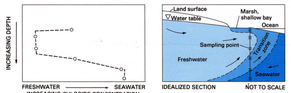
At the 29 zone of transition monitoring well sites shown in figures 14 and 18, groups of wells were installed to collect water samples at different depths for chloride analysis. The observed profiles of chloride concentration with depth exhibit several patterns which are related to the shape of the transition zone and are interpreted in the following diagrams.



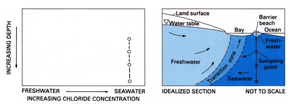
A. At well group A, the transition zone is penetrated by sampling points. Examples are sites YAW 173-178, BHW 221-224, TSW 234-236. At well group B, all sampling points are set above the transition zone. Examples are sites A1W 322-325, HJW 156-159.



B. Very fine sand, silt, and clay cause confined conditions and the transition zone is displaced offshore; freshwater occurs to bedrock at shoreline. Common on inner and mid-Cape along Cape Cod Bay. Example is site DGW 168, 193-195.



C. Source of shallow brackish ground water is periodic flooding by seawater. At depth, pattern is similar to (A) or (B) above. Examples are sites A1W 330-333, BMW 47-50, TSW 210-213.



D. All freshwater discharges to inland bay or wetland. Only saltwater is at depth at the group of wells. Examples are sites MIW 22-25, WNW 86-88.

Figure 15.—Patterns of chloride concentration with depth at the zone of transition monitoring sites in figures 14 and 18.

Regional movement of the freshwater-saltwater boundary has not been observed since the network of monitoring wells was installed in 1975. However, pumping from the freshwater zone in Truro has caused local intrusion of seawater. The Knowles Crossing well field (public-supply well P 115, fig. 18), 1,500 feet from the ocean, has a history of high chloride concentrations caused by seawater intrusion. The upward movement, or upconing, of the transition zone has been observed beneath a well in Truro (fig. 16). Upconing also was observed on Great Island in Wellfleet beneath a 35-foot-deep well pumping 100 gal/min (U.S. Geological Survey, 1966, p. A167).

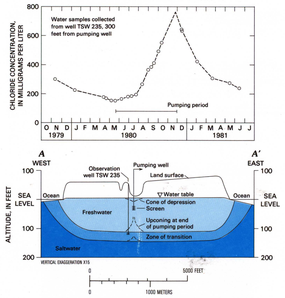
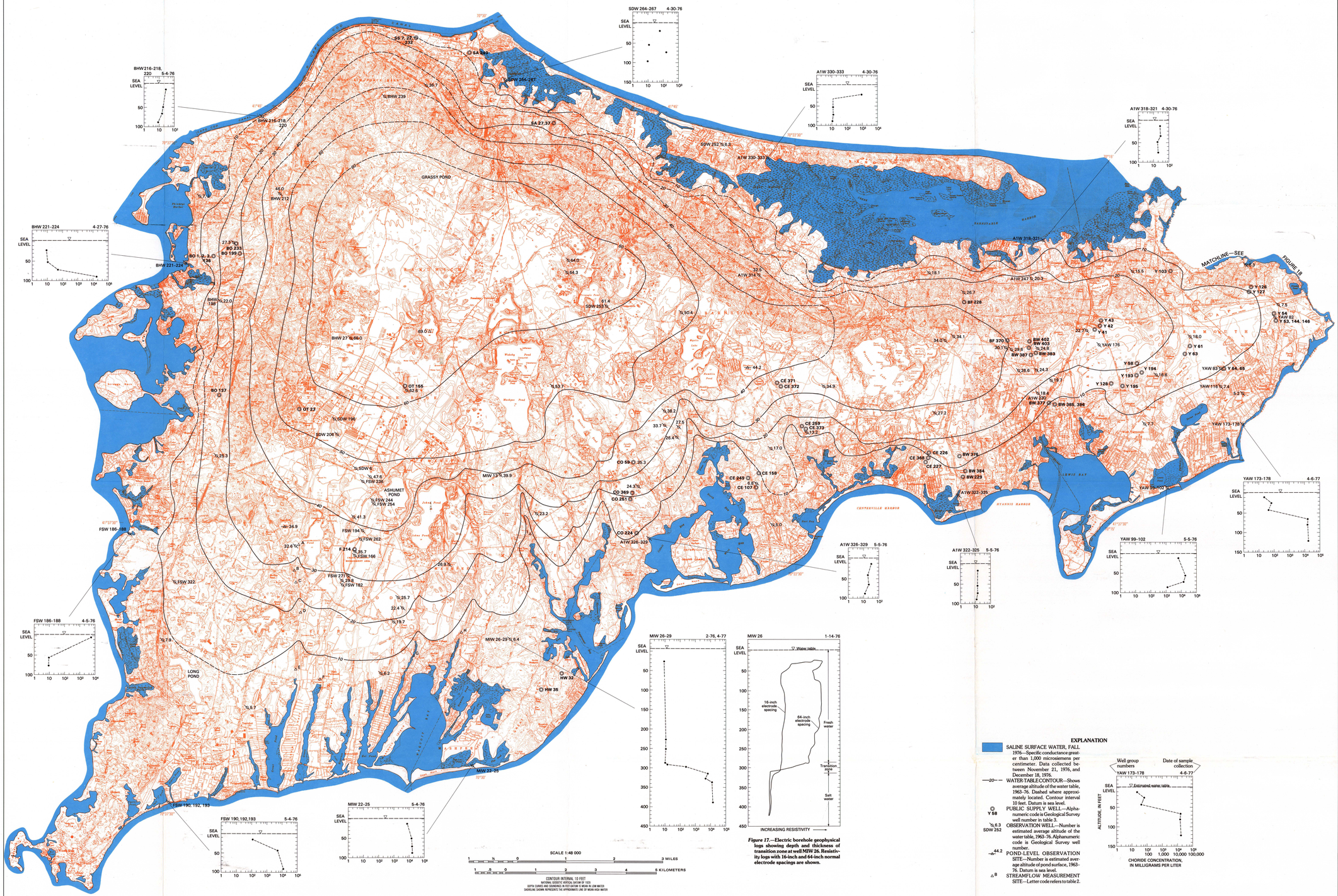


Figure 16.—Upconing of the zone of transition beneath a well in Truro pumping 440 gallons per minute, shown by (a) an increase in chloride concentrations in an observation well screened near the top of the transition zone, and (b) an idealized section of the freshwater lens at the beginning and end of the pumping period. Location of section line shown in figure 18.



Base from U.S. Geological Survey
Topographic quadrangles

Figure 14.—Average water-table contours for 1963-76, extent of saline surface water in late fall 1976, and chloride content of ground water with depth at selected sites: Cape Cod Canal to the Bass River.

Figure 17.—Electric borehole geophysical logs showing depth and thickness of transition zone at well MIW 26. Resistivity logs with 16-inch and 64-inch normal electrode spacings are shown.

EXPLANATION

- SALINE SURFACE WATER, FALL 1976—Specific conductance greater than 1,000 microsiemens per centimeter. Data collected between November 21, 1976, and December 18, 1976.
- —20— WATER-TABLE CONTOUR—Shows average altitude of the water table, 1963-76. Dashed where approximately located. Contour interval 10 feet. Datum is sea level.
- Y 58 PUBLIC SUPPLY WELL—Alphanumeric code is Geological Survey well number in table 3.
- 6.3 SDW 252 OBSERVATION WELL—Number is estimated average altitude of the water table, 1963-76. Alphanumeric code is Geological Survey well number.
- 44.2 POND-LEVEL OBSERVATION SITE—Number is estimated average altitude of pond surface, 1963-76. Datum is sea level.
- △B STREAMFLOW MEASUREMENT SITE—Letter code refers to table 2.

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GROUND-WATER RESOURCES OF CAPE COD, MASSACHUSETTS

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