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Appendix 4. Description of Selected Unconsolidated and Bedrock Aquifers

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Appendix 4. Description of Selected Unconsolidated and Bedrock Aquifers

Limited and discontinuous stratified-drift aquifers were present in the study area and were described by Moore (1990) and Stekl and Flanagan (1992). Many of these aquifers are hydraulically connected to bedrock aquifers that are undergoing increased use and development.

Seabrook

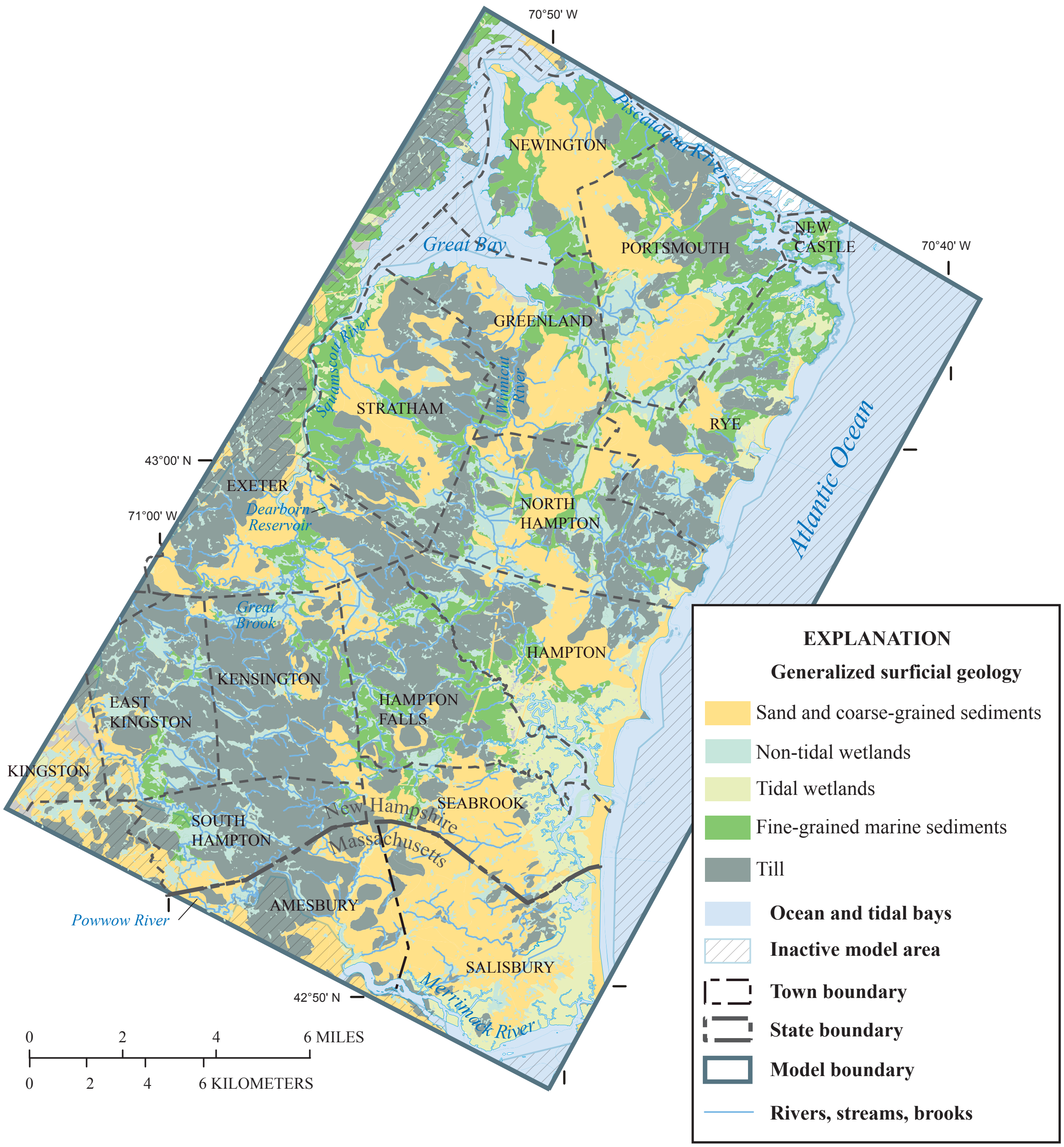
In the town of Seabrook several stratified-drift aquifers of limited extent and generally less than 40 ft thick were along the Salisbury, Mass., town line and at the boundary with South Hampton and Kensington (Stekl and Flanagan, 1992). These stratified-drift aquifers (fig. 4–1) were fully developed by the towns of Seabrook and Salisbury and unavailable for additional water supply. A well field in a stratified-drift aquifer that is a deltaic deposit (Koteff and Schafer, 1989) in the southwest part of town is a major source of water for Seabrook. This well field includes a few high-yield overburden and bedrock wells. In contrast, the towns of Hampton Falls, South Hampton, and Kensington have little stratified drift (fig. 4–1) and no large community ground-water systems. Three sand and gravel aquifers in the town of Seabrook were estimated from aquifer tests (Earth Tech, Inc., 1998) to have hydraulic conductivities of about 100 to nearly 400 ft/d and a storativity (defined as specific storage/thickness) of about 6×10^{-5}.

Seabrook operates five bedrock supply wells in the well field in the southwest part of town. Bedrock wells 1–4 were situated in an area of about 500 ft^2 and bedrock well 5 (SGW-93, fig. 4–2) is about 2,000 ft to the south of the other wells. The bedrock supply wells were all about 500 ft deep and near the contact between the Kittery and Eliot Formations. Wells 1–4 were operated together for a combined capacity of 1,300 gal/min, whereas well 5 has an operating capacity of about 560 gal/min. The specific capacity of bedrock well 5 was estimated at 5 gal/min/ft. The bedrock aquifer at the well field was estimated to have a hydraulic conductivity of about 3.3 ft/d, a storage coefficient of 4×10^{-4}, and a reported porosity of 0.02 (table 4–1) (Earth Tech, Inc., 1998). (Because the reported porosity is from a hydraulic test, it is likely a percent volume associated with gravity drainage and not an actual porosity). The bedrock aquifer responds as a leaky confined porous medium. The drillers of bedrock wells 1–4 reported caverns (Whitman and Howard, 1993) that may be the result of dissolution in calcareous or dolomitic metamorphic rock. In an investigation in the Eliot Formation about 10 mi south of Seabrook (Lyford and others, 2003; Walsh, 2001), calcareous lenses were associated with water-bearing fracture zones. Separate aquifer tests at the two well fields (Whitman and Howard, 1993) revealed only small drawdowns (less than 1 ft) resulting from pumping at the other site; this finding indicates that the well fields were not well connected hydraulically. Greater drawdowns caused by pumping at each site at test wells about 1,500 ft east of wells 1–4 indicate a greater hydraulic connection in that direction. During a prolonged aquifer test, the cone of depression for bedrock well 5 was found to be elliptical in a northeast direction (Earth Tech, Inc., 1998). Geophysical analyses indicate that a northeast-trending fracture zone at bedrock well 5 may be related to a N. 17 E. photolineament (Mack and others, 1998). Like the variographic analysis of bedrock well yields, these observations indicate a northeast anisotropy to the bedrock hydraulic properties.

Most of the town of Seabrook south and east of the well field and in areas of the ground-water-flow model in Massachusetts is underlain by dioritic rocks of the Newburyport Complex. Exploratory drilling programs in the towns of Salisbury, Mass., and Seabrook, which are seeking additional ground-water supplies, have found this complex to be generally poor-yielding.

Hampton/North Hampton

The Mill Road well field along the Hampton and North Hampton town line consists of four surficial and two bedrock wells. The surficial wells produced a combined annual total withdrawal of about 1 Mgal/d in 2002 and 2003. Two high-yield bedrock wells were brought on line in 2004. The permitted total production rate for the two wells, bedrock wells 20 and 21 (NSW-76 and NSW-77), spaced 356 ft apart, was 0.5 Mgal/d. A stratified-drift aquifer with a saturated thickness of 0 to 40 ft, and an area of 2.4 mi^2, includes nearly 1 mi^2 of the area upgradient of the well field. An area of about 0.5 mi^2 of this upgradient stratified-drift aquifer in the Little River drainage area (fig. 4–1 and subwatershed 11, fig. 4–3), produces a high yield and has a transmissivity of 2,000 ft^2/d or greater (Stekl and Flanagan, 1992), equivalent to a hydraulic conductivity greater than about 200 ft/d. This aquifer is 2 mi from both the Atlantic Ocean to the east and a large saltwater marsh to the south. Bedrock in this area is mapped as the Rye Complex and the contact with the Kittery Formation, which is the Portsmouth Fault, is believed to be about 1 mi to the



New Hampshire surficial geology base from 1:24,000 N.H. State Geologist, 2005
Massachusetts base from 1:250,000 MassGIS, 1999

Figure 4–1. Distribution of surficial sediments, wetlands, and water bodies in the Seacoast model area, southeastern New Hampshire. (This figure is the same as figure 3 on page 6 in the report.)

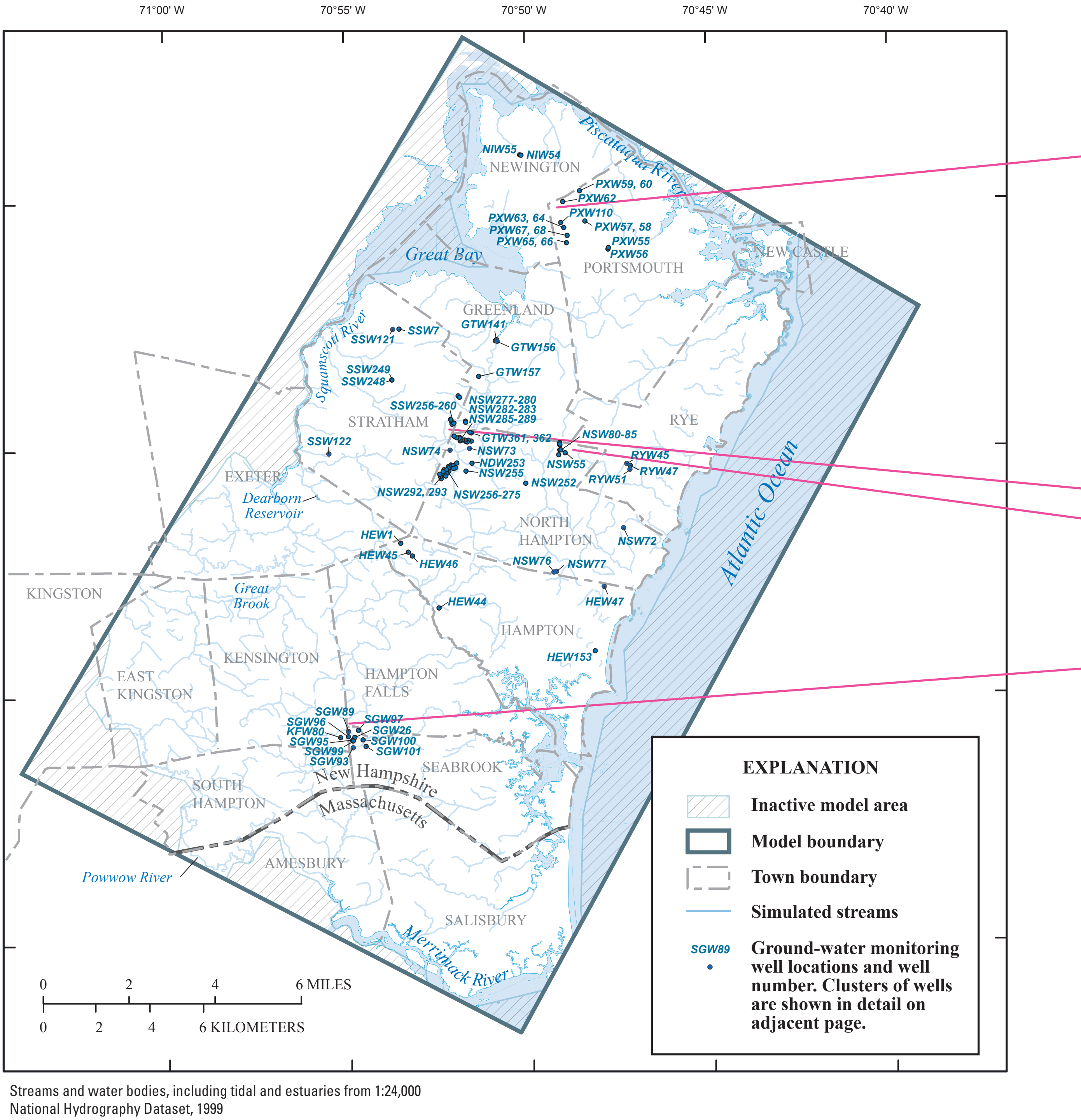


Figure 4–2. *(A)* Ground-water monitoring wells in the study area. (This figure is the same as figure 7 on page 16–17 in the report.)

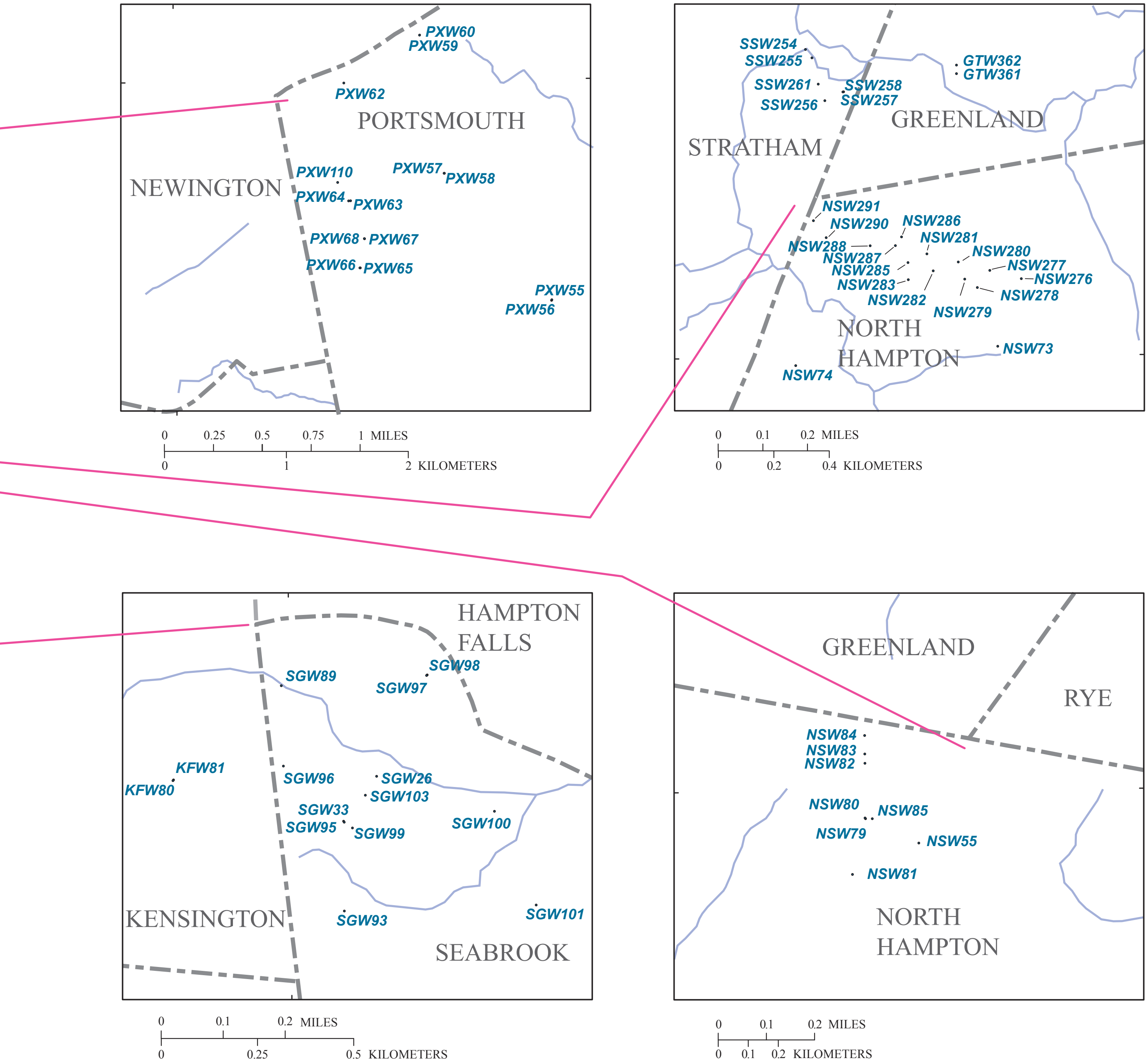

PXW60
PXW59
PXW62
PORTSMOUTH
NEWINGTON
PXW110
PXW57
PXW58
PXW64
PXW63
PXW68
PXW67
PXW66
PXW65
PXW55
PXW56
0 0.25 0.5 0.75 1 MILES
0 1 2 KILOMETERS
SSW254
SSW255
GTW362
GTW361
SSW261
SSW258
SSW256
SSW257
GREENLAND
STRATHAM
NSW291
NSW290
NSW286
NSW281
NSW288
NSW280
NSW287
NSW277
NSW285
NSW276
NSW283
NSW278
NSW282
NSW279
NORTH HAMPTON
NSW73
NSW74
0 0.1 0.2 MILES
0 0.2 0.4 KILOMETERS
HAMPTON FALLS
SGW98
SGW89
SGW97
KFW81
SGW96
SGW26
KFW80
SGW103
SGW33
SGW95
SGW99
SGW100
KENSINGTON
SGW93
SGW101
SEABROOK
0 0.1 0.2 MILES
0 0.25 0.5 KILOMETERS
GREENLAND
RYE
NSW84
NSW83
NSW82
NSW80
NSW85
NSW79
NSW55
NSW81
NORTH HAMPTON
0 0.1 0.2 MILES
0 0.1 0.2 KILOMETERS

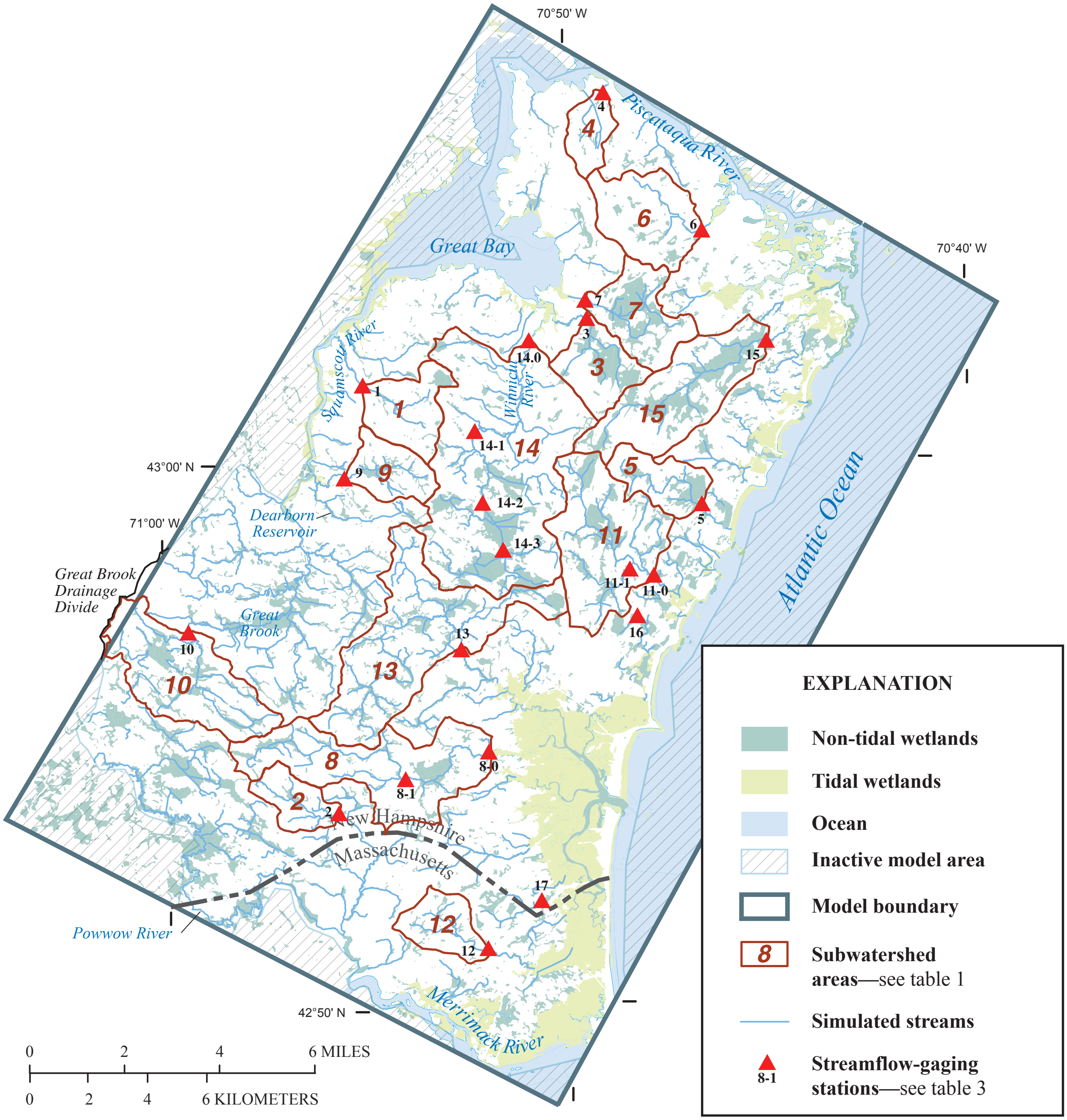
Table 4–1. Reported characteristics of selected bedrock wells, or well fields, in the Seacoast model area, southeastern New Hampshire.

[Wells shown on figure 4–2 unless otherwise indicated; gal/min, gallons per minute; ft/d, feet per day; gal/min/ft, gallons per minute per foot; *, not shown on figure 4–2; —, not available]

Town	Well site	Local well name	Average total yield or discharge (gal/min)	Depth (ft)	Drawdown (ft)	Storage coefficient	Hydraulic conductivity (ft/d)	Specific capacity (gal/min/ft)	Porosity or gravity drainage yield	Geologic unit	Reference
Seabrook	[2]SGW-89	Wells 1–4	1,300	500	—	4×10^{-4}	3.3	—	0.02	Kittery/Eliot	Earth Tech, Inc., 1998.
Seabrook	SGW-93	Well 5	560	492	—	4×10^{-4}	3.3	5	.02	Kittery/Eliot	Earth Tech, Inc., 1998.
North Hampton	NSW-76	Well 20	175	600	175	—	—	1.32	.02	Rye	Geosphere, Inc., 2003.
North Hampton	NSW-77	Well 21	200	600	440	—	—	.47	.02	Rye	Geosphere, Inc., 2003.
Rye	RYW-45	Bailey Brook	335	551	40	—	—	5.8	—	Rye	D.L. Maher, Inc., 1982.
Rye	RYW-51	Cedar Run	320	437	50	—	—	6	—	Rye	D.L. Maher, Inc., 1997b.
Stratham	*	Well 16	242	57	27	—	—	—	—	Kittery	D.L. Maher, Inc., 1997a.
North Hampton	NSW-78	Well 17	120	456	111 (80)[1]	—	—	[1]1.5	—	Kittery	D.L. Maher, Inc., 1996.
North Hampton	NSW-74	Well 18	150	600	109 (80)[1]	—	—	[1]1.9	—	Kittery	D.L. Maher, Inc., 1996.
North Hampton	NSW75	Well 19	220	435	133 (99)[1]	—	—	[1]2.2	—	Kittery	D.L. Maher, Inc., 1996.
Greenland	*	Assett 1	207	53	25	—	—	2.1	—	Kittery	Hydroterra Environmental, 2001.
Greenland	*	Assett 2	300	52	29	—	—	1.8	—	Kittery	Hydroterra Environmental, 2001.
Stratham	*	WM-1	42	400	69	—	—	.6	—	Kittery	Hydroterra Environmental, 2001.
Stratham	*	WM-2	43	400	54	—	—	.8	—	Kittery	Hydroterra Environmental, 2001.

[1] Estimated based on reported information.

[2] Wells 1, 3, and 4 are adjacent to SGW-89 (Well 2).



Streams and water bodies, including tidal and estuaries from 1:24,000
National Hydrography Dataset, 1999

Figure 4–3. Watershed drainage divides, tidal areas, and streamflow-gaging stations in the Seacoast model area, southeastern New Hampshire. (This figure is the same as figure 2 on page 5 in the report.)

west (Escamilla-Casas, 2003; Novotny, 1969). The pH of ground water withdrawn from the surficial aquifer is higher than water from other surficial aquifers (7 to 7.2) and indicates that some of the water in the surficial aquifer is likely to be supplied by the underlying bedrock aquifer (Raymond Talkington, Geosphere, Inc., oral commun., 2007) augmenting recharge directly on the aquifer. Thus, large ground-water withdrawals from the bedrock aquifer downgradient of the surficial aquifer probably are not supplied by recharge originating in the high-transmissivity surficial aquifer.

Lineaments were delineated in this area by Ferguson and others (1997a) and Geosphere, Inc. (2003). Most lineaments have a north-south orientation; however, several large lineaments, including a nearly 3-mi-long Landsat and 1-mi-long side-looking airborne radar (SLAR) lineament, were oriented in a northwest orientation along (or parallel to) a tributary to the Little River about 1,300 ft northeast of the well field. Several streams, including the Taylor River, Little River, and Bailey's Brook, have this same orientation (about N. 130 E.) and may represent a conjugate-fracture pattern orthogonal to the regional structure. Borehole and surface geophysical surveys conducted by Hager-Richter Geophysical, Inc. and reported by Geosphere, Inc., (2003) indicate that the predominant fracture orientation in the two wells is north-south and east-southeast, and that possible fracture zones also are oriented east-southeast. The east-west fractures at the site may intersect the large northwest-southeast trending lineaments (Geosphere, Inc., 2003). The specific capacities of wells 20 and 21 were calculated to be 1.32 and 0.47 gal/min/ft, with drawdowns of 175 and 440 ft, respectively, during an aquifer test of both wells (table 4–1) (Geosphere, Inc., 2003). A zero-drawdown distance was estimated to be 1,000 ft to the north, and 1,400 ft to the east. The porosity of the bedrock aquifer was assumed to be 2 percent. Withdrawals from this aquifer are distributed over the Aquarion Water Company system serving the towns of Hampton, North Hampton, and Rye.

Rye

High-yield bedrock aquifers have been identified in the town of Rye (Maher, 1982, 1997b). Lineament analysis indicated the presence of a possible fracture zone that may control the orientation of Berry's Brook (Maher, 1982). Lineaments along Berry's Brook (Ferguson and others, 1997b) and an unnamed tributary 3,000 ft south of the brook and south of Wallis Road both trend N. 50–70 E. in the direction of the regional structure. A 450-ft-deep bedrock well installed adjacent to Berry's Brook (RYW-52) with a reported yield of 150 gal/min was believed to be in a fault zone (Maher, 1982). Because the chloride concentration of the wells was 860 mg/L, it was suggested that the ground water may contain remnant saline water from the Pleistocene Epoch (Maher, 1982). The wells were not investigated further. A high-yield bedrock aquifer is also adjacent to Bailey Brook in Rye (Maher, 1997b). Bailey Brook well (RYW-45) and Cedar Run well (RYW-51, fig. 4–2), 920 ft southeast of the Bailey Brook well, both yield more than 300 gal/min with very little drawdown (about 50 ft) (table 4–1). This area is believed to be part of a broad northeast-trending fracture zone (Maher, 1997b). Borehole geophysical analysis (Johnson and others, 1999) identified northeast- and orthogonal northwest-trending fracture sets indicated in the lineament analyses of others. It is interesting to note that during drilling of the Bailey Brook well by high-pressure air-rotary methods, air bubbles were observed along the northwest-trending Bailey Brook (Gary Smith, Wright-Pierce, oral commun., 2004). The borehole analysis by Johnson and others (1999) also found the bedrock aquifer to be so highly fractured that the average radar-wave velocity approached values similar to those of an unconsolidated aquifer. Water-level monitoring at the Cedar Run well indicated very little interference—about 5 ft of drawdown—from withdrawals at the Bailey Brook well about 1,000 ft to the northwest. Withdrawals from this aquifer are distributed through the town of Rye's municipal water system.

Hampton/Stratham/Greenland

A high-yield bedrock aquifer is in an area surrounding the intersections of North Hampton, Stratham, and Greenland town lines in the Winnicut River watershed. This area, known as the Winnicut-Lovering Road (North Hampton) area, includes large withdrawal wells for the Aquarion Water Company. This area contains 3 overburden and 4 bedrock supply wells with combined yields of approximately 800 (overburden) and 700 (bedrock) gal/min, respectively. Ground-water levels in numerous residential wells in this area have been monitored since 1997 (Raymond Talkington, Geopshere, Inc., written commun., 2005). Well 16, the primary overburden well in this well field, is located in ice-contact glacial deposits of limited extent (fig. 4–1) that appear to follow a lineament identified by Ferguson and others (1997a) and Maher (1997a). Well 16 may be located in a trough in highly fractured Kittery Formation (Maher, 1997a). Three bedrock wells, 17, 18, and 19, were located 245 to 460 ft apart and had reported drillers yields of 175, 250, and 300 gal/min, respectively (Maher, 1997b). The total permitted pumping rate for this bedrock well field is 470 gal/min. Aquifer testing indicated that surficial and bedrock ground-water withdrawals at these wells most likely capture water discharging from the aquifer and do not induce infiltration from the Winnicut River (Maher, 1997a,b). Other nearby large ground-water withdrawals adjacent to the Winnicut River include ground water pumped seasonally for the Golf Club of New England (GCNE). Two sets of wells about 200 ft apart in Greenland (Assett 1 and 2), adjacent to the Winnicut River and in Stratham (MW-1 and MW-2), about 3,000 ft north of the Winnicut River were tested at a combined rate of 200 gal/min (Hydroterra Environmental Services, Inc., 2001). Aquifer tests at GCNE indicated that overburden aquifers (till and stratified drift, fig. 4–1) are well connected to the bedrock aquifer and that the Winnicut River may act as a hydraulic boundary limiting drawdowns in the bedrock aquifer (Hydroterra Environmental Services, Inc., 2001).

Greenland/Portsmouth/Newington

North of the Winnicut River watershed, the bedrock aquifer is not used for large ground-water withdrawals. Detailed characterizations of the bedrock hydraulic properties, however, have been conducted at the former Pease Air Force Base (PAFB) (Bechtel Environmental, Inc., 2000). Bedrock hydraulic conductivities vary from zero in unfractured rock to probably tens of feet per day in fractures. To determine bulk bedrock hydraulic properties, Bechtel Environmental Inc. (2000) conducted an aquifer test with three observation wells at least 450 ft from the pumped well, which is centrally located at PAFB near the contact between the Eliot and Kittery Formations. On the basis of this test, hydraulic conductivities of 2 to 15 ft/d and storage coefficients of 0.0002 and 0.0005 were calculated, and the bedrock aquifer was found to be hydraulically connected to a lower unconsolidated aquifer (Bechtel Environmental, Inc., 2000). At the northern area of the PAFB, hydraulic conductivity of 4 ft/d, storage of 2.6×10^{-4}, and a porosity[1] of 0.001 were estimated for the bedrock aquifer (Roy F. Weston, Inc., 1992).

[1] Because the reported porosity is from a hydraulic test, it is likely a percent volume associated with gravity drainage and not actual porosity.

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