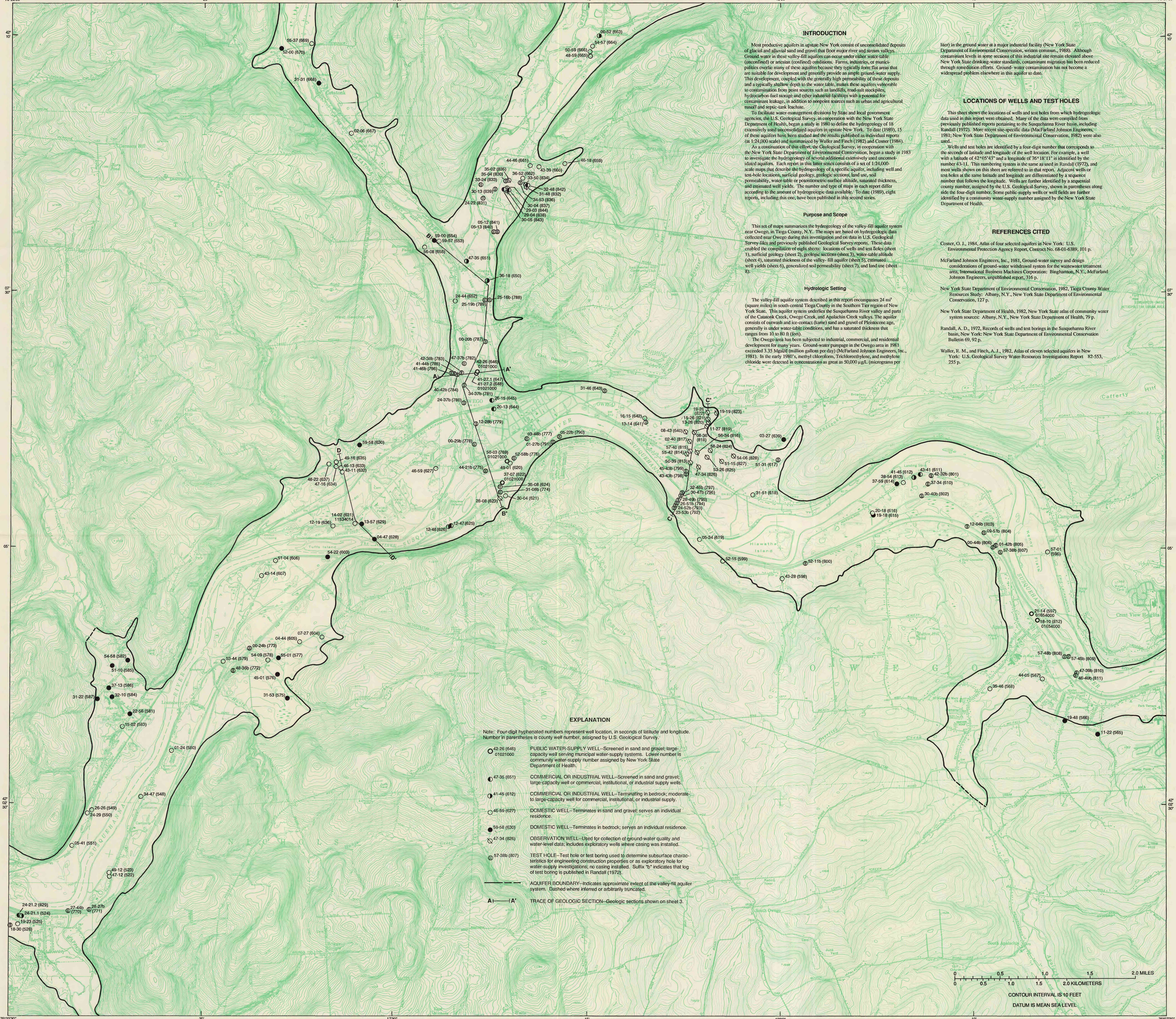

INTRODUCTION

Most productive aquifers in upstate New York consist of unconsolidated deposits of glacial and alluvial sand and gravel that floor major river and stream valleys. Ground water in these valley-fill aquifers can occur under either water-table (unconfined) or artesian (confined) conditions. Farms, industries, or municipalities overlie many of these aquifers because they typically form flat areas that are suitable for development and generally provide an ample ground-water supply. This development, coupled with the generally high permeability of these deposits and a typically shallow depth to the water table, makes these aquifers vulnerable to contamination from point sources such as landfills, road-salt stockpiles, hydrocarbon-fuel storage and other industrial facilities with a potential for contaminant leakage, in addition to nonpoint sources such as urban and agricultural runoff and septic-tank leachate.

To facilitate water-management decisions by State and local government agencies, the U.S. Geological Survey, in cooperation with the New York State Department of Health, began a study in 1980 to define the hydrogeology of 18 extensively used unconsolidated aquifers in upstate New York. To date (1989), 15 of these aquifers have been studied and the results published as individual reports (at 1:24,000 scale) and summarized by Waller and Finch (1982) and Cosner (1984).

As a continuation of this effort, the Geological Survey, in cooperation with the New York State Department of Environmental Conservation, began a study in 1983 to investigate the hydrogeology of several additional extensively used unconsolidated aquifers. Each report in this latter series consists of a set of 1:24,000-scale maps that describe the hydrogeology of a specific aquifer, including well and test-hole locations, surficial geology, geologic sections, land use, soil permeability, water-table or potentiometric-surface altitude, saturated thickness, and estimated well yields. The number and type of maps in each report differ according to the amount of hydrogeologic data available. To date (1989), eight reports, including this one, have been published in this second series.

Purpose and Scope

This set of maps summarizes the hydrogeology of the valley-fill aquifer system near Owego, in Tioga County, N.Y. The maps are based on hydrogeologic data collected near Owego during this investigation and on data in U.S. Geological Survey files and previously published Geological Survey reports. These data enabled the compilation of eight sheets: locations of wells and test holes (sheet 1), surficial geology (sheet 2), geologic sections (sheet 3), water-table altitude (sheet 4), saturated thickness of the valley- fill aquifer (sheet 5), estimated well yields (sheet 6), generalized soil permeability (sheet 7), and land use (sheet 8).

Hydrologic Setting

The valley-fill aquifer system described in this report encompasses 24 mi^2 (square miles) in south-central Tioga County in the Southern Tier region of New York State. This aquifer system underlies the Susquehanna River valley and parts of the Catatonk Creek, Owego Creek, and Apalachin Creek valleys. The aquifer consists of outwash and ice-contact (kame) sand and gravel of Pleistocene age, generally is under water-table conditions, and has a saturated thickness that ranges from 10 to 80 ft (feet).

The Owego area has been subjected to industrial, commercial, and residential development for many years. Ground-water pumpage in the Owego area in 1981 exceeded 3.35 Mgal/d (million gallons per day) (McFarland Johnson Engineers, Inc., 1981). In the early 1980's, methyl chloroform, Trichloroethylene, and methylene chloride were detected in concentrations as great as 50,000 µg/L (micrograms per liter) in the ground water at a major industrial facility (New York State Department of Enviromental Conservation, written commun., 1988). Although contaminant levels in some sections of this industrial site remain elevated above New York State drinking-water standards, contaminant migration has been reduced through remediation efforts. Ground- water contamination has not become a widespread problem elsewhere in this aquifer to date.

LOCATIONS OF WELLS AND TEST HOLES

This sheet shows the locations of wells and test holes from which hydrogeologic data used in this report were obtained. Many of the data were compiled from previously published reports pertaining to the Susquehanna River basin, including Randall (1972). More recent site-specific data (MacFarland Johnson Engineers, 1981; New York State Department of Environmental Conservation, 1982) were also used.

Wells and test holes are identified by a four-digit number that corresponds to the seconds of latitude and longitude of the well location. For example, a well with a latitude of 42°05'43" and a longitude of 76°18'11" is identified by the number 43-11. This numbering system is the same as used in Randall (1972), and most wells shown on this sheet are referred to in that report. Adjacent wells or test holes at the same latitude and longitude are differentiated by a sequence number that follows the longitude. Wells are further identified by a sequential county number, assigned by the U.S. Geological Survey, shown in parentheses along side the four-digit number. Some public-supply wells or well fields are further identified by a community water-supply number assigned by the New York State Department of Health.

REFERENCES CITED

Cosner, O. J., 1984, Atlas of four selected aquifers in New York: U.S. Environmental Protection Agency Report, Contract No. 68-01-6389, 101 p.

McFarland Johnson Engineers, Inc., 1981, Ground-water survey and design considerations of ground-water withdrawal system for the wastewater treatment area, International Business Machines Corporation: Binghamton, N.Y., McFarland Johnson Engineers, unpublished report, 316 p.

New York State Department of Environmental Conservation, 1982, Tioga County Water Resources Study: Albany, N.Y., New York State Department of Environmental Conservation, 127 p.

New York State Department of Health, 1982, New York State atlas of community water system sources: Albany, N.Y., New York State Department of Health, 79 p.

Randall, A. D., 1972, Records of wells and test borings in the Susquehanna River basin, New York: New York State Department of Environmental Conservation Bulletin 69, 92 p.

Waller, R. M., and Finch, A. J., 1982, Atlas of eleven selected aquifers in New York: U.S. Geological Survey Water-Resources Investigations Report 82-553, 255 p.

EXPLANATION

Note: Four-digit hyphenated numbers represent well location, in seconds of latitude and longitude. Number in parentheses is county well number, assigned by U.S. Geological Survey.

42-26 (646) 01021000	PUBLIC WATER-SUPPLY WELL--Screened in sand and gravel; large-capacity well serving municipal water-supply systems. Lower number is community water-supply number assigned by New York State Department of Health.
47-35 (651)	COMMERCIAL OR INDUSTRIAL WELL--Screened in sand and gravel; large-capacity well or commercial, institutional, or industrial supply wells.
41-45 (612)	COMMERCIAL OR INDUSTRIAL WELL--Terminating in bedrock; moderate- to large-capacity well for commercial, institutional, or industrial supply.
46-59 (627)	DOMESTIC WELL--Terminates in sand and gravel; serves an individual residence.
59-58 (630)	DOMESTIC WELL--Terminates in bedrock; serves an individual residence.
47-34 (826)	OBSERVATION WELL--Used for collection of ground-water quality and water-level data; includes exploratory wells where casing was installed.
57-38b (807)	TEST HOLE--Test hole or test boring used to determine subsurface characteristics for engineering construction properties or as exploratory hole for water-supply investigations; no casing installed. Suffix "b" indicates that log of test boring is published in Randall (1972).
	AQUIFER BOUNDARY--Indicates approximate extent of the valley-fill aquifer system. Dashed where inferred or arbitrarily truncated.
A—A'	TRACE OF GEOLOGIC SECTION--Geologic sections shown on sheet 3.

Base from New York State Department of Transportation, Apalachin, Candor, Newark Valley, Owego, NY, 1973, 1:24,000

Hydrogeology by R. J. Reynolds and J. D. Garry, 1988

HYDROGEOLOGY OF THE VALLEY-FILL AQUIFER AT OWEGO, TIOGA COUNTY, NEW YORK

By

Richard J. Reynolds and James D. Garry

Sheet 1. Location of Wells and Test Holes

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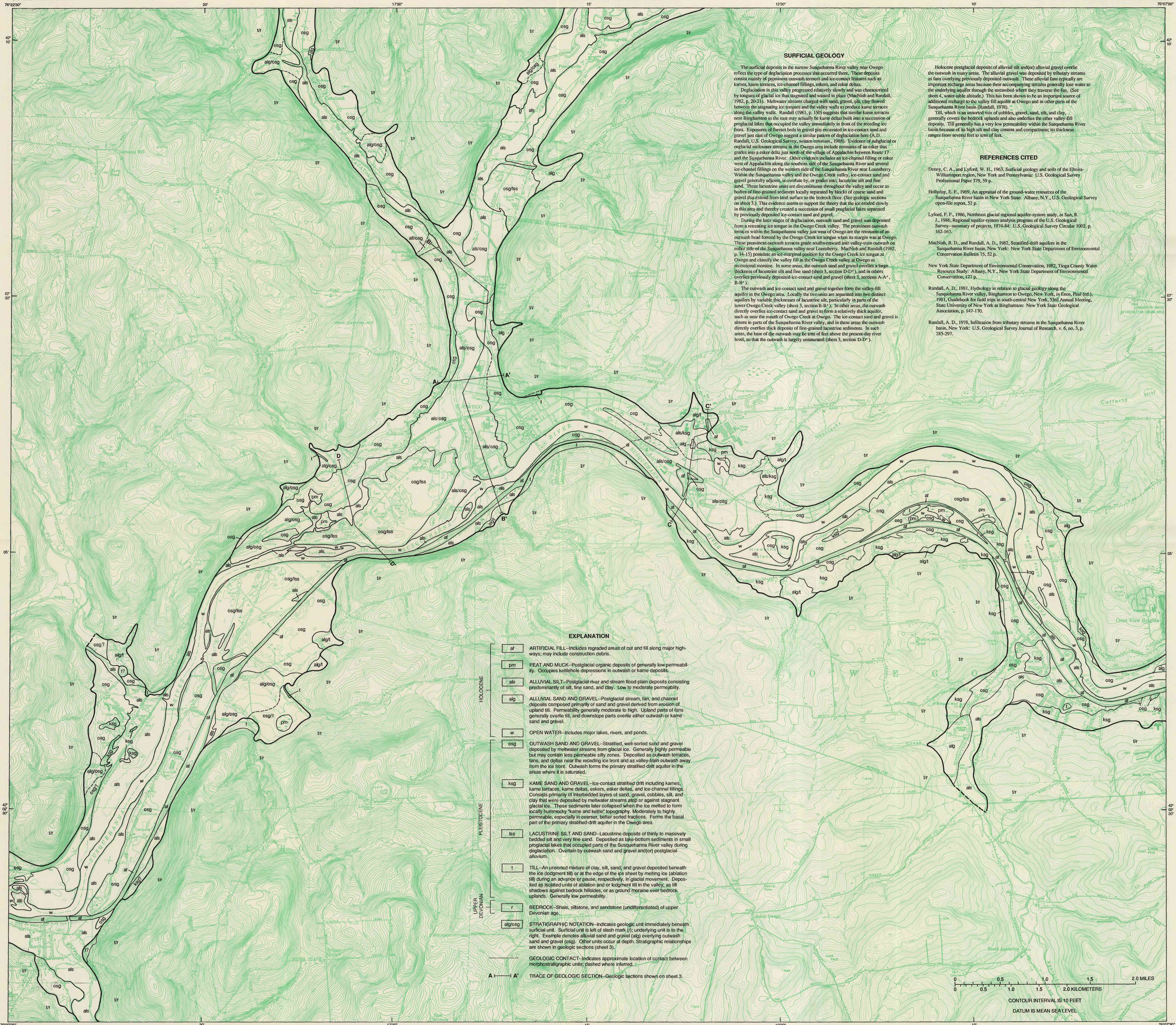

SURFICIAL GEOLOGY

The surficial deposits in the narrow Susquehanna River valley near Owego reflect the type of deglaciation processes that occurred there. These deposits consist mainly of prominent outwash terraces and ice-contact features such as kames, kame terraces, ice-channel fillings, eskers, and esker deltas.

Deglaciation in this valley progressed relatively slowly and was characterized by tongues of glacial ice that stagnated and wasted in place (MacNish and Randall, 1982, p. 20-21). Meltwater streams charged with sand, gravel, silt, clay flowed between the stagnating ice tongues and the valley walls to produce kame terraces along the valley walls. Randall (1981, p. 150) suggests that similar kame terraces near Binghamton to the east may actually be kame deltas built into a succession of proglacial lakes that occupied the valley immediately in front of the receding ice front. Exposures of foreset beds in gravel pits excavated in ice-contact sand and gravel just east of Owego suggest a similar pattern of deglaciation here (A.D. Randall, U.S. Geological Survey, written commun., 1988). Evidence of subglacial or englacial meltwater streams in the Owego area include remnants of an esker that grades into a esker delta just north of the village of Appalachin between Route 17 and the Susquehanna River. Other evidence includes an ice-channel filling or esker west of Appalachin along the southern side of the Susquehanna River and several ice-channel fillings on the western side of the Susquehanna River near Lounsberry. Within the Susquehanna valley and the Owego Creek valley, ice-contact sand and gravel generally adjoins, is overlain by, or grades into, lacustrine silt and fine sand. These lacustrine units are discontinuous throughout the valley and occur as bodies of fine-grained sediment locally separated by blocks of coarse sand and gravel that extend from land surface to the bedrock floor. (See geologic sections on sheet 3.) This evidence seems to support the theory that the ice eroded slowly in this area and thereby created a succession of small proglacial lakes separated by previously deposited ice-contact sand and gravel.

During the later stages of deglaciation, outwash sand and gravel was deposited from a retreating ice tongue in the Owego Creek valley. The prominent outwash terraces within the Susquehanna valley just west of Owego are the remnants of an outwash head formed by the Owego Creek ice tongue when its margin was at Owego. These prominent outwash terraces grade southwestward into valley-train outwash on either side of the Susquehanna valley near Lounsberry. MacNish and Randall (1982, p. 14-15) postulate an ice-marginal position for the Owego Creek ice tongue at Owego and classify the valley fill in the Owego Creek valley at Owego as recessional moraine. In some areas, the outwash sand and gravel overlies a large thickness of lacustrine silt and fine sand (sheet 3, section D-D′), and in others overlies previously deposited ice-contact sand and gravel (sheet 3, sections A-A′, B-B′).

The outwash and ice-contact sand and gravel together form the valley-fill aquifer in the Owego area. Locally the two units are separated into two distinct aquifers by variable thicknesses of lacustrine silt, particularly in parts of the lower Owego Creek valley (sheet 3, section B-B′). In other areas, the outwash directly overlies ice-contact sand and gravel to form a relatively thick aquifer, such as near the mouth of Owego Creek at Owego. The ice-contact sand and gravel is absent in parts of the Susquehanna River valley, and in these areas the outwash directly overlies thick deposits of fine-grained lacustrine sediments. In such areas, the base of the outwash may be tens of feet above the present-day river level, so that the outwash is largely unsaturated (sheet 3, section D-D′).

Holocene postglacial deposits of alluvial silt and(or) alluvial gravel overlie the outwash in many areas. The alluvial gravel was deposited by tributary streams as fans overlying previously deposited outwash. These alluvial fans typically are important recharge areas because their accompanying streams generally lose water to the underlying aquifer through the streambed where they traverse the fan. (See sheet 4, water-table altitude.) This has been shown to be an important source of additional recharge to the valley fill aquifer at Owego and in other parts of the Susquehanna River basin (Randall, 1978).

Till, which is an unsorted mix of cobbles, gravel, sand, silt, and clay, generally covers the bedrock uplands and also underlies the other valley-fill deposits. Till generally has a very low permeability within the Susquehanna River basin because of its high silt and clay content and compactness; its thickness ranges from several feet to tens of feet.

REFERENCES CITED

Denny, C. A., and Lyford, W. H., 1963, Surficial geology and soils of the Elmira-Williamsport region, New York and Pennsylvania: U.S. Geological Survey Professional Paper 379, 59 p.

Hollyday, E. F., 1969, An appraisal of the ground-water resources of the Susquehanna River basin in New York State: Albany, N.Y., U.S. Geological Survey open-file report, 52 p.

Lyford, F. P., 1986, Northeast glacial regional aquifer-system study, *in* Sun, R. J., 1986, Regional squifer-system analysis program of the U.S. Geological Survey--summary of projects, 1974-84: U.S. Geological Survey Circular 1002, p. 162-167.

MacNish, R. D., and Randall, A. D., 1982, Stratified-drift aquifers in the Susquehanna River basin, New York: New York State Department of Environmental Conservation Bulletin 75, 52 p.

New York State Department of Environmental Conservation, 1982, Tioga County Water Resource Study: Albany, N.Y., New York State Department of Environmental Conservation, 127 p.

Randall, A. D., 1981, Hydrology in relation to glacial geology along the Susquehanna River valley, Binghamton to Owego, New York, *in* Enos, Paul (ed.), 1981, Guidebook for field trips in south-central New York, 53rd Annual Meeting, State University of New York at Binghamton: New York State Geological Association, p. 147-170.

Randall, A. D., 1978, Infiltration from tributary streams in the Susquehanna River basin, New York: U.S. Geological Survey Journal of Research, v. 6, no. 3, p. 285-297.

EXPLANATION

HOLOCENE

af — ARTIFICIAL FILL--Includes regraded areas of cut and fill along major highways; may include construction debris.

pm — PEAT AND MUCK--Postglacial organic deposits of generally low permeability. Occupies kettlehole depressions in outwash or kame deposits.

als — ALLUVIAL SILT--Postglacial river and stream flood-plain deposits consisting predominantly of silt, fine sand, and clay. Low to moderate permeabiity.

alg — ALLUVIAL SAND AND GRAVEL--Postglacial stream, fan, and channel deposits composed primarily of sand and gravel derived from erosion of upland till. Permeability generally moderate to high. Upland parts of fans generally overlie till, and downslope parts overlie either outwash or kame sand and gravel.

w — OPEN WATER--Includes major lakes, rivers, and ponds.

PLEISTOCENE

osg — OUTWASH SAND AND GRAVEL--Stratified, well-sorted sand and gravel deposited by meltwater streams from glacial ice. Generally highly permeable but may contain less permeable silty zones. Deposited as outwash terraces, fans, and deltas near the receding ice front and as valley-train outwash away from the ice front. Outwash forms the primary stratified-drift aquifer in the areas where it is saturated.

ksg — KAME SAND AND GRAVEL--Ice-contact stratified drift including kames, kame terraces, kame deltas, eskers, esker deltas, and ice-channel fillings. Consists primarily of interbedded layers of sand, gravel, cobbles, silt, and clay that were deposited by meltwater streams atop or against stagnant glacial ice. These sediments later collapsed when the ice melted to form locally hummocky "kame and kettle" topography. Moderately to highly permeable, especially in coarser, better sorted fractions. Forms the basal part of the primary stratified-drift aquifer in the Owego area.

lss — LACUSTRINE SILT AND SAND--Lacustrine deposits of thinly to massively bedded silt and very fine sand. Deposited as lake-bottom sediments in small proglacial lakes that occupied parts of the Susquehanna River valley during deglaciation. Overlain by outwash sand and gravel and(or) postglacial alluvium.

t — TILL--An unsorted mixture of clay, silt, sand, and gravel deposited beneath the ice (lodgment till) or at the edge of the ice sheet by melting ice (ablation till) during an advance or pause, respectively, in glacial movement. Deposited as isolated units of ablation and or lodgment till in the valley, as till shadows against bedrock hillsides, or as ground moraine over bedrock uplands. Generally low permeability.

UPPER DEVONIAN

r — BEDROCK--Shale, siltstone, and sandstone (undifferentiated) of upper Devonian age.

alg/osg — STRATIGRAPHIC NOTATION--Indicates geologic unit immediately beneath surficial unit. Surficial unit is left of slash mark (/); underlying unit is to the right. Example denotes alluvial sand and gravel (alg) overlying outwash sand and gravel (osg). Other units occur at depth. Stratigraphic relationships are shown in geologic sections (sheet 3).

GEOLOGIC CONTACT--Indicates approximate location of contact between morphostratigraphic units; dashed where inferred.

A —— A′ TRACE OF GEOLOGIC SECTION--Geologic sections shown on sheet 3.

0 0.5 1.0 1.5 2.0 MILES
0 0.5 1.0 1.5 2.0 KILOMETERS

CONTOUR INTERVAL IS 10 FEET

DATUM IS MEAN SEA LEVEL

Base from New York State Department of Transportation, Apalachin, Candor, Newark Valley, Owego, NY, 1973, 1:24,000

Surficial geology modified from Denny and Lyford, 1963; Randall, 1981; and Randall (unpublished field maps), 1966; by R. J. Reynolds, 1988

HYDROGEOLOGY OF THE VALLEY-FILL AQUIFER AT OWEGO, TIOGA COUNTY, NEW YORK

By

Richard J. Reynolds and James D. Garry

Sheet 2. Surficial Geology

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GEOLOGIC SECTIONS

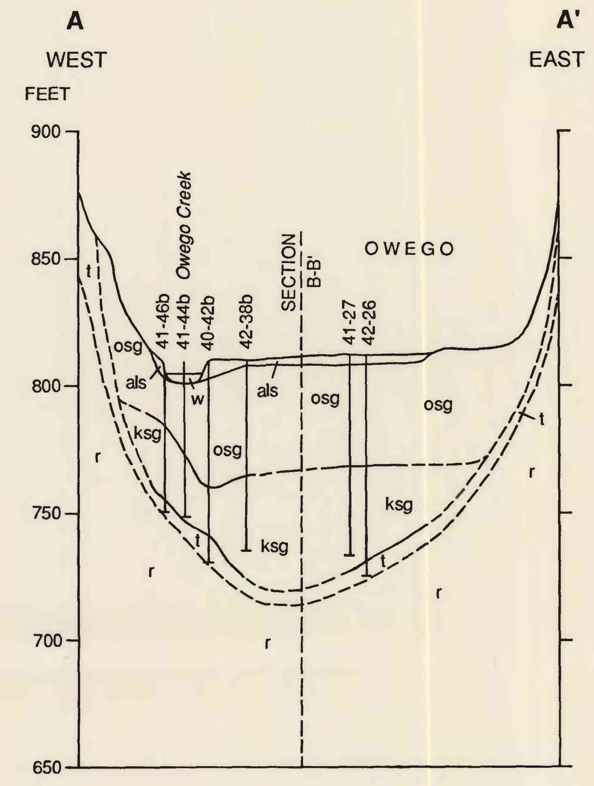
Hydrogeologic data obtained from drillers' logs, logs of test holes, consultant's reports, and published reports of the U.S. Geologic Survey were used to construct four geologic sections showing the thickness of aquifer material and the stratigraphic relations among the various types of valley-fill deposits in the Owego area. The geologic sections are presented at a horizontal scale of 1:12,000; their traces are shown on sheets 1 and 2. For clarity, many of the smaller lithologic units are combined and represented as a single geologic unit.

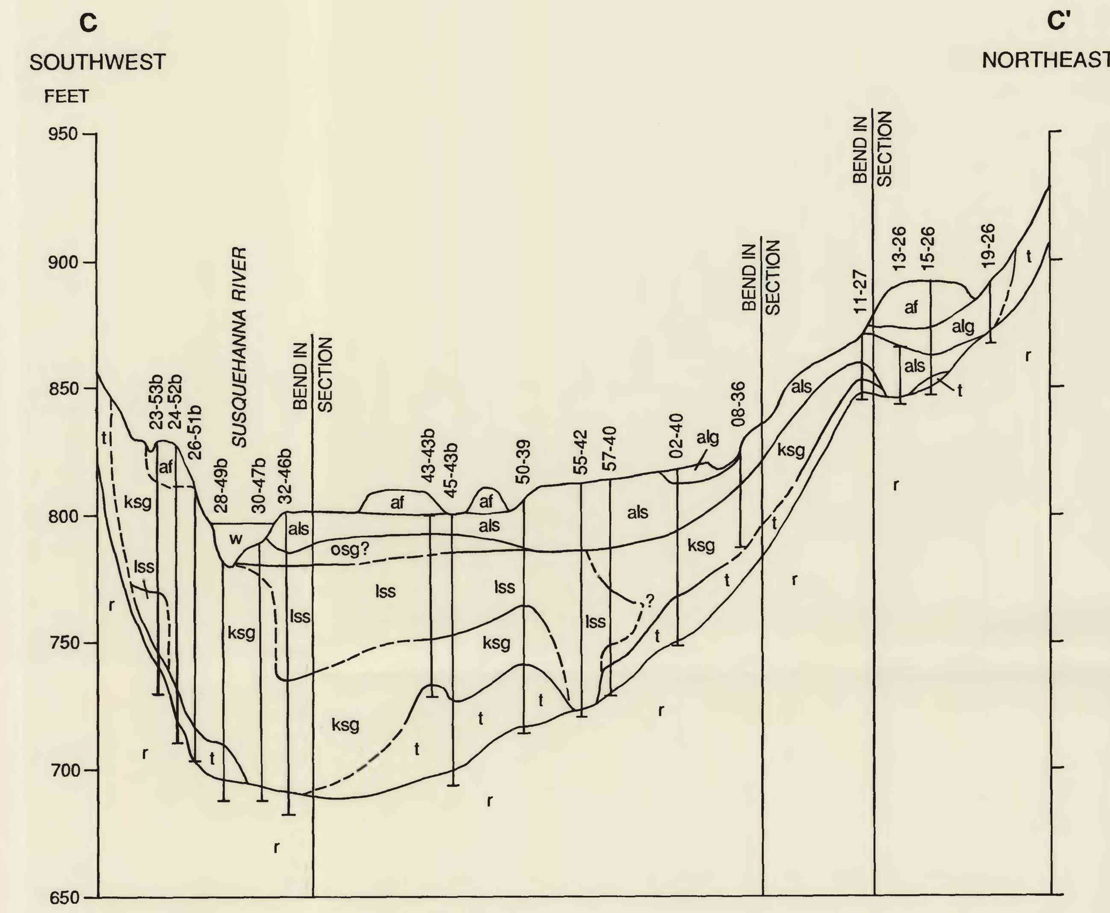
Section A-A′, across the Owego Creek valley at Owego, shows approximately 45 ft of outwash sand and gravel overlying an equal thickness of ice-contact sand and gravel. Both wells of the Owego Water Works (41-27 and 42-26) are screened in the more permeable zones of the kame sand and gravel. The saturated thickness of the sand and gravel aquifer here is approximately 65 ft.

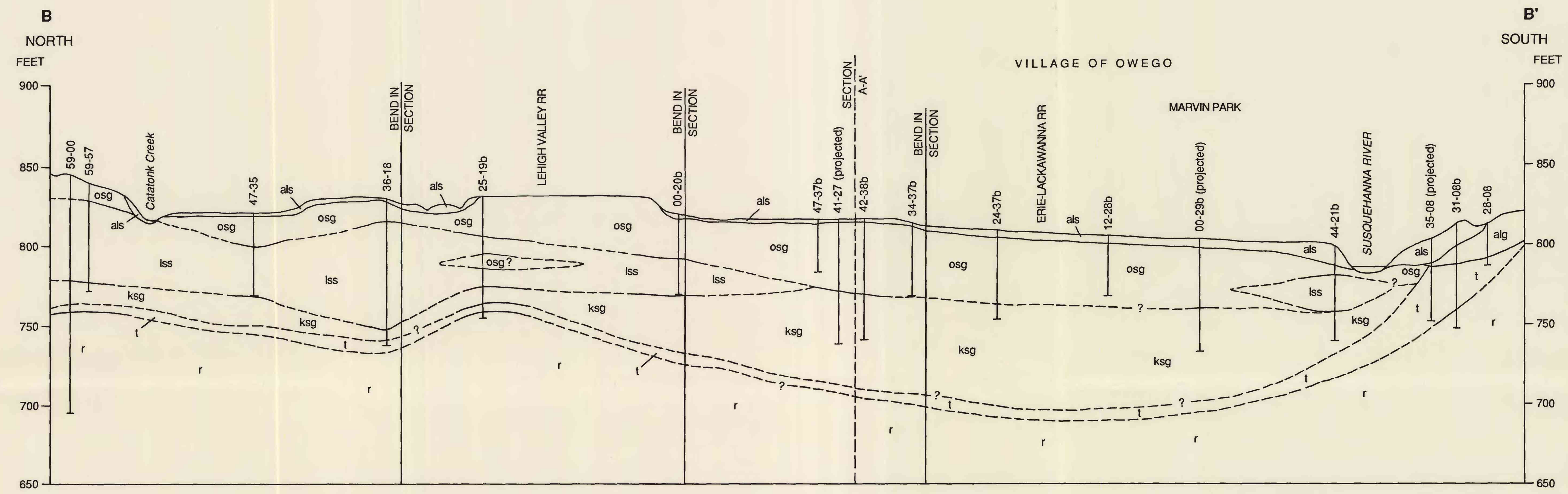
Section B-B′ extends from the mouth of Catatonk Creek, along Owego Creek and across the Susquehanna River valley. The northern half of the section shows that the outwash sand and gravel aquifer is separated from the underlying kame sand and gravel by a lacustrine silt and sand unit. This lacustrine unit thins southward and pinches out in the vicinity of test boring 47-37b, so that south of this area, the outwash directly overlies the kame sand and gravel unit to form a single aquifer with a saturated thickness of at least 80 ft. Near the Susquehanna River, the two sand and gravel units are again separated by another fine-grained lacustrine unit approximately 25 ft thick.

Section C-C′, which crosses the Susquehanna River valley near Barnes Creek, indicates a more complex stratigraphy. A relatively thick unit of kame sand and gravel underlies most of the valley floor, and overlying this unit is a body of lacustrine silt and fine sand that extends from the Susquehanna River to the north valley wall. This lacustrine unit, which locally is as much as 60 feet thick along the section line, is overlain by thin outwash sand and gravel along the river. Overlying this outwash is Holocene postglacial alluvial silt and fine sand of variable thickness, deposited by the Susquehanna River and its nearby tributary streams. Data from test holes indicate that a considerable thickness of till underlies this entire stratigraphic sequence but is discontinous and highly variable in thickness.

Section D-D′, which traverses the Susquehanna River valley of west of Owego, shows that the outwash terraces in the center of the valley are underlain by as much as 140 ft of lacustrine silt and very fine sand. Because these outwash terraces are as much as 45 ft above the present river level in this area, the outwash is largely unsaturated or only thinly saturated.







EXPLANATION

HOLOCENE

- w — WATER--Major rivers shown in section.
- af — ARTIFICIAL FILL--Includes areas of cut and fill, construction debris.
- pm — PEAT, MUCK, SILT, CLAY--Bog deposits of postglacial age.
- als — ALLUVIAL SILT--Flood-plain deposits of postglacial age; predominantly silt and fine sand.
- alg — ALLUVIAL SAND AND GRAVEL--Stream, fan, channel, and terrace sand and gravel deposits of postglacial age.

PLEISTOCENE

- osg — OUTWASH SAND AND GRAVEL--Stratified, well-sorted glaciofluvial sand and gravel.
- ksg — KAME SAND AND GRAVEL--Ice-contact deposits of sand and gravel kames, kame terraces, kame deltas, eskers, and esker deltas.
- lss — LACUSTRINE SILT AND SAND--Lacustrine bottom deposits of proglacial lakes, thinly bedded to massive silt and very fine sand.
- t — TILL--Ablation or lodgment till; a poorly sorted mixture of sand, gravel, silt, and clay.

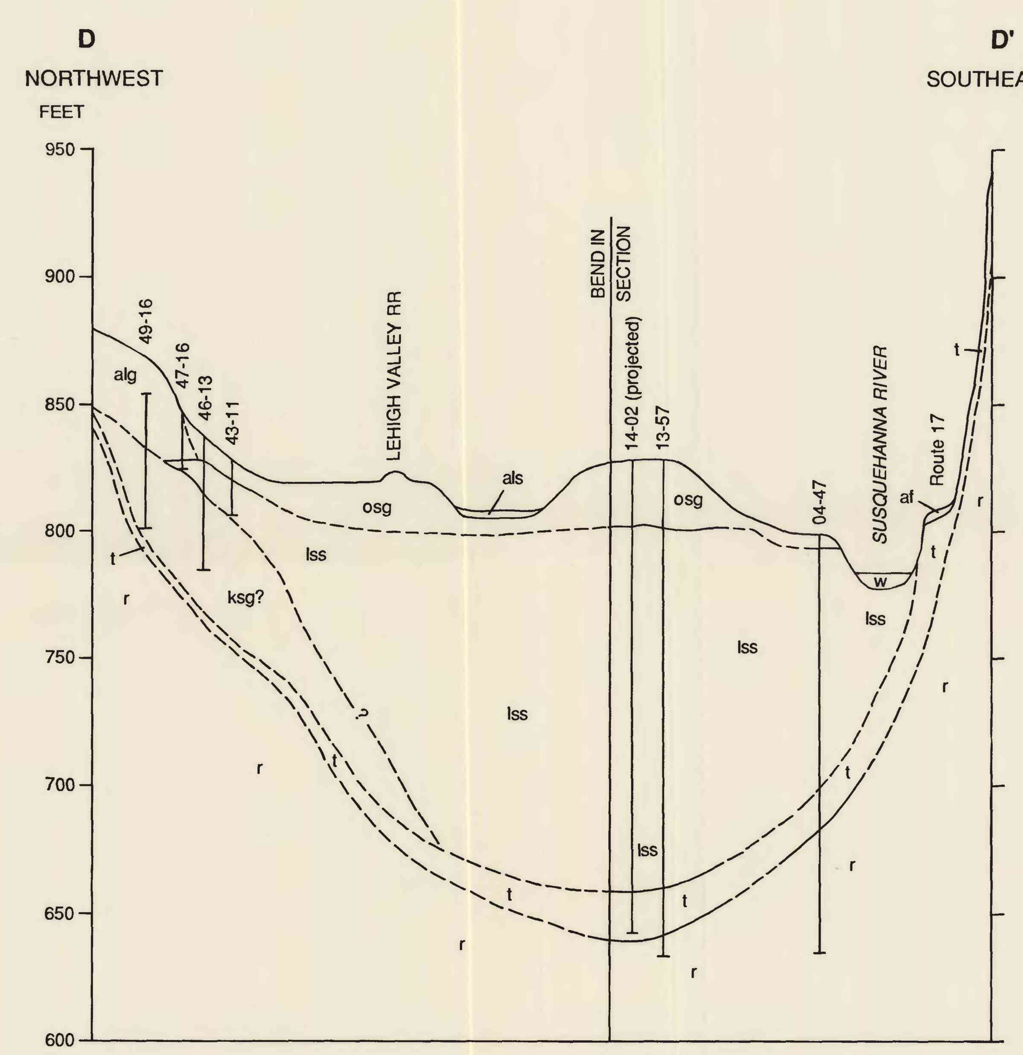
UPPER DEVONIAN

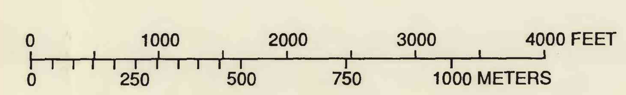
- r — BEDROCK--Shale, siltstone, and sandstone (undifferentiated) of upper Devonian age.

GEOLOGIC CONTACT--Approximately located; dashed where inferred.

43-11 — WELL--From which geologic information was obtained.

32-46b — TEST BORING--Boring or exploratory well from which geologic information was obtained. Hyphenated number is well number, representing seconds of latitude and longitude. Suffix "b" indicates test boring.





VERTICAL EXAGGERATION X 20

DATUM IS MEAN SEA LEVEL

TRACES OF SECTIONS SHOWN ON SHEETS 1 AND 2

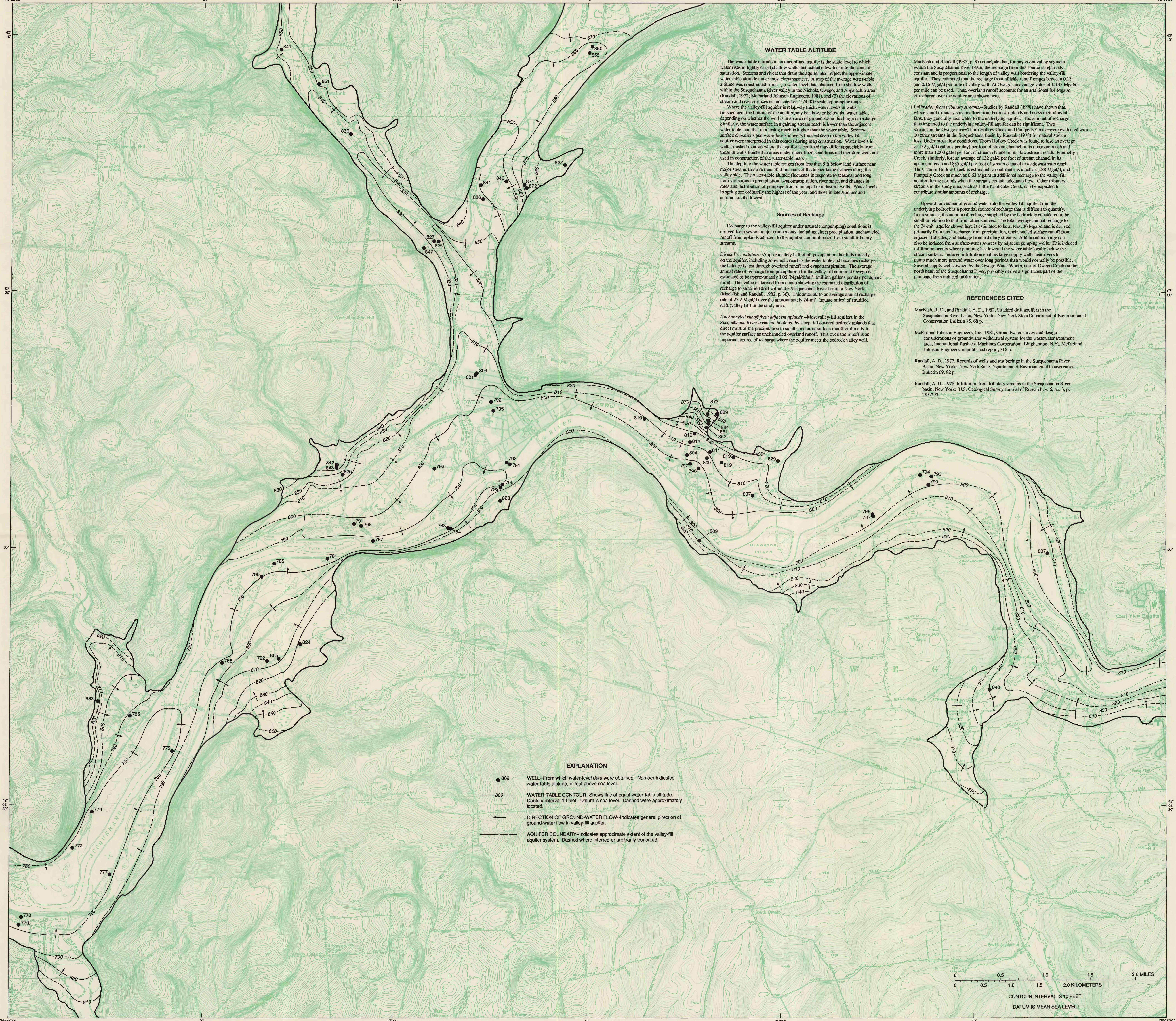
Hydrogeology by R. J. Reynolds, 1988

HYDROGEOLOGY OF THE VALLEY-FILL AQUIFER AT OWEGO, TIOGA COUNTY, NEW YORK

By

Richard J. Reynolds and James D. Garry

Sheet 3. Geologic Sections



WATER TABLE ALTITUDE

The water-table altitude in an unconfined aquifer is the static level to which water rises in tightly cased shallow wells that extend a few feet into the zone of saturation. Streams and rivers that drain the aquifer also reflect the approximate water-table altitude under most circumstances. A map of the average water-table altitude was constructed from: (1) water-level data obtained from shallow wells within the Susquehanna River valley in the Nichols, Owego, and Appalachin area (Randall, 1972; McFarland Johnson Engineers, 1981), and (2) the elevations of stream and river surfaces as indicated on 1:24,000-scale topographic maps.

Where the valley-fill aquifer is relatively thick, water levels in wells finished near the bottom of the aquifer may be above or below the water table, depending on whether the well is in an area of ground-water discharge or recharge. Similarly, the water surface in a gaining stream reach is lower than the adjacent water table, and that in a losing reach is higher than the water table. Stream-surface elevations and water levels in wells finished deep in the valley-fill aquifer were interpreted in this context during map construction. Water levels in wells finished in areas where the aquifer is confined may differ appreciably from those in wells finished in areas under unconfined conditions and therefore were not used in construction of the water-table map.

The depth to the water table ranges from less than 5 ft below land surface near major streams to more than 50 ft on some of the higher kame terraces along the valley side. The water-table altitude fluctuates in response to seasonal and long-term variations in precipitation, evapotranspiration, river stage, and changes in rates and distribution of pumpage from municipal or industrial wells. Water levels in spring are ordinarily the highest of the year, and those in late summer and autumn are the lowest.

Sources of Recharge

Recharge to the valley-fill aquifer under natural (nonpumping) conditions is derived from several major components, including direct precipitation, unchanneled runoff from uplands adjacent to the aquifer, and infiltration from small tributary streams.

Direct Precipitation.--Approximately half of all precipitation that falls directly on the aquifer, including snowmelt, reaches the water table and becomes recharge; the balance is lost through overland runoff and evapotranspiration. The average annual rate of recharge from precipitation for the valley-fill aquifer at Owego is estimated to be approximately 1.05 (Mgal/d)/mi^2 (million gallons per day per square mile). This value is derived from a map showing the estimated distribution of recharge to stratified drift within the Susquehanna River basin in New York (MacNish and Randall, 1982, p. 36). This amounts to an average annual recharge rate of 25.2 Mgal/d over the approximately 24-mi^2 (square miles) of stratified drift (valley fill) in the study area.

Unchanneled runoff from adjacent uplands.--Most valley-fill aquifers in the Susquehanna River basin are bordered by steep, till-covered bedrock uplands that direct most of the precipitation to small streams as surface runoff or directly to the aquifer surface as unchanneled overland runoff. This overland runoff is an important source of recharge where the aquifer meets the bedrock valley wall. MacNish and Randall (1982, p. 37) conclude that, for any given valley segment within the Susquehanna River basin, the recharge from this source is relatively constant and is proportional to the length of valley wall bordering the valley-fill aquifer. They estimated that the recharge from hillside runoff ranges between 0.13 and 0.16 Mgal/d per mile of valley wall. At Owego, an average value of 0.145 Mgal/d per mile can be used. Thus, overland runoff accounts for an additional 8.4 Mgal/d of recharge over the aquifer area shown here.

Infiltration from tributary streams.--Studies by Randall (1978) have shown that, where small tributary streams flow from bedrock uplands and cross their alluvial fans, they generally lose water to the underlying aquifer. The amount of recharge thus imparted to the underlying valley-fill aquifer can be significant. Two streams in the Owego area--Thorn Hollow Creek and Pumpelly Creek--were evaluated with 10 other streams in the Susquehanna Basin by Randall (1978) for natural stream loss. Under most flow conditions, Thorn Hollow Creek was found to lose an average of 132 gal/d (gallons per day) per foot of stream channel in its upstream reach and more than 1,000 gal/d per foot of stream channel in its downstream reach. Pumpelly Creek, similarly, lost an average of 132 gal/d per foot of stream channel in its upstream reach and 835 gal/d per foot of stream channel in its downstream reach. Thus, Thorn Hollow Creek is estimated to contribute as much as 1.88 Mgal/d, and Pumpelly Creek as much as 0.63 Mgal/d in additional recharge to the valley-fill aquifer during periods when the streams contain adequate flow. Other tributary streams in the study area, such as Little Nanticoke Creek, can be expected to contribute similar amounts of recharge.

Upward movement of ground water into the valley-fill aquifer from the underlying bedrock is a potential source of recharge that is difficult to quantify. In most areas, the amount of recharge supplied by the bedrock is considered to be small in relation to that from other sources. The total average annual recharge to the 24-mi^2 aquifer shown here is estimated to be at least 36 Mgal/d and is derived primarily from areal recharge from precipitation, unchanneled surface runoff from adjacent hillsides, and leakage from tributary streams. Additional recharge can also be induced from surface-water sources by adjacent pumping wells. This induced infiltration occurs where pumping has lowered the water table locally below the stream surface. Induced infiltration enables large supply wells near rivers to pump much more ground water over long periods than would normally be possible. Several supply wells owned by the Owego Water Works, east of Owego Creek on the north bank of the Susquehanna River, probably derive a significant part of their pumpage from induced infiltration.

REFERENCES CITED

MacNish, R. D., and Randall, A. D., 1982, Stratifed drift aquifers in the Susquehanna River basin, New York: New York State Department of Environmental Conservation Bulletin 75, 68 p.

McFarland Johnson Engineers, Inc., 1981, Groundwater survey and design considerations of groundwater withdrawal system for the wastewater treatment area, International Business Machines Corporation: Binghamton, N.Y., McFarland Johnson Engineers, unpublished report, 316 p.

Randall, A. D., 1972, Records of wells and test borings in the Susquehanna River Basin, New York: New York State Department of Environmental Conservation Bulletin 69, 92 p.

Randall, A. D., 1978, Infiltration from tributary streams in the Susquehanna River basin, New York: U.S. Geological Survey Journal of Research, v. 6, no. 3, p. 285-297.

EXPLANATION

- ● 809 — WELL--From which water-level data were obtained. Number indicates water-table altitude, in feet above sea level.
- —— 800 - - — WATER-TABLE CONTOUR--Shows line of equal water-table altitude. Contour interval 10 feet. Datum is sea level. Dashed were approximately located.
- ← — DIRECTION OF GROUND-WATER FLOW--Indicates general direction of ground-water flow in valley-fill aquifer.
- ▬▬ ▬ ▬ — AQUIFER BOUNDARY--Indicates approximate extent of the valley-fill aquifer system. Dashed where inferred or arbitrarily truncated.

Base from New York State Department of Transportation, Apalachin, Candor, Newark Valley, Owego, NY, 1973, 1:24,000

HYDROGEOLOGY OF THE VALLEY-FILL AQUIFER AT OWEGO, TIOGA COUNTY, NEW YORK

By

Richard J. Reynolds and James D. Garry

Sheet 4. Altitude of the Water Table

Hydrology by R. J. Reynolds and J. D. Garry, 1988

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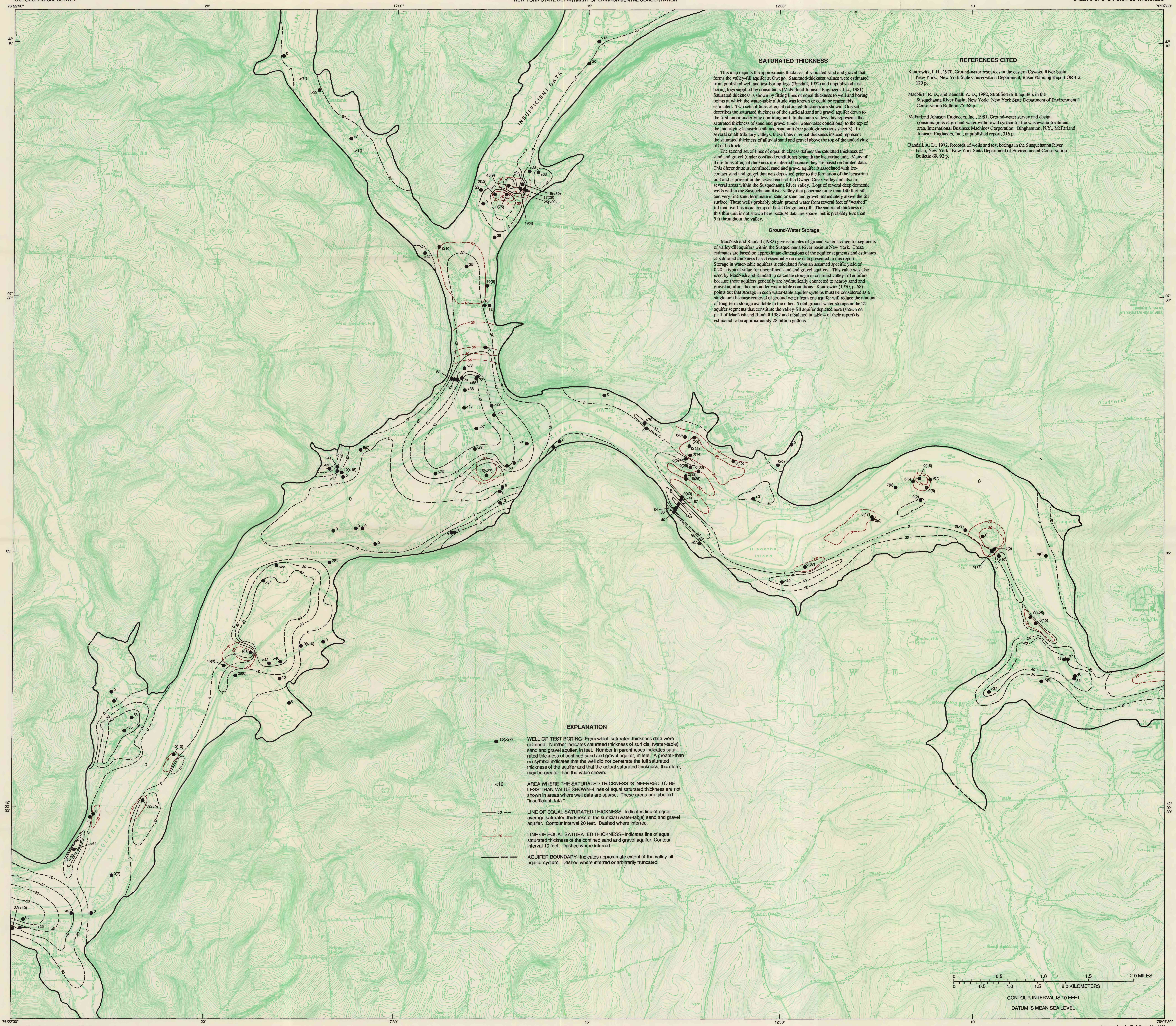

SATURATED THICKNESS

This map depicts the approximate thickness of saturated sand and gravel that forms the valley-fill aquifer at Owego. Saturated-thickness values were estimated from published well and test-boring logs (Randall, 1972) and unpublished test-boring logs supplied by consultants (McFarland Johnson Engineers, Inc., 1981). Saturated thickness is shown by fitting lines of equal thickness to well and boring points at which the water-table altitude was known or could be reasonably estimated. Two sets of lines of equal saturated thickness are shown. One set describes the saturated thickness of the surficial sand and gravel aquifer down to the first major underlying confining unit. In the main valleys this represents the saturated thickness of sand and gravel (under water-table conditions) to the top of the underlying lacustrine silt and sand unit (see geologic sections sheet 3). In several small tributary valleys, these lines of equal thickness instead represent the saturated thickness of alluvial sand and gravel above the top of the underlying till or bedrock.

The second set of lines of equal thickness defines the saturated thickness of sand and gravel (under confined conditions) beneath the lacustrine unit. Many of these lines of equal thickness are inferred because they are based on limited data. This discontinuous, confined, sand and gravel aquifer is associated with ice-contact sand and gravel that was deposited prior to the formation of the lacustrine unit and is present in the lower reach of the Owego Creek valley and also in several areas within the Susquehanna River valley. Logs of several deep domestic wells within the Susquehanna River valley that penetrate more than 140 ft of silt and very fine sand terminate in sand or sand and gravel immediately above the till surface. These wells probably obtain ground water from several feet of "washed" till that overlies more compact basal (lodgment) till. The saturated thickness of this thin unit is not shown here because data are sparse, but is probably less than 5 ft throughout the valley.

Ground-Water Storage

MacNish and Randall (1982) give estimates of ground-water storage for segments of valley-fill aquifers within the Susquehanna River basin in New York. These estimates are based on approximate dimensions of the aquifer segments and estimates of saturated thickness based essentially on the data presented in this report. Storage in water-table aquifers is calculated from an assumed specific yield of 0.20, a typical value for unconfined sand and gravel aquifers. This value was also used by MacNish and Randall to calculate storage in confined valley-fill aquifers because these aquifers generally are hydraulically connected to nearby sand and gravel aquifers that are under water-table conditions. Kantrowitz (1970, p. 68) points out that storage in such water-table aquifer systems must be considered as a single unit because removal of ground water from one aquifer will reduce the amount of long-term storage available in the other. Total ground-water storage in the 24 aquifer segments that constitute the valley-fill aquifer depicted here (shown on pl. 1 of MacNish and Randall 1982 and tabulated in table 4 of their report) is estimated to be approximately 28 billion gallons.

REFERENCES CITED

Kantrowitz, I. H., 1970, Ground-water resources in the eastern Oswego River basin, New York: New York State Conservation Department, Basin Planning Report ORB-2, 129 p.

MacNish, R. D., and Randall, A. D., 1982, Stratified-drift aquifers in the Susquehanna River Basin, New York: New York State Department of Environmental Conservation Bulletin 75, 68 p.

McFarland Johnson Engineers, Inc., 1981, Ground-water survey and design considerations of ground-water withdrawal system for the wastewater treatment area, International Business Machines Corporation: Binghamton, N.Y., McFarland Johnson Engineers, Inc., unpublished report, 316 p.

Randall, A. D., 1972, Records of wells and test borings in the Susquehanna River basin, New York: New York State Department of Environmental Conservation Bulletin 69, 92 p.

EXPLANATION

● 15(>27) WELL OR TEST BORING--From which saturated-thickness data were obtained. Number indicates saturated thickness of surficial (water-table) sand and gravel aquifer, in feet. Number in parentheses indicates saturated thickness of confined sand and gravel aquifer, in feet. A greater-than (>) symbol indicates that the well did not penetrate the full saturated thickness of the aquifer and that the actual saturated thickness, therefore, may be greater than the value shown.

<10 AREA WHERE THE SATURATED THICKNESS IS INFERRED TO BE LESS THAN VALUE SHOWN--Lines of equal saturated thickness are not shown in areas where well data are sparse. These areas are labelled "insufficient data."

40 LINE OF EQUAL SATURATED THICKNESS--Indicates line of equal average saturated thickness of the surficial (water-table) sand and gravel aquifer. Contour interval 20 feet. Dashed where inferred.

10 LINE OF EQUAL SATURATED THICKNESS--Indicates line of equal saturated thickness of the confined sand and gravel aquifer. Contour interval 10 feet. Dashed where inferred.

AQUIFER BOUNDARY--Indicates approximate extent of the valley-fill aquifer system. Dashed where inferred or arbitrarily truncated.

Base from New York State Department of Transportation, Apalachin, Candor, Newark Valley, Owego, NY, 1973, 1:24,000

Hydrogeology by R. J. Reynolds, 1988

HYDROGEOLOGY OF THE VALLEY-FILL AQUIFER AT OWEGO, TIOGA COUNTY, NEW YORK

By

Richard J. Reynolds and James D. Garry

Sheet 5. Saturated Thickness of the Valley-fill Aquifer

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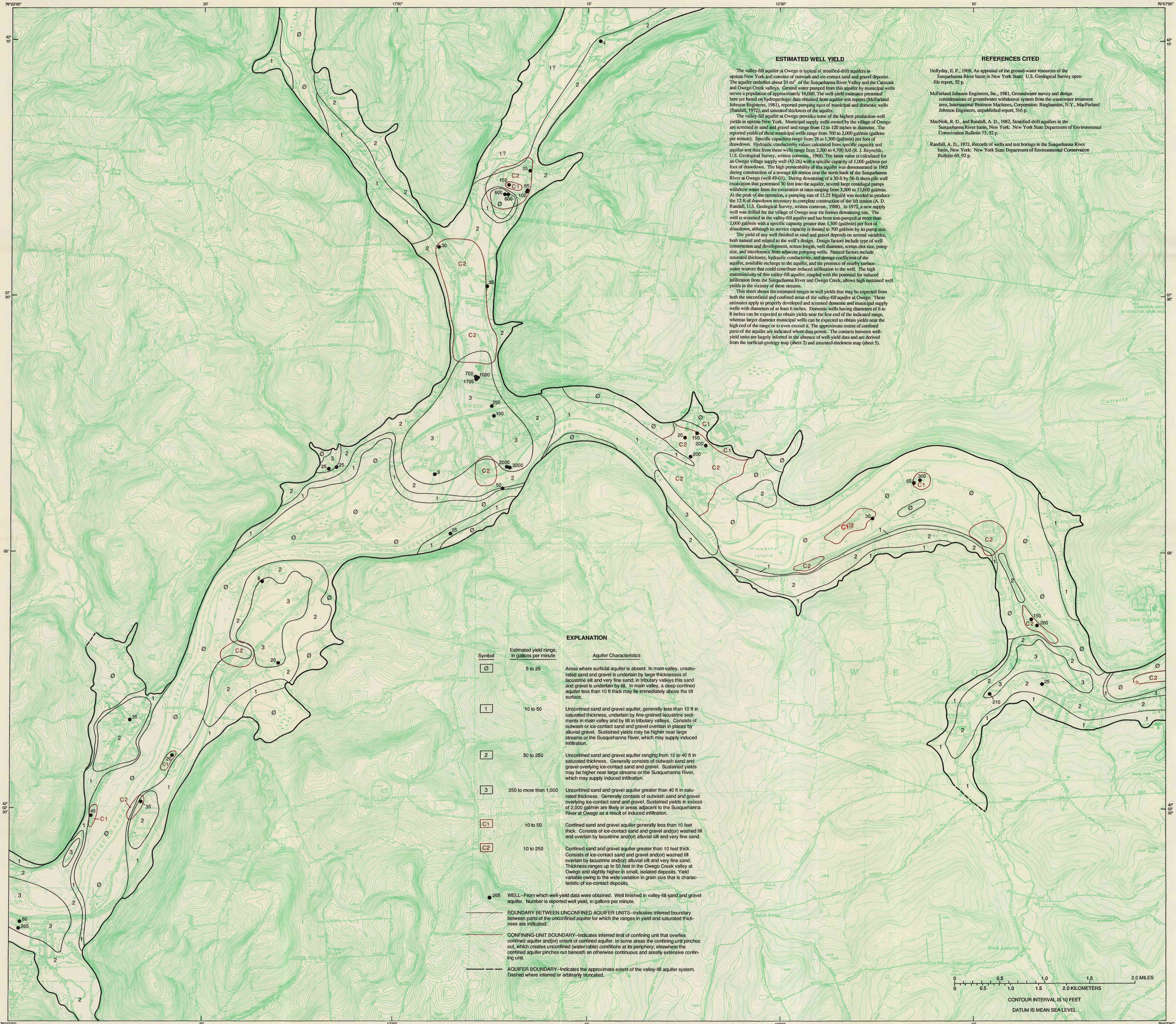

ESTIMATED WELL YIELD

The valley-fill aquifer at Owego is typical of stratified-drift aquifers in upstate New York and consists of outwash and ice-contact sand and gravel deposits. The aquifer underlies about 24 mi^2 of the Susquehanna River Valley and the Catatonk and Owego Creek valleys. Ground water pumped from this aquifer by municipal wells serves a population of approximately 16,000. The well-yield estimates presented here are based on hydrogeologic data obtained from aquifer-test reports (McFarland Johnson Engineers, 1981), reported pumping rates of municipal and domestic wells (Randall, 1972), and saturated thickness of the aquifer.

The valley-fill aquifer at Owego provides some of the highest production-well yields in upstate New York. Municipal supply wells owned by the village of Owego are screened in sand and gravel and range from 12 to 120 inches in diameter. The reported yields of these municipal wells range from 700 to 2,000 gal/min (gallons per minute). Specific capacities range from 78 to 1,300 (gal/min) per foot of drawdown. Hydraulic conductivity values calculated from specific capacity and aquifer-test data from these wells range from 2,200 to 4,700 ft/d (R. J. Reynolds, U.S. Geological Survey, written commun., 1988). The latter value is calculated for an Owego village supply well (42-26) with a specific capacity of 1,000 gal/min per foot of drawdown. The high permeability of this aquifer was demonstrated in 1965 during construction of a sewage lift station near the north bank of the Susquehanna River at Owego (well 49-01). During dewatering of a 30-ft by 56-ft sheet-pile wall excavation that penetrated 30 feet into the aquifer, several large centifugal pumps withdrew water from the excavation at rates ranging from 3,200 to 13,600 gal/min. At the peak of the operation, a pumping rate of 13.25 Mgal/d was needed to produce the 12 ft of drawdown necessary to complete construction of the lift station (A. D. Randall, U.S. Geological Survey, written commun., 1988). In 1972, a new supply well was drilled for the village of Owego near the former dewatering site. The well is screened in the valley-fill aquifer and has been test-pumped at more than 2,000 gal/min with a specific capacity greater than 1,300 (gal/min) per foot of drawdown, although its service capacity is limited to 700 gal/min by its pump size.

The yield of any well finished in sand and gravel depends on several variables, both natural and related to the well's design. Design factors include type of well construction and development, screen length, well diameter, screen-slot size, pump size, and interference from adjacent pumping wells. Natural factors include saturated thickness, hydraulic conductivity, and storage coefficient of the aquifer, available recharge to the aquifer, and the presence of nearby surface-water sources that could contribute induced infiltration to the well. The high transmissivity of this valley-fill aquifer, coupled with the potential for induced infiltration from the Susquehanna River and Owego Creek, allows high sustained well yields in the vicinity of these streams.

This sheet shows the estimated ranges in well yields that may be expected from both the unconfined and confined areas of the valley-fill aquifer at Owego. These estimates apply to properly developed and screened domestic and municipal supply wells with diameters of at least 6 inches. Domestic wells having diameters of 6 to 8 inches can be expected to obtain yields near the low end of the indicated range, whereas larger diameter municipal wells can be expected to obtain yields near the high end of the range or to even exceed it. The approximate extent of confined parts of the aquifer are indicated where data permit. The contacts between well-yield units are largely inferred in the absence of well-yield data and are derived from the surficial-geology map (sheet 2) and saturated-thickness map (sheet 5).

REFERENCES CITED

Hollyday, E. F., 1969, An appraisal of the ground-water resources of the Susquehanna River basin in New York State: U.S. Geological Survey open-file report, 52 p.

McFarland Johnson Engineers, Inc., 1981, Groundwater survey and design considerations of groundwater withdrawal system from the wastewater treatment area, International Business Machines, Corporation: Binghamton, N.Y., MacFarland Johnson Engineers, unpublished report, 316 p.

MacNish, R. D., and Randall, A. D., 1982, Stratified-drift aquifers in the Susquehanna River basin, New York: New York State Department of Environmental Conservation Bulletin 75, 52 p.

Randall, A. D., 1972, Records of wells and test borings in the Susquehanna River basin, New York: New York State Department of Environmental Conservation Bulletin 69, 92 p.

EXPLANATION

Symbol	Estimated yield range, in gallons per minute	Aquifer Characteristics
Ø	5 to 25	Areas where surficial aquifer is absent. In main valley, unsaturated sand and gravel is underlain by large thicknesses of lacustrine silt and very fine sand; in tributary valleys this sand and gravel is underlain by till. In main valley, a deep confined aquifer less than 10 ft thick may lie immediately above the till surface.
1	10 to 50	Unconfined sand and gravel aquifer, generally less than 10 ft in saturated thickness, underlain by fine-grained lacustrine sediments in main valley and by till in tributary valleys. Consists of outwash or ice-contact sand and gravel overlain in places by alluvial gravel. Sustained yields may be higher near large streams or the Susquehanna River, which may supply induced infiltration.
2	50 to 250	Unconfined sand and gravel aquifer ranging from 10 to 40 ft in saturated thickness. Generally consists of outwash sand and gravel overlying ice-contact sand and gravel. Sustained yields may be higher near large streams or the Susquehanna River, which may supply induced infiltration.
3	250 to more than 1,000	Unconfined sand and gravel aquifer greater than 40 ft in saturated thickness. Generally consists of outwash sand and gravel overlying ice-contact sand and gravel. Sustained yields in excess of 2,000 gal/min are likely in areas adjacent to the Susquehanna River at Owego as a result of induced infiltration.
C1	10 to 50	Confined sand and gravel aquifer generally less than 10 feet thick. Consists of ice-contact sand and gravel and(or) washed till and overlain by lacustrine and(or) alluvial silt and very fine sand.
C2	10 to 250	Confined sand and gravel aquifer greater than 10 feet thick. Consists of ice-contact sand and gravel and(or) washed till overlain by lacustrine and(or) alluvial silt and very fine sand. Thickness ranges up to 50 feet in the Owego Creek valley at Owego and slightly higher in small, isolated deposits. Yield variable owing to the wide variation in grain size that is characteristic of ice-contact deposits.

● 265 WELL--From which well-yield data were obtained. Well finished in valley-fill sand and gravel aquifer. Number is reported well yield, in gallons per minute.

BOUNDARY BETWEEN UNCONFINED AQUIFER UNITS--Indicates inferred boundary between parts of the unconfined aquifer for which the ranges in yield and saturated thickness are indicated.

CONFINING-UNIT BOUNDARY--Indicates inferred limit of confining unit that overlies confined aquifer and(or) extent of confined aquifer. In some areas the confining unit pinches out, which creates unconfined (water-table) conditions at its periphery; elsewhere the confined aquifer pinches out beneath an otherwise continuous and areally extensive confining unit.

AQUIFER BOUNDARY--Indicates the approximate extent of the valley-fill aquifer system. Dashed where inferred or arbitrarily truncated.

Base from New York State Department of Transportation, Apalachin, Candor, Newark Valley, Owego, NY, 1973, 1:24,000

Hydrogeology by R. J. Reynolds, 1988

HYDROGEOLOGY OF THE VALLEY-FILL AQUIFER AT OWEGO, TIOGA COUNTY, NEW YORK

By

Richard J. Reynolds and James D. Garry

Sheet 6. Estimated Well Yields

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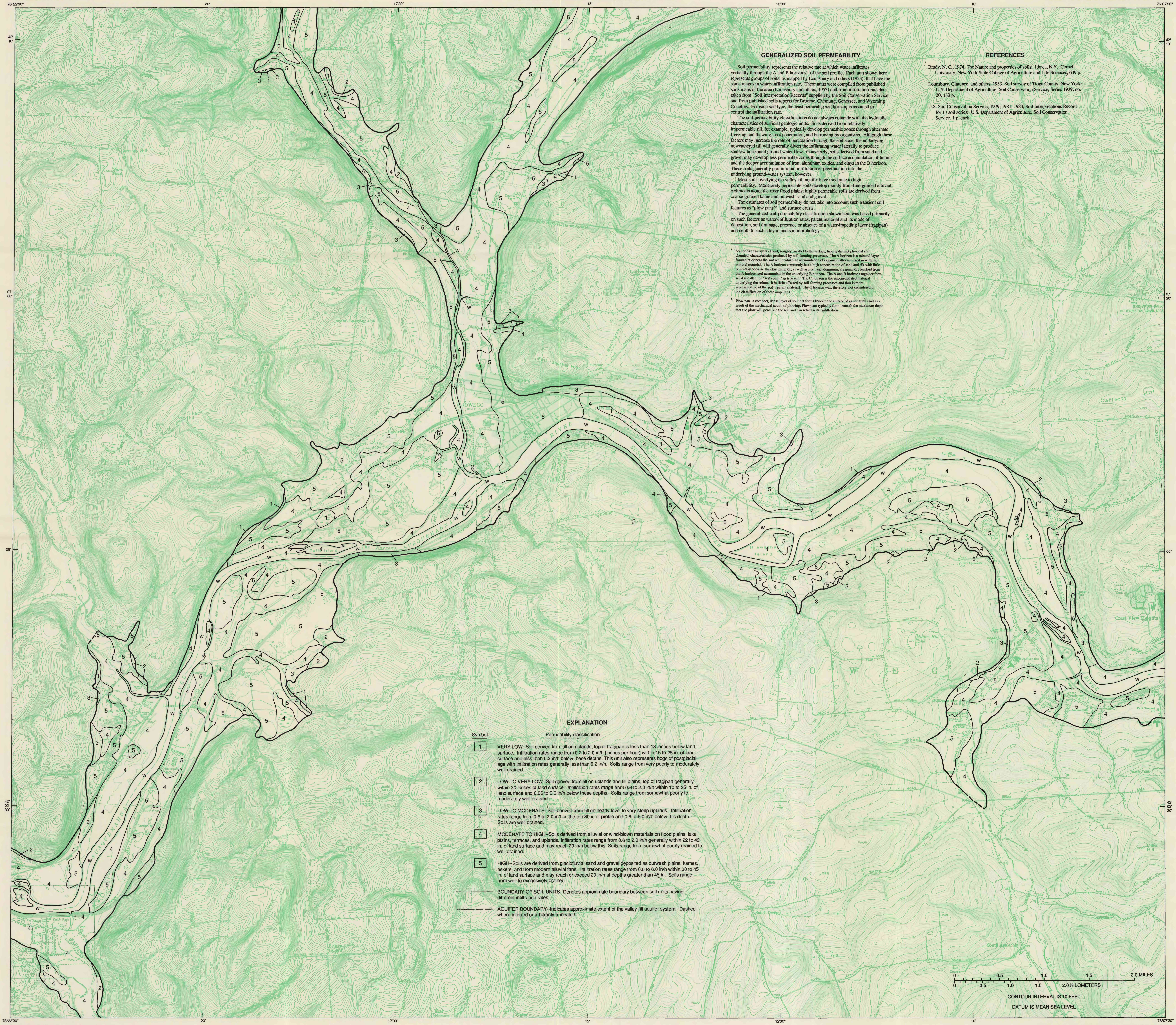

GENERALIZED SOIL PERMEABILITY

Soil permeability represents the relative rate at which water infiltrates vertically through the A and B horizons[1] of the soil profile. Each unit shown here represents groups of soils, as mapped by Lounsbury and others (1953), that have the same ranges in water-infiltration rate. These units were compiled from published soils maps of the area (Lounsbury and others, 1953) and from infiltration-rate data taken from "Soil Interpretation Records" supplied by the Soil Conservation Service and from published soils reports for Broome, Chemung, Genessee, and Wyoming Counties. For each soil type, the least permeable soil horizon is assumed to control the infiltration rate.

The soil-permeability classifications do not always coincide with the hydraulic characteristics of surficial geologic units. Soils derived from relatively impermeable till, for example, typically develop permeable zones through alternate freezing and thawing, root penetration, and burrowing by organisms. Although these factors may increase the rate of percolation through the soil zone, the underlying unweathered till will generally divert the infiltrating water laterally to produce shallow horizontal ground-water flow. Conversely, soils derived from sand and gravel may develop less permeable zones through the surface accumulation of humus and the deeper accumulation of iron, aluminum oxides, and clays in the B horizon. These soils generally permit rapid infiltration of precipitation into the underlying ground-water system, however.

Most soils overlying the valley-fill aquifer have moderate to high permeability. Moderately permeable soils develop mainly from fine-grained alluvial sediments along the river flood plains; highly permeable soils are derived from coarse-grained kame and outwash sand and gravel.

The estimates of soil permeability do not take into account such transient soil features as "plow pans"[2] and surface crusts.

The generalized soil-permeability classification shown here was based primarily on such factors as water-infiltration rates, parent material and its mode of deposition, soil drainage, presence or absence of a water-impeding layer (fragipan) and depth to such a layer, and soil morphology.

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1 Soil horizons--layers of soil, roughly parallel to the surface, having distinct physical and chemical characteristics produced by soil-forming processes. The A horizon is a mineral layer formed at or near the surface in which an accumulation of organic matter is mixed in with the mineral material. The A horizon commonly has a high concentration of sand and silt with little or no clay because the clay minerals, as well as iron, and aluminum, are generally leached from the A horizon and accumulate in the underlying B horizon. The A and B horizons together form what is called the "soil solum" or true soil. The C horizon is the unconsolidated material underlying the solum. It is little affected by soil-forming processes and thus is more representative of the soil's parent material. The C horizon was, therefore, not considered in the classification of these map units.

2 Plow pan--a compact, dense layer of soil that forms beneath the surface of agricultural land as a result of the mechanical action of plowing. Plow pans typically form beneath the maximum depth that the plow will penetrate the soil and can retard water infiltration.

REFERENCES

Brady, N. C., 1974, The Nature and properties of soils: Ithaca, N.Y., Cornell University, New York State College of Agriculture and Life Sciences, 639 p.

Lounsbury, Clarence, and others, 1953, Soil survey of Tioga County, New York: U.S. Department of Agriculture, Soil Conservation Service, Series 1939, no. 20, 133 p.

U.S. Soil Conservation Service, 1979, 1981, 1983, Soil Interpretations Record for 17 soil series: U.S. Department of Agriculture, Soil Conservation Service, 1 p. each

EXPLANATION

Symbol	Permeability classification
1	VERY LOW--Soil derived from till on uplands; top of fragipan is less than 18 inches below land surface. Infiltration rates range from 0.2 to 2.0 in/h (inches per hour) within 15 to 25 in. of land surface and less than 0.2 in/h below these depths. This unit also represents bogs of postglacial age with infiltration rates generally less than 0.2 in/h. Soils range from very poorly to moderately well drained.
2	LOW TO VERY LOW--Soil derived from till on uplands and till plains; top of fragipan generally within 30 inches of land surface. Infiltration rates range from 0.6 to 2.0 in/h within 10 to 25 in. of land surface and 0.06 to 0.6 in/h below these depths. Soils range from somewhat poorly to moderately well drained.
3	LOW TO MODERATE--Soil derived from till on nearly level to very steep uplands. Infiltration rates range from 0.6 to 2.0 in/h in the top 30 in of profile and 0.6 to 6.0 in/h below this depth. Soils are well drained.
4	MODERATE TO HIGH--Soils derived from alluvial or wind-blown materials on flood plains, lake plains, terraces, and uplands. Infiltration rates range from 0.6 to 2.0 in/h generally within 22 to 42 in. of land surface and may reach 20 in/h below this. Soils range from somewhat poorly drained to well drained.
5	HIGH--Soils are derived from glaciofluvial sand and gravel deposited as outwash plains, kames, eskers, and from modern alluvial fans. Infiltration rates range from 0.6 to 6.0 in/h within 30 to 45 in. of land surface and may reach or exceed 20 in/h at depths greater than 45 in. Soils range from well to excessively drained.
———	BOUNDARY OF SOIL UNITS--Denotes approximate boundary between soil units having different infiltration rates.
——— — —	AQUIFER BOUNDARY--Indicates approximate extent of the valley-fill aquifer system. Dashed where inferred or arbitrarily truncated.

Base from New York State Department of Transportation,
Apalachin, Candor, Newark Valley, Owego, NY, 1973, 1:24,000

Hydrology modified from Lounsberry and others, 1953, by J. D. Garry, 1987

HYDROGEOLOGY OF THE VALLEY-FILL AQUIFER AT OWEGO, TIOGA COUNTY, NEW YORK

By

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Sheet 7. Generalized Soil Permeability

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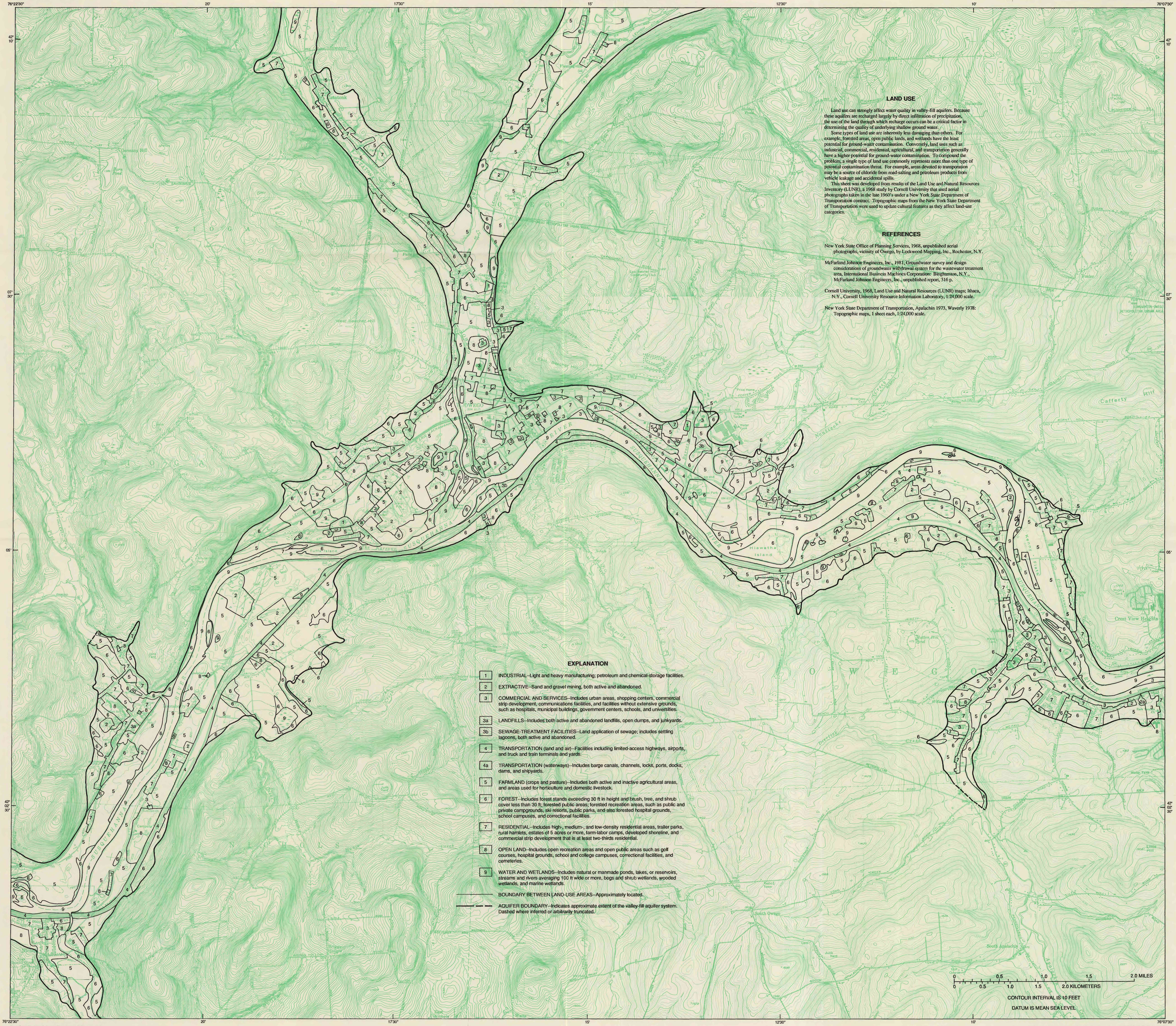

LAND USE

Land use can strongly affect water quality in valley-fill aquifers. Because these aquifers are recharged largely by direct infiltration of precipitation, the use of the land through which recharge occurs can be a critical factor in determining the quality of underlying shallow ground water.

Some types of land use are inherently less damaging than others. For example, forested areas, open public lands, and wetlands have the least potential for ground-water contamination. Conversely, land uses such as industrial, commercial, residential, agricultural, and transportation generally have a higher potential for ground-water contamination. To compound the problem, a single type of land use commonly represents more than one type of potential contamination threat. For example, areas devoted to transporation may be a source of chloride from road-salting and petroleum products from vehicle leakage and accidental spills.

This sheet was developed from results of the Land Use and Natural Resources Inventory (LUNR), a 1968 study by Cornell University that used aerial photographs taken in the late 1960's under a New York State Department of Transportation contract. Topographic maps from the New York State Department of Transportation were used to update cultural features as they affect land-use categories.

REFERENCES

New York State Office of Planning Services, 1968, unpublished aerial photographs, vicinity of Owego, by Lockwood Mapping, Inc., Rochester, N.Y.

McFarland Johnson Engineers, Inc., 1981, Groundwater survey and design considerations of groundwater withdrawal system for the wastewater treatment area, International Business Machines Corporation: Binghamton, N.Y., McFarland Johnson Engineers, Inc., unpublished report, 316 p.

Cornell University, 1968, Land Use and Natural Resources (LUNR) maps; Ithaca, N.Y., Cornell University Resource Information Laboratory, 1:24,000 scale.

New York State Department of Transportation, Apalachin 1973, Waverly 1978: Topographic maps, 1 sheet each, 1:24,000 scale.

EXPLANATION

1	INDUSTRIAL--Light and heavy manufacturing; petroleum and chemical-storage facilities.
2	EXTRACTIVE--Sand and gravel mining, both active and abandoned.
3	COMMERCIAL AND SERVICES--Includes urban areas, shopping centers, commercial strip development, communications facilities, and facilities without extensive grounds, such as hospitals, municipal buildings, government centers, schools, and universities.
3a	LANDFILLS--Includes both active and abandoned landfills, open dumps, and junkyards.
3b	SEWAGE-TREATMENT FACILITIES--Land application of sewage; includes settling lagoons, both active and abandoned.
4	TRANSPORTATION (land and air)--Facilities including limited-access highways, airports, and truck and train terminals and yards.
4a	TRANSPORTATION (waterways)--Includes barge canals, channels, locks, ports, docks, dams, and shipyards.
5	FARMLAND (crops and pasture)--Includes both active and inactive agricultural areas, and areas used for horticulture and domestic livestock.
6	FOREST--Includes forest stands exceeding 30 ft in height and brush, tree, and shrub cover less than 30 ft; forested public areas; forested recreation areas, such as public and private campgrounds, ski resorts, public parks, and also forested hospital grounds, school campuses, and correctional facilities.
7	RESIDENTIAL--Includes high-, medium-, and low-density residential areas, trailer parks, rural hamlets, estates of 5 acres or more, farm-labor camps, developed shoreline, and commercial strip development that is at least two-thirds residential.
8	OPEN LAND--Includes open recreation areas and open public areas such as golf courses, hospital grounds, school and college campuses, correctional facilities, and cemeteries.
9	WATER AND WETLANDS--Includes natural or manmade ponds, lakes, or reservoirs, streams and rivers averaging 100 ft wide or more, bogs and shrub wetlands, wooded wetlands, and marine wetlands.
———	BOUNDARY BETWEEN LAND-USE AREAS--Approximately located.
━━ ━ ━	AQUIFER BOUNDARY--Indicates approximate extent of the valley-fill aquifer system. Dashed where inferred or arbitrarily truncated.

Base from New York State Department of Transportation, Apalachin, Candor, Newark Valley, Owego, NY, 1973, 1:24,000

Modified from Cornell University LUNR land use maps, (1968), by J. D. Garry, 1988

HYDROGEOLOGY OF THE VALLEY-FILL AQUIFER AT OWEGO, TIOGA COUNTY, NEW YORK

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Sheet 8. Land Use

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