PREPARED IN COOPERATION WITH THE
COMMONWEALTH OF MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
DIVISION OF WATER RESOURCES
BOSTON, MASSACHUSETTS

INTRODUCTION

A hydrologic study of the Westfield and Farmington River basins in Massachusetts was conducted by the U.S. Geological Survey, in cooperation with the Commonwealth of Massachusetts Department of Environmental Management, Division of Water Resources, from 1984 to 1986. The study was the final part of a statewide basin-by-basin investigations program designed to provide baseline information on the State's water resources.

Purpose and Scope

The objectives of this report are to: (1) delineate the stratified-drift aquifers of the Westfield and Farmington River basins and present descriptions of their water-yielding characteristics; (2) describe low-flow characteristics, regulation, and diversion of streamflow in the basins; and (3) characterize the quality of ground water and surface water in the basins. The report shows the transmissivity of unconsolidated materials, the availability of ground water, and the surficial geology of the area on a 1:48,000-scale map. High- and low-flow analysis, regional flood-flow equations, diversions, water quality, and water use are also described.

Description of the Study Area

The Westfield and Farmington River basins occupy 675 mi^2 (square miles) in western Massachusetts (fig. 1) and comprise about 25 percent of that part of the Connecticut River drainage area that lies within Massachusetts. The study area includes all or part of 32 municipalities in Berkshire, Franklin, Hampden, and Hampshire Counties.

The basins are bordered on the west by the Housatonic River basin, on the north by the Deerfield River basin, on the east by the Connecticut River lowlands, and on the south by the Farmington River basin in Connecticut. The principal tributaries to the Westfield River are the West Branch Westfield River, Middle Branch Westfield River, Swift River, and Little River. Clam River and Sandy Brook are the principal tributaries to the West Branch Farmington River in Massachusetts. Altitude of the land surface in the Westfield River basin ranges from 50 feet above sea level at the mouth of the Westfield River to 2,300 feet along the northwestern basin divide in Windsor, and in the Farmington River basin from 650 feet on the West Branch Farmington River at the Connecticut State line to 2,050 feet along the northwestern corner of the basin divide in Becket. Population is concentrated mainly in the southeastern corner of the Westfield River basin; the remainder of the area is sparsely populated.

Bedrock forms a small-yield aquifer in the region and is the only practical source of ground water in the hilly parts of the area. Many wells completed in bedrock are capable of yielding adequate amounts of water to meet domestic needs and small commercial and industrial requirements. The movement of water, which occurs mainly in joints, fractures, and bedding planes, is controlled by the number, size, and degree of interconnection of these openings.

During continental glaciation, the ice scoured hills and deepened some valleys. The unconsolidated material picked up by the ice was then deposited on bedrock as till and stratified drift. Outwash and ice-contact deposits consist of sand and gravel that was deposited by meltwater streams and form the principal aquifers in the Westfield and Farmington basins. Glaciolacustrine deposits of silt and clay were accumulated as bottom sediments in proglacial Lake Hitchcock (Lougee, 1939). The thickness of these materials ranges from a few feet to more than 200 feet. Generally, the lacustrine deposits are too fine grained to form significant aquifers, except in relatively coarse-grained deposits in deltas at the margins of valleys.

The mean annual precipitation in the region is about 47 inches. Mean monthly precipitation ranges from slightly less than 3 inches in February to more than 4 inches in November. More than one-half of the precipitation runs overland and discharges directly to streams. Air temperature in the area changes with altitude. The mean annual temperature ranges from 44°F (degrees Fahrenheit) in the western mountains to 50°F on the eastern plains.

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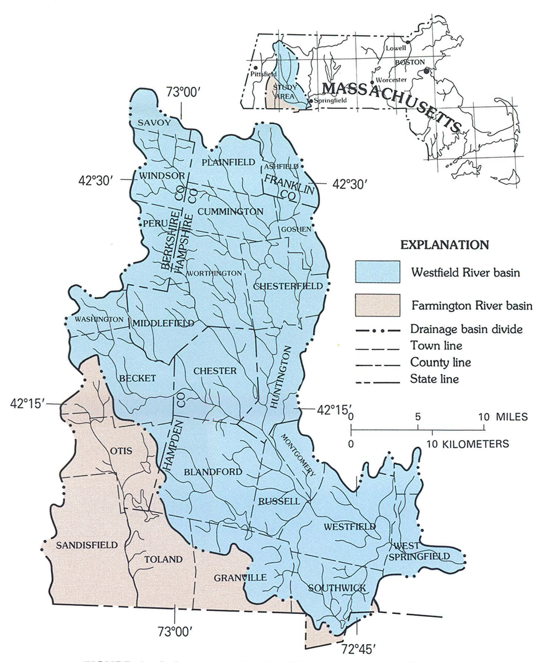


FIGURE 1.—Index maps of the Westfield and Farmington River basins.

GEOLOGY

Unconsolidated glacial drift, which is composed of loose rock particles, was deposited by glacial ice and meltwater. The two major types of unconsolidated material in the basins are unstratified till and stratified drift.

A nearly continuous sheet of till was laid down over bedrock by glacial ice, either buried beneath the ice as the glacier moved overland or dropped out of the ice as the glacier melted. The till is composed of materials ranging in size from clay to boulders. Thickness of the till generally is less than 20 feet. However, till is as much as 200 feet thick beneath the crest of some drumlins.

Stratified sand and gravel overlie till in many areas of the upland valleys and central lowland. The stratified drift was deposited by meltwater streams during glacial ice wastage and retreat in the valleys and is now the most productive source of ground water in the study area. These deposits differ greatly in thickness, mineral composition, and particle-size distribution. The thickness of stratified drift ranges from a few feet to more than 300 feet in some valleys.

Post glacial alluvium—the youngest unconsolidated deposit—covers the flood plains of the Westfield, Farmington, and Little Rivers and their tributaries (fig. 2). The alluvial deposits, which consist of clay, silt, sand, and gravel, generally are less than 50 feet thick.

Delineation of the surficial geology was based on information obtained from the following geologic quadrangles, materials maps, and reports (indicated in patterns on the explanation shown as part of figure 2): Becket (Holmes, 1967); Blandford (Holmes, 1968); Chester (Hatch and others, 1970); East Lee (Holmes, 1967); Goshen (Holmes, 1968); Monterey (Holmes, 1964); Mount Tom (Larsen, 1972); Otis (Holmes, 1965); Peru (Norton, 1974); Pittsfield East (Holmes, 1968); Plainfield (Osberg and others, 1971); South Sandisfield (Holmes, 1964); Southwick (Schnabel, 1974); Springfield South (Hartshorn and Koteff, 1967); West Granville (Schnabel, 1973); West Springfield (Colton and Hartshorn, 1971); Windsor (Holmes, 1965); Woronoco (Holmes, 1968); Worthington (Hatch, 1969); and Franklin, Hampshire, and Hampton Counties (Emerson, 1898). Reconnaissance mapping and compilation of published geologic data was done in 1984–85.

Bedrock composed of gneiss, schist, and quartzite, which locally is intruded by granite, underlies most of the unconsolidated deposits. Relatively unaltered sedimentary rocks, such as sandstone, siltstone, and shale, are present only in valley flats of the eastern part of the Westfield River basin. All of these rocks were intruded with basaltic dikes and diabasic sills during later volcanic activity and subsequently faulted and tilted. The basalt and diabase, which are relatively resistant to erosion, now form ridges.

Seismic-refraction surveys were done in 1985 and 1986 to determine the approximate thickness of unsaturated and saturated zones and the depth to bedrock from the land surface. Selected seismic-refraction survey profiles (those with section end-points identified by letters) showing elevations of land surface, altitudes of the water table and bedrock surface, and boundaries of surficial deposits, are shown on sheet 1 (fig. 3).

GROUND WATER

Availability of Ground Water

Stratified glacial drift, composed chiefly of sand and gravel, in stream and river valleys is the major source of ground water in the Westfield and Farmington River basins (fig. 2). The sand and gravel aquifers that have the greatest water-yielding potential are located in the southeastern half of the Westfield River basin. The two most productive of these aquifers were mapped in 13 mi^2 of the Pond Brook and Great Brook valleys in the towns of Westfield and Southwick. Together the aquifers have a combined potential yield estimated to be more than 10 Mgal/d (million gallons per day), based on the actual production before the wells in Southwick were shut down because of contamination.

Determination of transmissivity is an important step in estimating the yield of aquifers. Transmissivity of the major aquifers was calculated from estimates of horizontal hydraulic conductivity and saturated thickness of the aquifer. Local variations in horizontal hydraulic conductivity and saturated thickness affect estimates of transmissivity, and may cause actual well yields to be different from those estimates illustrated in figure 2. Accordingly, the transmissivity map (fig. 2) is a general guide and is not intended to be substituted for site investigations. Because the lithology of the stratified drift and till can differ both vertically and horizontally over short distances, exploratory test drilling would be necessary to determine saturated thickness and lithology in a given area. Also, aquifer tests may be necessary to evaluate the water-yielding capability of the aquifer and to design the well and pumping system.

The yield of water from crystalline and sedimentary bedrock is controlled by the number, size, and degree of interconnection of joints, fractures, and bedding planes. The average yield reported for 400 domestic wells in bedrock distributed throughout the basins is 6 gal/min (gallons per minute). A common household bedrock well, 6 inches in diameter, stores 1.46 gallons of water per foot of depth below the water table. Therefore, 200 gallons of water is stored in a 140-foot well that is nearly full.

Glacial till has low permeability and its yield is inadequate for development of large water supplies. Most wells in till are 2 to 4 feet in diameter and less than 30 feet deep. Yields of wells in till commonly are very low; however, each foot of water in a 36-inch-diameter well represents a storage of 53 gallons. Therefore, a depth of 4 feet of water (212 gallons) is adequate for most short-term household demands. However, shallow till wells may be unreliable during drought periods. The normal fluctuation of water levels in till ranges from 7 to 16 feet annually (Maevsky, 1976).

EXPLANATION

Surficial Geology

- GRAVEL – Well-sorted to poorly sorted stratified gravel; gravel, sand, and discontinuous lenses of fine sand
- SAND AND GRAVEL – Thinly layered, well-sorted sand and gravel; or pocket lenses of well-sorted to poorly sorted sand and gravel within the layered material
- SAND – Stratified sand with minor amounts of gravel and fine sand. Commonly well-sorted to poorly sorted
- FINE SAND, SILT, AND CLAY – Lacustrine deposits of stratified fine sand and discontinuous layers of silt and clay; contains scattered pebbles. Well-sorted very fine sand and silt locally alternates with well-sorted clay, or forms massive beds of very fine sand, silt, and clay. Thickness ranges from a few feet to more than 210 feet
- WETLAND DEPOSITS – Dark, decomposed organic matter (peat and muck) interbedded and intermixed in places with various amounts of sand, silt, clay, and scattered stones. Deposits generally are less than 5 feet thick but are as much as 25 feet thick locally
- TILL AND BEDROCK – Till is an unstratified, unsorted mixture of boulders, gravel, sand, silt, and clay. Two types of till are: (1) sandy, loose, very stony in places, and commonly less than 10 feet thick; and (2) silt- and clay-rich, with minor amounts of sand, few large stones, generally slightly to very compact, and a few feet to more than 205 feet thick. Where two types of till are found together, loose, sandy till invariably overlies finer, compact till. Bedrock is exposed at the land surface throughout the basins

118 PUBLIC-SUPPLY WELL – Number indicates estimated yield, in gallons per minute

WVW162 GROUND-WATER OBSERVATION WELL – WVW 162 is the local well number, which consists of a three-character alphanumeric code indicating the town and a sequential number assigned by the U.S. Geological Survey for wells within that town

BASIN BOUNDARY

50 BEDROCK CONTOUR – Shows altitude of bedrock surface. Contour interval 50 feet. National Geodetic Vertical Datum of 1929

LOCATION OF PRECLACIAL CONNECTICUT RIVER CHANNEL

I I′ LOCATION OF SEISMIC-REFRACTION SURVEY

X – 41 KNOWN ALTITUDE OF BEDROCK, IN FEET BELOW SEA LEVEL

Transmissivity

Transmissivity of the sand and gravel was calculated by two methods: (1) from specific-capacity and lithologic logs of 20 wells, and (2) from hydraulic-conductivity and saturated-thickness values of 210 wells and borings in sand and gravel deposits. Transmissivity of glacial drift ranges from less than 4 ft^2/d (feet squared per day) for thin silt, clay, and till, to more than 26,500 ft^2/d for thick sand and gravel. The transmissivity estimates illustrated in figure 2 are:

- Transmissivity greater than 4,000 ft^2/d (potential well yield greater than 300 gal/min)
- Transmissivity 1,400 to 4,000 ft^2/d (potential well yield 100 to 300 gal/min)
- Transmissivity 100 to 1,400 ft^2/d (potential well yield less than 100 gal/min)
- Transmissivity less than 100 ft^2/d (potential well yield less than 10 gal/min)

EXAMPLE

Estimating transmissivity from lithologic data and horizontal hydraulic conductivity

Depth below land surface, in feet	LOG WVW–134	Saturated thickness (feet)		Horizontal hydraulic conductivity (feet per day)		Transmissivity (feet squared per day)
0–7						
7–27	Fine sand	20	x	55	=	1,100
27–68	Medium sand	41	x	105	=	4,305
68–75	Coarse sand	7	x	135	=	945
75–99	Coarse sand and fine gravel	24	x	200	=	4,800
99–120	Medium and coarse sand	21	x	115	=	2,415
120–128	Fine sand	8	x	55	=	440
					Total transmissivity =	14,005

HORIZONTAL HYDRAULIC CONDUCTIVITIES OF SATURATED MATERIALS USED TO ESTIMATE TRANSMISSIVITY IN THE WESTFIELD AND FARMINGTON RIVER BASINS

[Modified from Rosenshein and others, 1968]

Material	Horizontal hydraulic conductivity (K), in feet per day
Gravel:	
Coarse	300 to 700
Medium	200 to 470
Fine	180 to 200
Sand:	
Sand and gravel	200
Coarse	80 to 135
Medium	70 to 105
Fine	35 to 55
Very fine	10 to 20
Silt	4
Clay (till)	0.1

HYDROGEOLOGY OF UNCONSOLIDATED DEPOSITS

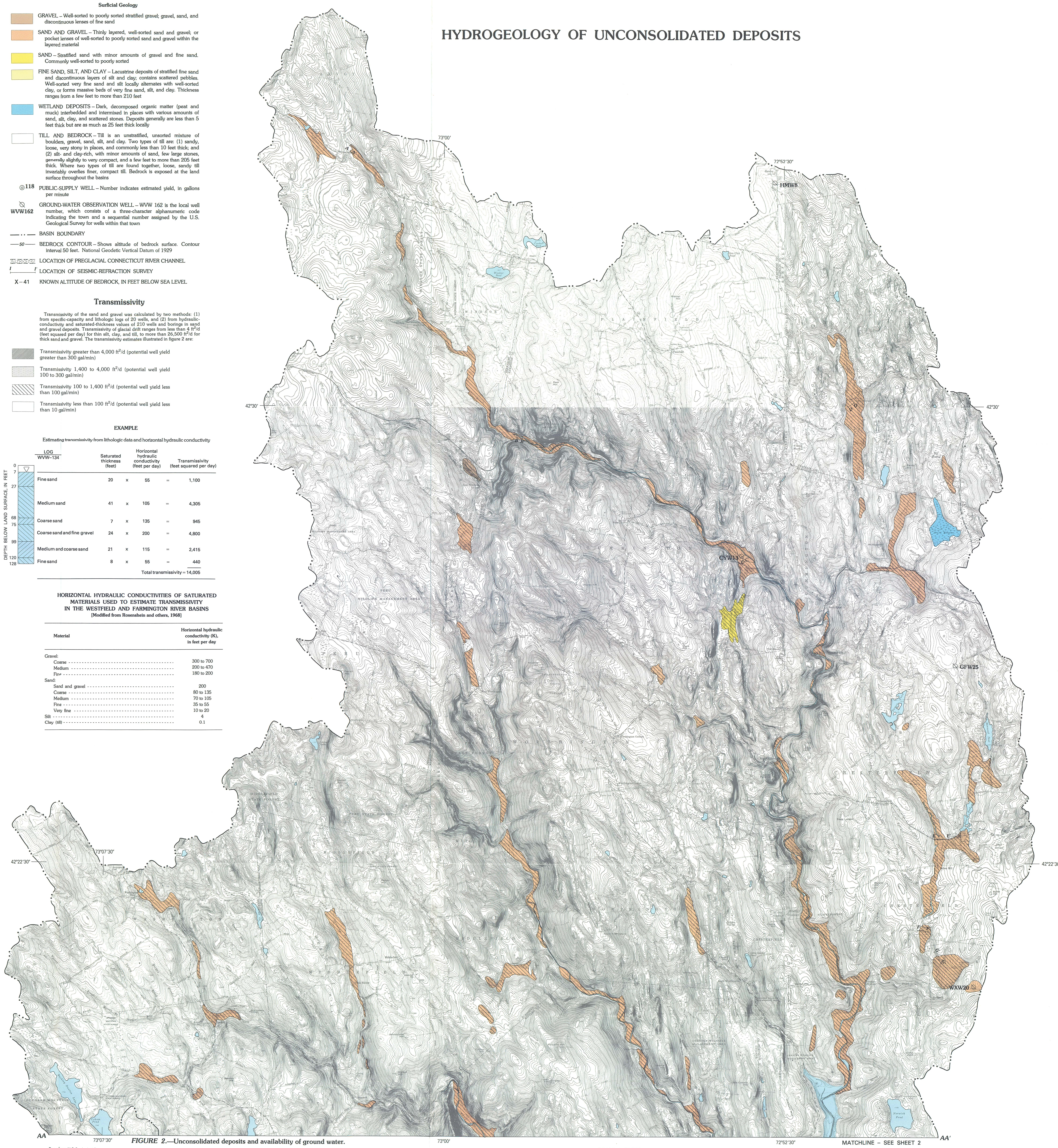
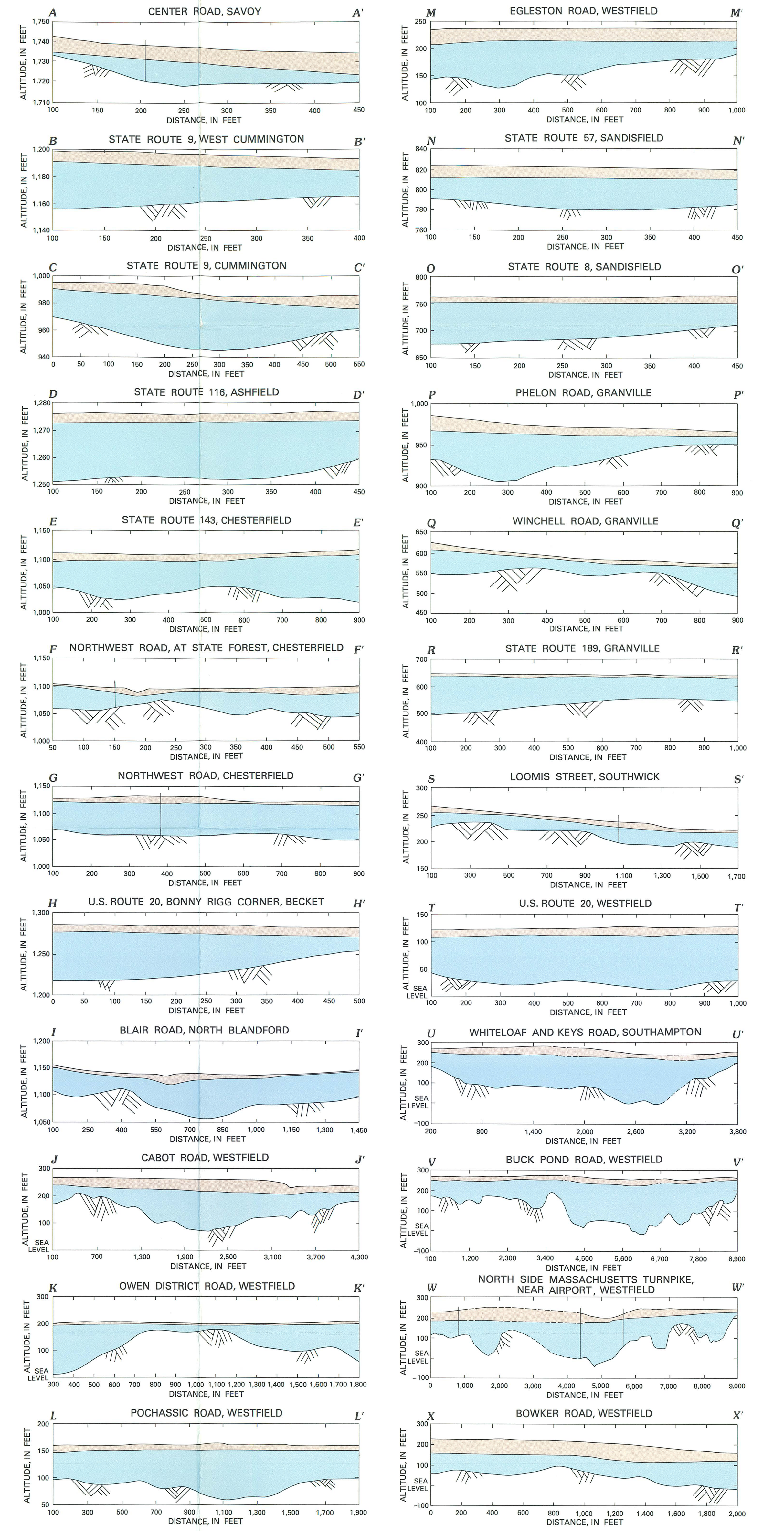


FIGURE 2.—Unconsolidated deposits and availability of ground water.



EXPLANATION OF SEISMIC-REFRACTION SURVEY PROFILES

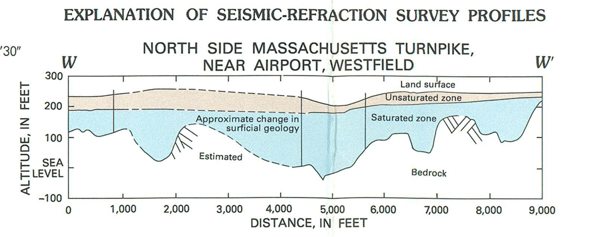


FIGURE 3.—Selected seismic-refraction survey profiles:

A–A′	Center Road, Savoy
B–B′	State Route 9, West Cummington
C–C′	State Route 9, Cummington
D–D′	State Route 116, Ashfield
E–E′	State Route 143, Chesterfield
F–F′	Northwest Road, at State forest, Chesterfield
G–G′	Northwest Road, Chesterfield
H–H′	U.S. Route 20, Bonny Rigg Corner, Becket
I–I′	Blair Road, North Blandford
J–J′	Cabot Road, Westfield
K–K′	Owen District Road, Westfield
L–L′	Pochassic Road, Westfield
M–M′	Egleston Road, Westfield
N–N′	State Route 57, Sandisfield
O–O′	State Route 8, Sandisfield
P–P′	Phelon Road, Granville
Q–Q′	Winchell Road, Granville
R–R′	State Route 189, Granville
S–S′	Loomis Street, Southwick
T–T′	U.S. Route 20, Westfield
U–U′	Whiteloaf and Keys Roads, Southampton
V–V′	Buck Pond Road, Westfield
W–W′	North side of Massachusetts Turnpike, near airport, Westfield
X–X′	Bowker Road, Westfield

Note: Location of profiles H–H′ through X–X′ can be found on the map on sheet 2.

CONVERSION FACTORS AND ABBREVIATIONS

For the convenience of readers who may prefer to use metric (International System) units rather than the inch-pound units used in this report, values may be converted by using the following factors:

Multiply inch–pound units	By	To obtain metric units
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
million gallons (Mgal)	3.785×10^{-3}	cubic hectometer (hm^3)
million cubic feet per square mile (Mft^3/mi^2)	0.01093	cubic hectometers per square kilometer (hm^3/km^2)
	Flow	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer [$(mi^3/s)/km^2$]
gallon per minute (gal/min)	6.309×10^{-5}	cubic meter per second (m^3/s)
gallon per day (gal/d)	3.785×10^{-3}	cubic meter per day (m^3/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
	Hydraulic conductivity	
foot per day (ft/d)	0.3048	meter per day (m/d)
	Transmissivity	
foot squared per day (ft^2/d)	0.0929	meter squared per day (m^2/d)
	Temperature	
degree Fahrenheit (°F)	°C = 5/9 (°F − 32)	degree Celsius (°C)

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1990

WATER RESOURCES OF THE WESTFIELD AND FARMINGTON RIVER BASINS, MASSACHUSETTS

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1990

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