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Evaluation Of The Federal-State Cooperative Observation Well Network In Upstate New York, 1995-97

U.S. GEOLOGICAL SURVEY
Open File Report 99-468

Prepared in cooperation with the
New York State Department of Environmental Conservation

Cover: Observation well A-636, in Albany County, provides continuous ground-water level data as part of the Federal-State Cooperative Observation Well Network. (Photo by author, January 2000)

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2000

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

Multiply	by	To Obtain
	Length	
inch (in.)	2.54	centimeter
foot (ft)	0.3048	meter
mile (m)	1.609	kilometer
foot per mile (ft/mi)	0.1894	meter per kilometer
	Area	
square mile (mi^2)	2.59	square kilomter

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 the United States and Canada, formerly called Sea level Datum of 1929.

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By Richard J. Reynolds

Abstract

The U.S. Geological Survey's Federal-State cooperative observation well network in upstate New York was evaluated in terms of areal coverage, objectives, and short- and long-term expansion plans. This report presents a history of the observation well network in upstate New York and depicts, on maps, the distribution of observation wells with respect to climatic regions, physiographic regions, and aquifer type (bedrock, till, and stratified drift) within New York State. It also describes siting criteria for observation wells, outlines the objectives of three types of observation well subnetworks, and offers suggestions for short- and long-term improvements of the current network. Two appendixes contain (1) a table of selected well data, and (2) hydrographs and boxplots that show median monthly water levels and monthly percentile statistics for water levels in the 46 observation wells.

INTRODUCTION

The U.S. Geological Survey (USGS) has maintained an observation well network in upstate New York (excluding Long Island) since 1933, funded largely through a cooperative program with the New York State Department of Environmental Conservation (NYSDEC). Under this program, the costs of maintaining the network (known as the USGS Federal-State cooperative observation well network) and processing and publishing the resulting data are shared between the USGS and the NYSDEC. In 1996, the observation well network in upstate New York was drastically reduced in size, from 46 wells to 8 wells, in response to a reduction in State funding. Funding was partly restored the following year and, since 1997, the network has consisted of 15 wells. In 1998, the USGS, in cooperation with the NYSDEC, conducted a study to (1) evaluate the 1997 observation well network in terms of hydrologic objectives, adequacy of coverage, and degree to which the network meets its objectives, and (2) to make specific suggestions for improving the network.

Purpose and Scope

This report describes the observation well network in upstate New York for 1995 and 1997, outlines the development, history of the network, describes the hydrologic objectives of several categories of observation well sub-networks and the criteria for well selection, and tabulates selected data for the wells in the 1995 and 1997 networks. It also presents both specific and general suggestions for the future expansion and improvement of the network. A table of selected well data, along with ten-year hydrographs and boxplots showing median monthly water levels and monthly percentile statistics for water levels in the observation wells in the 1995 and 1997 networks are presented as appendixes.

History of the Network

The U.S. Geological Survey began a formal, nationwide observation-well program in 1934 that was subsequently expanded in response to the drought of the mid-1930's. The USGS Federal-State cooperative observation-well program in New York began in 1933 with the installation of three wells as part of a long-term study of reforestation in Cortland County in central New York. Water-level data from this study were subsequently published (Harrington, 1935); however, a statewide network of observation wells was not officially established until the USGS began a series of county ground-water studies in cooperation with the NYSDEC (then the New York State Conservation Department) and the New York State Water Power Control Commission during the 1940's and 1950's.

Temporary observation wells were established as part of these county ground-water studies to obtain data on local hydrologic conditions in each study area. As each study ended, selected wells were retained and incorporated into the statewide network. Most of these wells were privately owned, and because they had either been previously abandoned or were otherwise unused, the owners had allowed the USGS to use them for water-level measurements. Therefore, very few of the wells that were incorporated into the expanding network during this period were designed and installed to function exclusively as observation wells; rather, they were originally constructed as domestic water supply wells and later adapted for use as observation wells.

Water-level data also were obtained from local agencies that had been maintaining observation wells, and some of these wells were subsequently incorporated into the statewide network; notably Oe-151 in Oneida County, which was installed in 1926 (Cullings, 1936); well P-609 in Putnam County, installed in 1935; and well We-3 in Westchester County, installed in 1934 (fig. 1). These three wells provide the longest continuous record of ground-water levels in upstate New York. Earlier records were reported by Robert E. Horton, a consulting hydraulic engineer, who measured water levels in three wells at Voorheesville, in Albany County during 1915-36 (Holland and Jarvis, 1938), and by Emery (1889), who reported water-level observations at Geneva, in Ontario County from 1886 to 1889.

Observation wells were added to or dropped from the network from 1935 through the early 1960’s, depending mainly on the requirements of the individual county ground-water studies; therefore, the network’s growth was somewhat slow and unsystematic in the absence of clear-cut objectives. In 1965, the USGS, in cooperation with the New York State Department of Conservation (now the NYSDEC) proposed that the observation-well network be expanded and that it consist of two components—a “baseline” network of wells that would reflect seasonal variations in recharge and storage in representative topographic settings, and a “water-management” network of wells installed near major wellfields to monitor the response of the aquifers to pumping-induced stresses. The proposed “baseline” network consisted of wells representing three main types of hydrogeologic settings—valley floors, hillslopes, and hilltops—to assess the effect of topography on seasonal water-level fluctuations. As a result, 16 wells were added to the network in the mid-1960’s to document the effects of (1) topography, and (2) seasonal fluctuations in recharge, on ground-water storage. By 1968, the network consisted of 48 wells, most of which were in the “baseline” category; only a few wells were in the “water-management” category. By 1983, the network had decreased to 43 wells, but by 1995 had increased to 46 wells. In 1996, the network was sharply reduced to 8 wells as a consequence of the elimination of cooperative funding from New York State. Funding was partly restored the following year, however, and 8 wells were restored to the network to make a network total of 16 wells in 1997.

OBSERVATION WELL NETWORK

The network of 46 wells in 1995 was virtually the same as it had been for the preceding 3 decades, although some of the older wells had been replaced by successor wells during this time. The original observation well network had certain deficiencies in areal coverage, which became evident as a result of (1) widespread drought conditions in the late 1970’s, and (2) a State mandate (New York State Department of Environmental Conservation and New York State Department of Health, 1982) to manage the State’s major “primary”[1] stratified-drift aquifers.

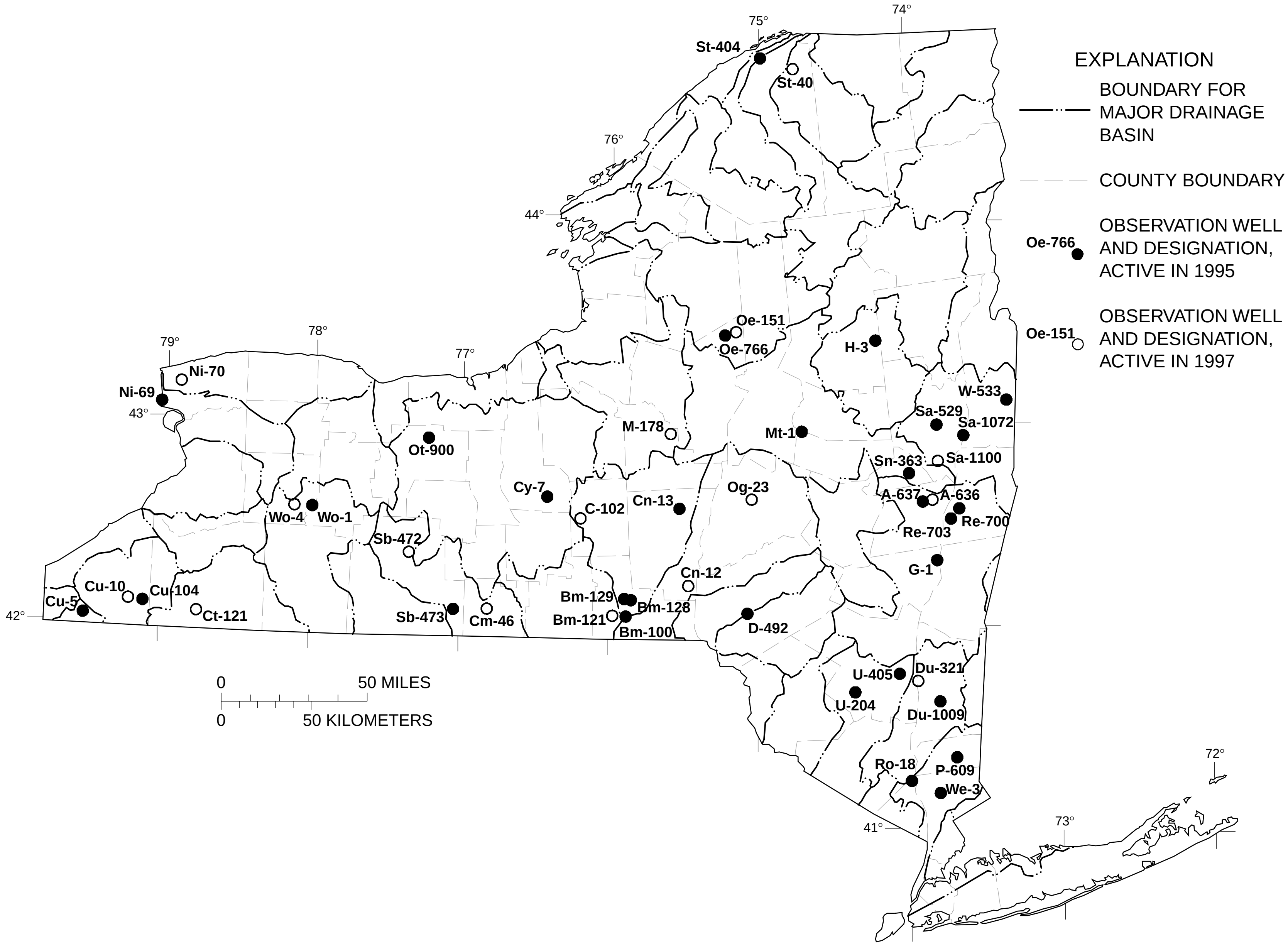
Distribution of Network Wells in 1995 and 1997.

The deficiencies in areal coverage, such as along most of the northern border of New York, prompted the USGS to examine the distribution of observation wells in the State with respect to climatic region, physiographic region, aquifer system, and topographic setting (R.M. Waller, U.S. Geological Survey, written commun., 1985). The principal findings in relation to each of these four categories are summarized below.

By Climatic Region

The National Weather Service has divided New York State into 10 regions, each differing from the others in climatic characteristics (Pack, 1972). The distribution of observation wells with respect to climatic region were examined because ground-water levels in stratified-drift aquifers within any given climatic region can be expected to respond similarly across that region, as can water levels in bedrock aquifers. The distribution of the 1995 and 1997 observation-well networks in relation to climatic regions is depicted in figure 2. Wells in both net-

[1]primary aquifers--Defined by the New York State Department of Environmental Conservation as “...highly productive aquifers presently being utilized as sources of water supply by major municipal water supply systems.”



Base from U.S. Geological Survey digital data, 1:2,000,000, 1972
Albers Equal-Area Conic projection
Standard parallels 29°30' and 45°30', central meridian -96°00'

Figure 1. Location and distribution of observation wells in the Federal-State cooperative network in New York in 1995 and 1997.

works were sparse in the four northern regions and were absent in the Champlain Valley and eastern Great Lakes regions.

By Physiographic Regions

The distribution of observation wells with respect to physiographic region was examined because local topography can affect ground-water levels and because regional physiography, in part, controls the directions of regional ground-water flow. New York State has been divided into nine physiographic provinces by Fenneman (1938) and Thompson (1966). The distribution of network wells in 1995 and 1997 with respect to physiographic province is shown in figure 3. Most of the observation wells are in the Appalachian Upland and Hudson-Mohawk Lowland provinces; coverage within the Adirondack Mountains is extremely sparse.

Within Bedrock and Till Aquifers

The distribution of observation wells completed in bedrock and till aquifers was examined because most of the rural population of upstate New York relies on self-supplied water from drilled or dug domestic wells. The observation well network in 1995 contained seven wells that were completed in bedrock-aquifer systems, most of which are in southeastern New York (fig. 4), and eight wells completed in till deposits, most of which are in upland settings. In 1997, however, the network contained one bedrock well and only one well completed in till. Bedrock aquifers, especially the large regional sandstone aquifers that underlie the Tug Hill Plateau and the Ontario and St. Lawrence Low lands (fig. 4), are poorly represented in the upstate observation well network.

Within Stratified-Drift Aquifers

Stratified-drift aquifers are the main focus of the upstate observation well program because most of the publicly supplied ground water in upstate New York is pumped from these aquifers. Of the 46 wells in the 1995 network, 26 were completed in stratified-drift aquifers, 17 of which are in valley-floor settings, and 9 of which are in upland or hillslope settings. The distribution of network observation wells completed in stratified-drift aquifers in 1995 and 1997 is shown in figure 5. Eight of the 17 valley-floor observation wells in the 1995 network were classified as “water-management” wells and were screened in 7 of the 18 primary aquifers as defined by the New York State Department of Health (Waller and Finch, 1982; Cosner, 1984). The remaining 18 network wells completed in stratified-drift aquifers in 1995 were classified as “baseline” wells. Two of the 9 upland wells in the 1995 network were classified as “water-management” wells because they were completed in aquifers that are intermittently used for public supply.

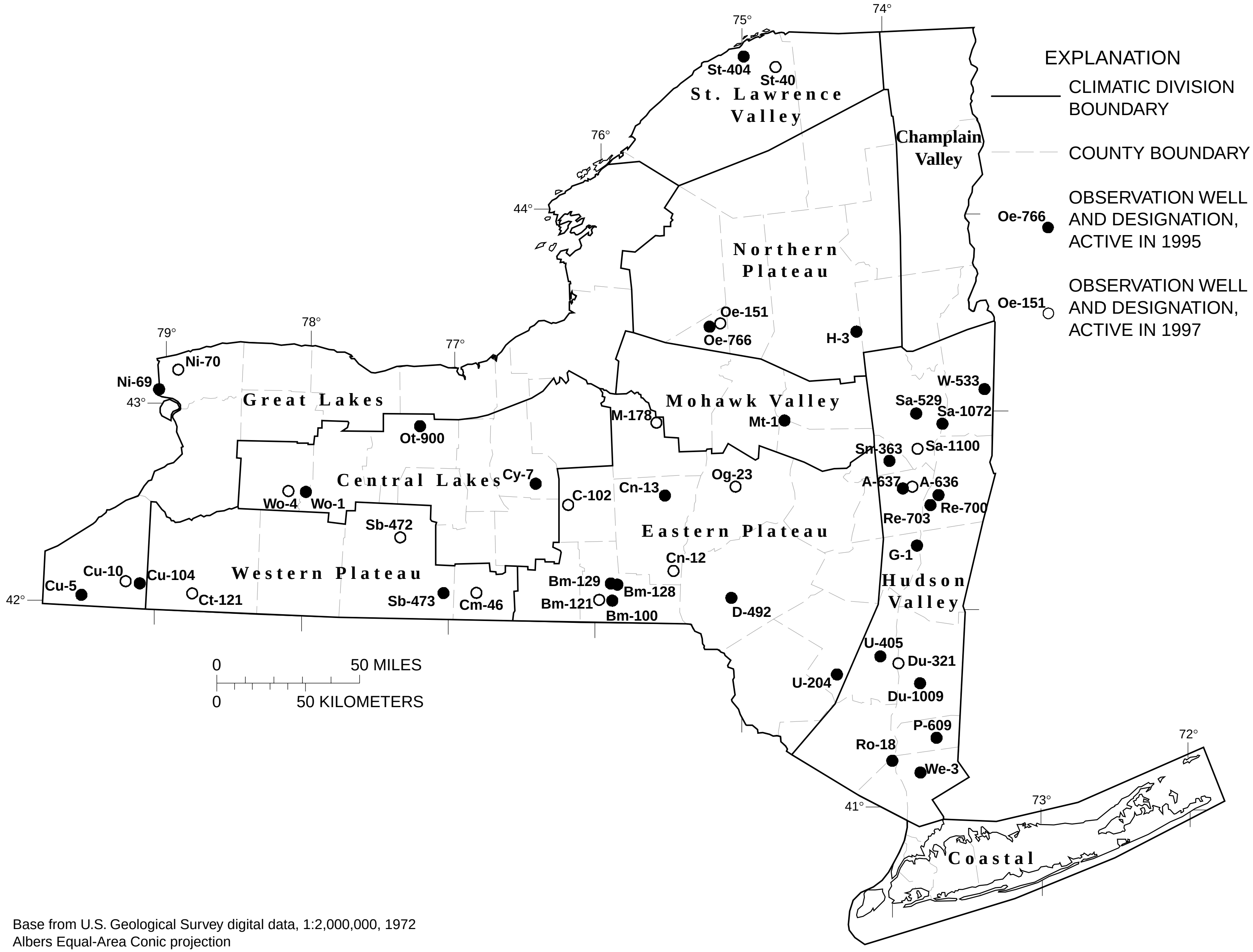
Of the 16 wells in the 1997 network, 14 were completed in stratified drift, one in bedrock, and one in till. Twelve of the 16 wells were considered “baseline” wells, and 4 were considered “water-management” wells. Seven of the 16 wells were in valley-floor settings, 3 were in upland-plain settings, 2 were in upland settings, 2 were in plain settings, one was in an upland valley setting, and one was in a hilltop setting.

Siting Criteria for Observation wells

The upstate observation-well network consists of two subnetworks—“water management” and “baseline”-each of which has separate objectives and, thus, somewhat different siting criteria. A third type of subnetwork, a “hydrologic monitoring” network, is used to monitor the effects of local hydrologic stresses in individual aquifers. These three types of observation-well subnetworks are described in Heath (1976); the objectives and products of each are summarized in table 1.

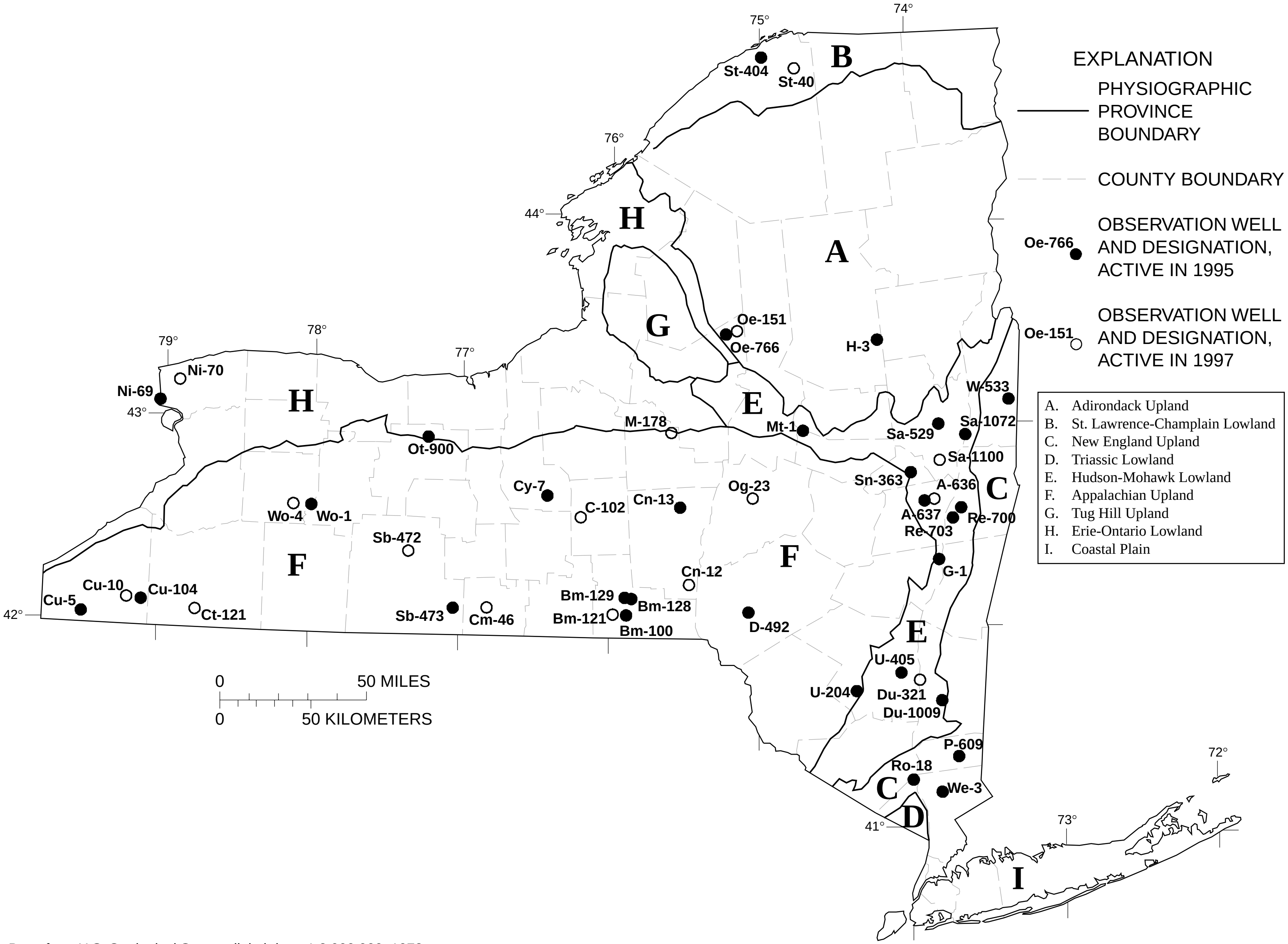
Baseline Subnetwork

The objectives of the baseline subnetwork, as indicated in table 1, are to: (1) indicate the effects of climatic changes (seasonal variations in recharge) on ground-water storage, and (2) define the effect of topography and(or) geologic conditions on the response of water levels to climatic changes. Ideally, this subnetwork would consist of observation wells screened in major unconfined (water-table) sand and gravel aquifers in areas not significantly affected by ground-water withdrawals or artificial recharge. Water-level data from this subnetwork would indicate only the response of the ground-water system to seasonal and long-term variations in recharge and, thus, would provide baseline data needed to interpret data from the water-management subnetwork and any detailed hydrologic subnetworks.



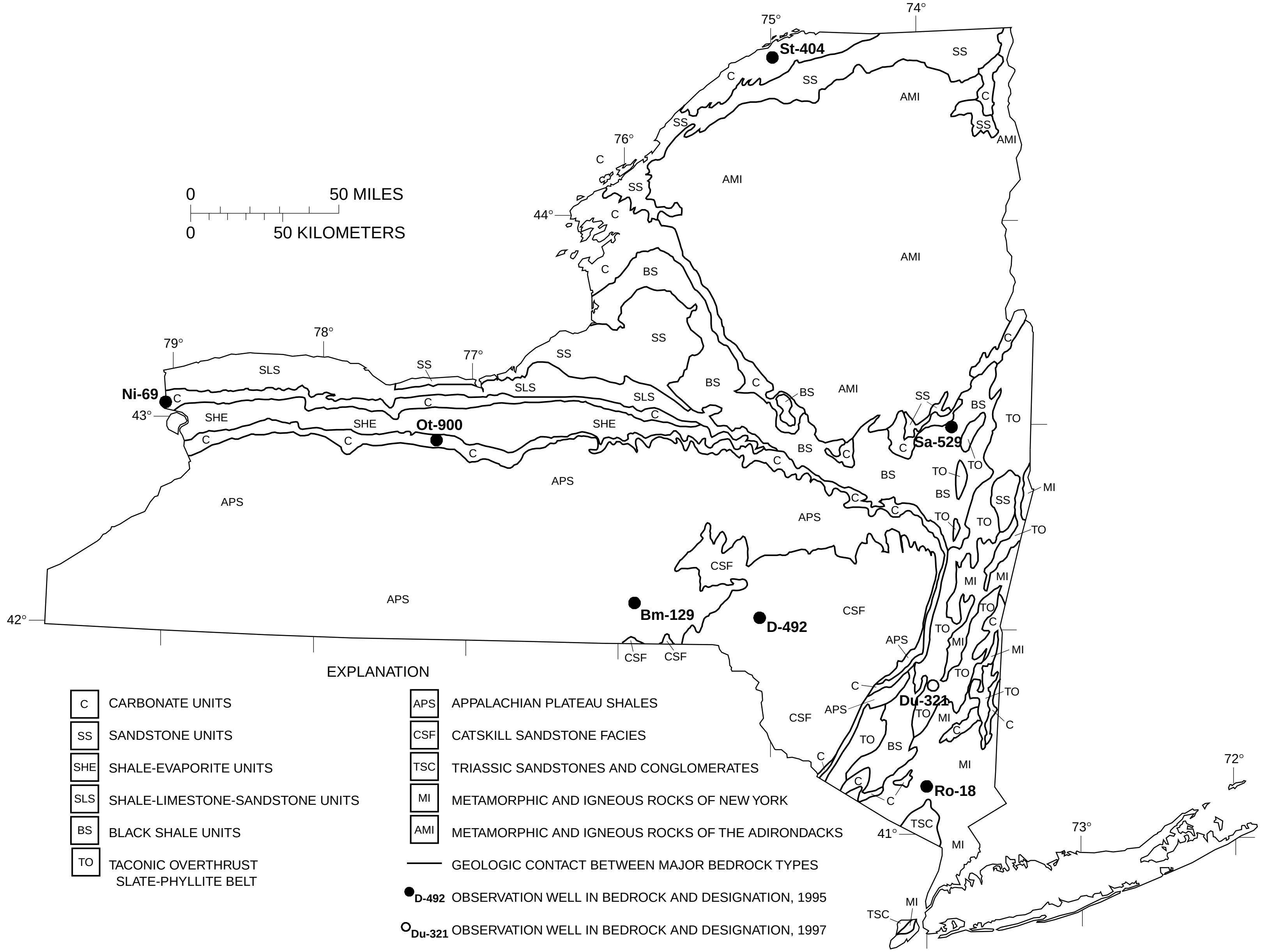
Base from U.S. Geological Survey digital data, 1:2,000,000, 1972
Albers Equal-Area Conic projection
Standard parallels 29°30' and 45°30', central meridian -96°00'

Figure 2. Distribution of observation wells within climatic regions of New York in 1995 and 1997.



Base from U.S. Geological Survey digital data, 1:2,000,000, 1972
Albers Equal-Area Conic projection
Standard parallels 29°30' and 45°30', central meridian -96°00'

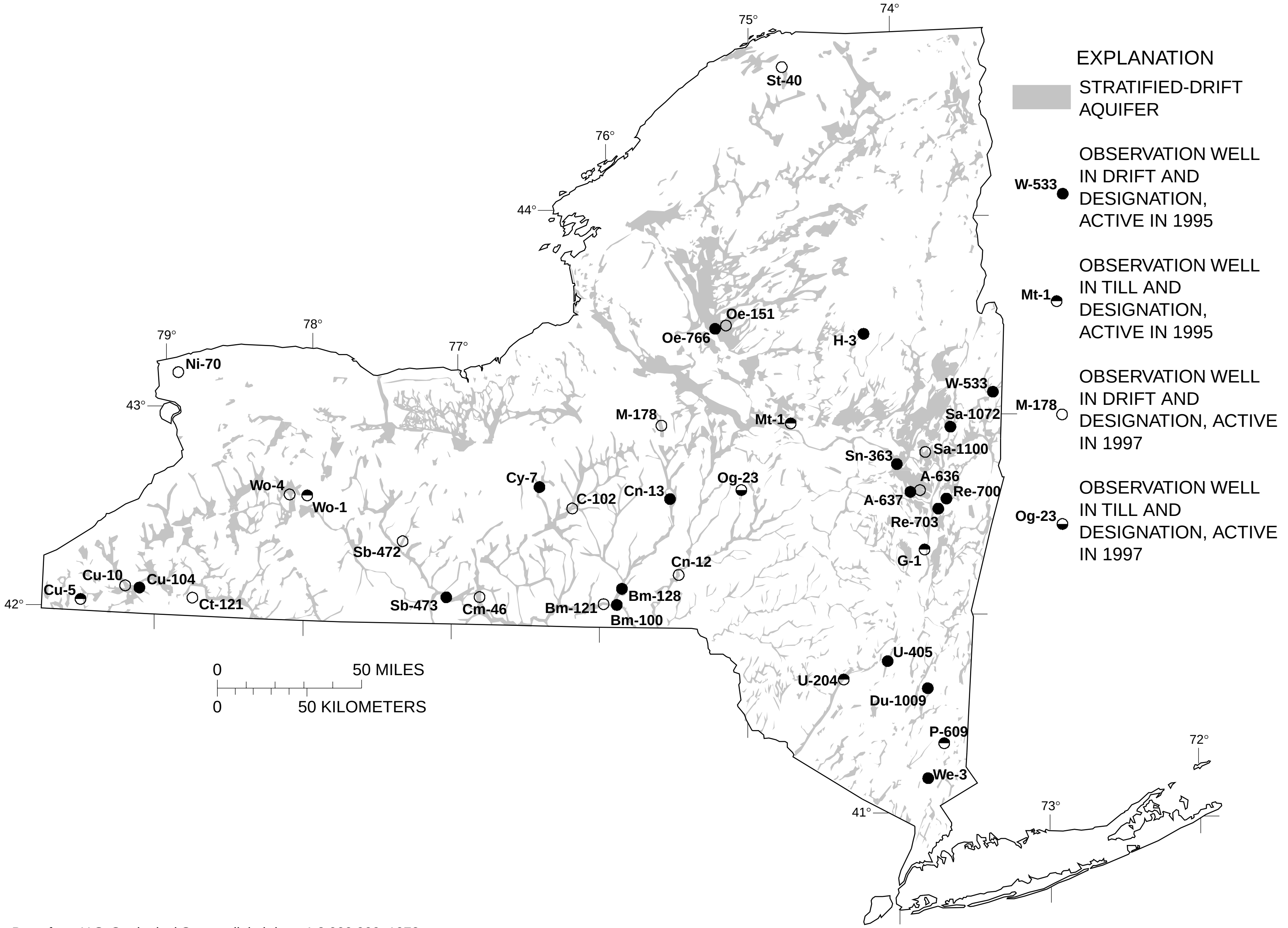
Figure 3. Distribution of observation wells within physiographic provinces of New York in 1995 and 1997.



Base from U.S. Geological Survey digital data, 1:2,000,000, 1972
Albers Equal-Area Conic projection
Standard parallels 29°30' and 45°30', central meridian -96°00'

Geology modified from Fisher and others (1970), by R.J. Reynolds

Figure 4. Distribution of observation wells among generalized bedrock units of New York in 1995 and 1997.



Base from U.S. Geological Survey digital data, 1:2,000,000, 1972
Albers Equal-Area Conic projection
Standard parallels 29°30' and 45°30', central meridian -96°00'

Figure 5. Distribution of observation wells among stratified-drift aquifers of New York in 1995 and 1997.

The typical baseline-well subnetwork can be divided into groups A and B (table 1), as follows:

Group A—This group consists solely of wells that indicate only the effect of areal variations in precipitation on ground-water storage. Ideally, all wells in this group would be of nearly identical construction and would be located in areas with nearly identical geologic and topographic conditions. For valley-fill aquifers, this means that all wells would be located on the valley floor, but away from rivers or streams that could induce water-level fluctuations in the well. Further requirements for these wells, as outlined by Heath (1976), are that:

1. The wells are screened in the unconfined (water-table) aquifer, which typically responds more directly to recharge and evapotranspiration than do confined aquifers.

2. The depth to the water table below land surface is roughly the same at all wells so that traveltime for recharge through the unsaturated zone can be ignored in hydrograph comparisons between wells.

3. All wells are in a similar topographic setting to eliminate the effects of local topography on water levels.

4. All wells have a similar casing diameter, screen length, and general construction.

In addition, these wells should be installed far enough away from surface-water bodies (especially rivers and streams) that can induce, or moderate, water-level fluctuations in the aquifer. In valley-fill aquifers, this could mean installing the well on the opposite side of the valley from a river that flanks a valley wall. Ideally, observation wells that are used to monitor changes in storage in valley-fill (or sand-plain) aquifers would be installed close to a ground-water divide to insure that:

1. The well will be located in an area of ground-water recharge, not discharge, and

2. The well will, in all probability, record the greatest changes in storage at this location than at any other in the aquifer.

Group B—This group consists of wells needed in the evaluation of the effect of topography and geologic conditions on the response of aquifers to fluctuations in recharge. Wells in this group ideally would be placed near some or all of the wells in group A, but in different topographic settings and(or) completed in different aquifers. For example, an existing group A observation well completed in a surficial outwash aquifer might be paired with a new group B well completed in either an underlying confined ice-contact sand and gravel aquifer or in the underlying bedrock; alternatively, it might be paired with group B wells finished in till or bedrock on the adjacent hillsides and hilltops.

Table 1. Objectives and products of three types of observation-well subnetworks [From Heath, 1976, table 2].

Type	Objectives	Products
Hydrologic monitoring	Define status of ground-water storage	Regional water-table and(or) potentiometric-surface maps
	Delineate areal extent of aquifers	Maps showing net change on water levels or storage over a selected period
Water management	Measure effect of stresses on recharge and discharge conditions	Local water-level maps
	Estimate hydraulic characteristics of aquifers	Hydrographs showing change in water levels through time
	Estimate degree of confinement	Graphs of water levels in relation to pumping rates
Baseline (storage)	A. Define effects of climate on ground-water storage	Hydrographs showing storage changes in different aquifers and topographic settings within each climatic zone
	B. Define effect of topography and geologic conditions on water-level response to climatic fluctuations	

Water-Management Subnetwork

The primary objective of the water-management subnetwork is to quantify the effect of ground-water withdrawals (or injection) on aquifer storage and natural aquifer discharge. This type of network provides (1) information on the response of ground-water systems to pumping-induced stresses, and (2) water-level data needed for management decisions.

The number of wells needed in a water-management network will differ from place to place, depending on the type of aquifer and the number and magnitude of pumping centers. Heath (1976) notes that, ". . . as a minimum, at least one observation well should be located near every major pumping center" and further stipulates that "near" in this context means that the observation well should be placed close enough to the pumping center to record the composite drawdown of the wellfield, but not so close to any specific pumping well that the pumping well's daily cycle of operation obscures the effects of more distant wells. Ideally, the observation wells near major pumping centers would be screened in the production zone and placed at various distances from the pumping center and, if feasible, would include wells screened in the overlying zone as well as the underlying zones to indicate the three-dimensional response of the ground-water system to pumping. Properly placed observation wells in a water-management network are reliable indicators of overdevelopment, or "mining", of ground water. A sample hydrograph from a properly placed water-management well (well A637, in Guilderland, N.Y.; for calendar years 1987-93) and a bar chart of the corresponding total monthly pumpage from the Guilderland municipal wellfield, approximately 0.5 mi northwest of A637, is shown in figure 6. The observation well (A637) and the three pumping wells at the wellfield are screened in a confined, ice-contact sand-and-gravel deposit about 200 ft below land surface. The hydrograph clearly shows that, as total monthly withdrawals from the wellfield fluctuated between 10 and 15 million gallons for the winter months to more than 25 million gallons for the summer months from 1987 through 1990, the potentiometric surface declined concurrently, with cyclical water-level fluctuations superimposed on the declining water level trend. When winter pumpage was sharply curtailed, starting in December 1990, the water level quickly responded, and rose during the fall and winter of each successive year until 1994, when it reached pre-pumping levels.

Hydrologic Monitoring Subnetwork

A hydrologic monitoring subnetwork consists of observation wells installed at multiple locations to monitor the local water-level response to fluctuations in recharge to, and pumping from, a single local or regional aquifer. Water levels in hydrologic monitoring subnetworks for specific aquifers generally are measured on the same day, several times a year, in order to develop a synoptic map of the water table or potentiometric surface. Such networks are valuable because successive sets of water-level measurements permit the construction of "net change" maps that indicate (1) temporal trends in water levels, and (2) areas where ground-water storage has been depleted and where recharge is taking place.

The installation of such networks to permit construction of water-table or potentiometric-surface maps and net-change maps can be thought of as an ultimate goal for the ground-water management of upstate aquifers. Such networks are in place for only a few aquifers in upstate New York, however, because their installation and maintenance are costly. Most of the existing hydrologic monitoring networks in New York are the result of current or past USGS ground-water investigations. These networks generally are not maintained by the USGS after a study has been completed, but, some local cooperating agencies have continued to make regular water-level measurements and to maintain the wells in certain networks. Some recent or current hydrologic monitoring networks in upstate New York include those in the Otter-Creek/Dry-Creek aquifer at Cortland, the Irondo-Genesee aquifer in Monroe County, a network at Olean, and a network in Clifton Park. Of these, only the Irondo-Genesee and the Clifton Park networks are currently (1999) being monitored.

The establishment of hydrologic monitoring networks requires considerable time and expense because the elevation of the measuring point of each well must determined to 1/100 ft through leveling procedures. This is necessary so that (1) the elevation of the water table or potentiometric surface above sea level can be measured precisely, and (2) successive water-level measurements can be accurately compared. The most comprehensive hydrologic monitoring network maintained by the USGS in New York is on Long Island, where 617 wells are measured annually to produce potentiometric maps of the three main aquifers (upper glacial, Magothy and Lloyd) (Busciolano and others, 1998).

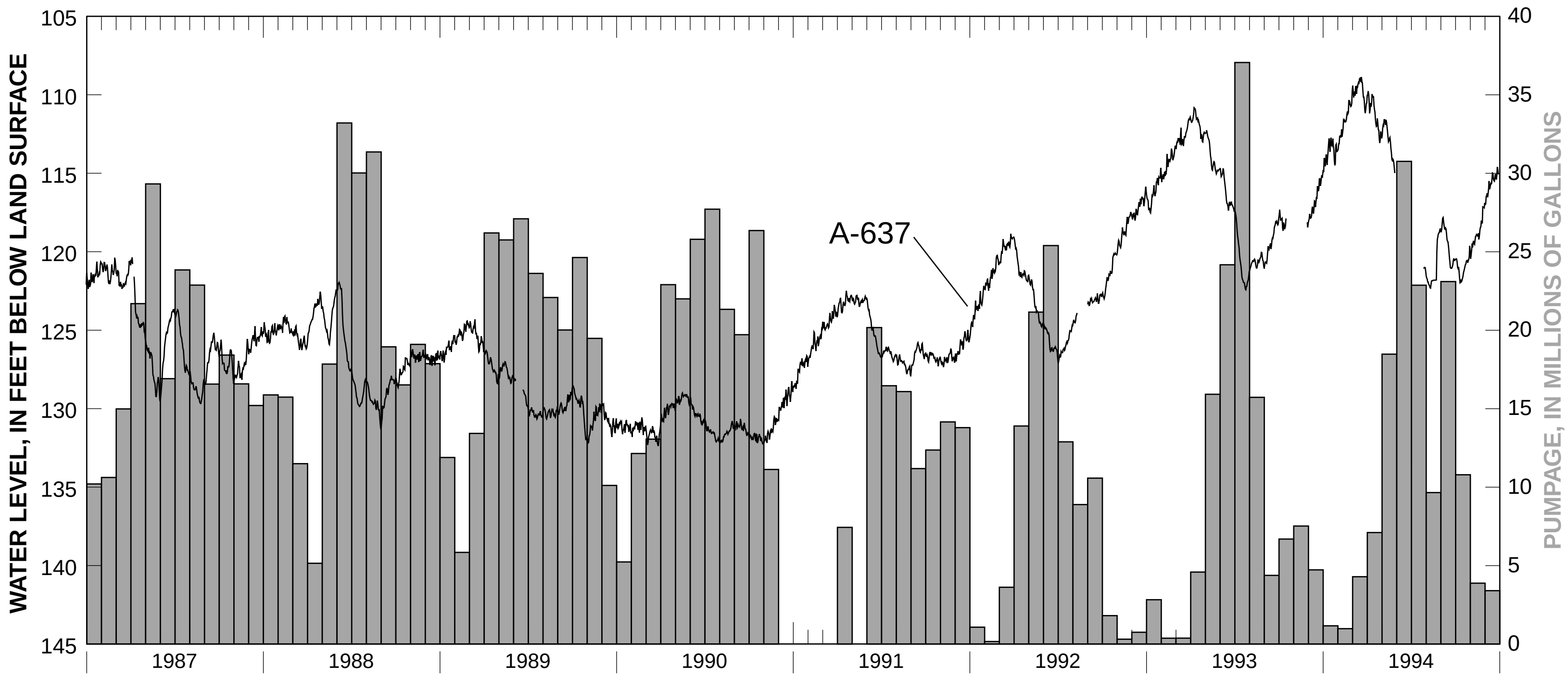


Figure 6. Hydrograph of water levels in well A-637, Albany County, and total monthly pumpage from Guilderland municipal wellfield, 1987-94.

NETWORK EVALUATION

The statewide observation well network has been in continuous operation (in the present form) since 1965, and its operation within New York is evaluated periodically. Individual wells that constitute the network in any given year are evaluated on an annual basis as part of the management of the network.

Methods

The annual evaluation includes an inspection of the annual hydrograph of each well to determine whether the water level was responding to recharge and(or) nearby pumping (if a management well), or whether the water level record was being affected by changes in stage of a nearby stream. Results of these annual evaluations are summarized and stored in each individual well's file. The annual evaluations of individual wells were supplemented by network evaluations conducted in 1968 by W.A. Hobba, Jr. (U.S. Geological Survey, written commun.) and in 1985 by R. M. Waller (U.S. Geological Survey, written commun.). These evaluations were never published, but their major recommendations for network improvement are incorporated into the present study.

Review of Well Data and Water Level Hydrographs

In this study, each well's file was examined and notations made regarding previously described deficiencies in well placement, performance, and(or) construction. Previous recommendations for replacement of wells are incorporated into this report because the original reasons for replacement of most wells have not changed. The finished well depth was compared with the lowest water level on record for each well to identify those wells that do not penetrate far enough into the saturated zone and, thus, should be replaced or deepened. A hydrograph of the last 10 years was plotted for each of the 46 observation wells in the 1995 network and examined to verify that each well was responding to seasonal and annual variations in recharge; in addition, boxplots of median monthly water levels at each well were generated. The 10-year hydrographs and boxplots for each well are shown in appendix 2.

Construction and Analysis of Boxplots

Boxplots are a method used to graphically summarize the characteristics of one or more data sets. They are commonly used as alternatives to histograms and are particularly useful for comparison of multiple data sets. The boxplots in appendix 2 display:

1. The median value of the data (the median is shown by the center line of the box)

2. The variation or "spread" of the data (indicated by the 75th and 25th percentile of the values), referred to as the interquartile range and indicated by the box length.

3. The skewness of the data set, as indicated by the size of the box halves and length of whiskers. The 90th and 10th percentiles are represented by the whisker ends.

4. The presence of unusual or extreme values, shown as an asterisk.

The boxplots of median monthly water levels can be used to assess the variability of water levels from month to month at the same well, and, when taken as a 12-month data set, can be used to qualitatively compare the annual variability of water levels at two or more wells. The plots give median monthly water levels (for the period of record); the 90th, 75th, 25th, and 10th percentiles; and the presence of extreme water levels (outliers) shown as an asterisk. The boxplots also show whether the data are approximately symmetrical about each monthly mean or are skewed, and can help to indicate whether water levels at a particular well are highly responsive to recharge events (indicated by extreme variability in spring) or are affected by nearby pumping (extreme variability in summer and autumn).

A boxplot of a water-level data from a "baseline" well that responds only to natural fluctuations in recharge would be expected to show approximately the same range of water-level fluctuation in each month, as shown, for example, by well A-636 (appendix 2, fig. A1). Similarly, a boxplot of a well that is affected by nearby pumping such as wells Sa-1100 (fig. A5) and Bm-128 (fig. B1), or by stage fluctuations in a nearby stream, will indicate large fluctuations in water levels, particularly during the late summer.

Suggestions For Network Improvement

Only 16 of the 46 wells in the upstate Federal-State Cooperative Network were funded and continued to operate in 1997. Suggestions to improve this network to meet its objectives can be grouped into two categories—short-term goals and long-term goals.

Short-term Goals

The main short-term goal is the reactivation of (1) discontinued wells in the "baseline" and "water-management" subnetworks, and (2) wells that reflect long-term changes in storage in the State's stratified-drift aquifers. This reactivation will help meet the objectives of the NYSDEC and the State Department of Health, as expressed in their "Framework for Ground-Water Management" (1982), which is:

". . . to assure that ground-water withdrawals do not endanger the value of the aquifer and to monitor ground water to determine baselines and trends. . .".

Specific wells that warrant reactivation include:

1. A-637, a "water-management" well in Guilderland (Albany County), that reflects municipal pumping from a segment of the confined Colonie Channel aquifer. Period of record 1976-95.

2. Re-703, a "water-management" well in East Greenbush (Rensselaer County) and screened in ice-contact deposits of the Schodack Terrace aquifer. Period of record 1982-95.

3. W-533, a "baseline" well in Washington County that reflects natural fluctuations in storage in a valley-fill aquifer. Period of record 1965-95.

4. Bm-100, a "baseline" well at the eastern end of the Johnson City-Binghamton primary aquifer (Broome County) that reflects natural fluctuations in storage. Period of record 1946-95.

5. Bm-128, a "baseline" well in Kattelville (Broome County), that monitors natural fluctuations in storage in a separated segment of valley-fill aquifer. Period of record 1980-95.

6. Cn-13, a "baseline" well in a separated valley-fill aquifer (without a major stream) near Sherburne, Chenango County. Designed as a network well, it reflects natural fluctuations in storage in an area unaffected by municipal pumping. Period of record 1980-95.

Long-term Goals

One of the main uses of the upstate network is to ascertain the status of ground-water storage in primary aquifers during drought conditions. Two priority long-term goals, therefore, are to (1) replace observation wells currently in either the "water-management" or "baseline" category that provide marginal data because of either improper well placement, lack of well screen, insufficient depth, or infilling with sediment with 6-inch-diameter drilled wells equipped with appropriate screens, and (2) install similar new "water-management" and "baseline" wells in primary aquifers throughout the State. The first aquifers in New York State, that would indicate a decline in ground-water storage in response to drought conditions are those that do not discharge directly to a major stream or river system—notably sand-plain aquifers, bedrock or till aquifers, and, to some extent, headwater and separated-valley aquifers. These aquifers, therefore, warrant representative "baseline" wells within each of the climatic zones described previously.

The "baseline" subnetwork would require at least one well finished in the sandstone and limestone aquifers of the St. Lawrence, Lake Champlain, Eastern Lake Ontario, and Lake Erie drainage systems (fig. 1); these wells also would fill the data deficiencies for bedrock aquifers in the corresponding climatic divisions and physiographic regions. Additionally, one or more baseline observation wells are needed in the shales of the Appalachian Plateau and in the igneous-metamorphic system of the Adirondacks (fig. 4). Till aquifers in the uplands were comparatively well represented in 1995 but not in 1997; selected wells finished in till warrant reactivation as the network is rebuilt.

Discussions with NYSDEC staff concerning areas of upstate New York into which the network should be expanded resulted in the identification of six areas in which ground-water-level data from stratified-drift aquifers are needed. These areas are:

1. South Fallsburg, in Sullivan County or Port Jervis, in Orange County

2. the Mohawk-Little Falls-Fonda area, in Herkimer and Montgomery Counties

3. the Elizabethtown area, in Essex County

4. the Oswego area, in Oswego County

5. the Seneca Falls - Auburn area, in Seneca and Cayuga Counties

6. the Batavia area, in Genesee County

The addition of baseline observation wells in these six areas would provide the necessary ground-water level data from stratified-drift aquifers needed during critical drought periods in NYSDEC Drought Management Regions 2, 4, 5, 6, and 7. The locations of these expansion areas and the NYSDEC Drought Management Regions are shown in figure 7.

In addition, many “water-management” wells screened in primary aquifers warrant evaluation for replacement in accordance with the site-selection criteria set forth by Heath (1976). For example, Schenectady County well Sn-363, a well that is not currently monitored, is screened within the cone of depression of the Schenectady well field and might be supplemented or replaced by a current NYSDEC observation well, about 2,000 ft to the southeast, and whose location might be better suited to record the collective drawdown of the wellfield. Other primary aquifers may require additional observation wells that meet the siting criteria for “water-management” wells. In addition, some of the current “baseline” wells are now affected by nearby pumping and could, therefore, be reassigned to the “water-management” network, and replacement “baseline” wells could be installed in more appropriate locations within each aquifer. The hydrographs and monthly water-level boxplots generated for the 1995 network of 46 wells (appendix 2) were inspected to identify which wells reflected the effects of pumping, and which wells responded properly as “baseline” wells.

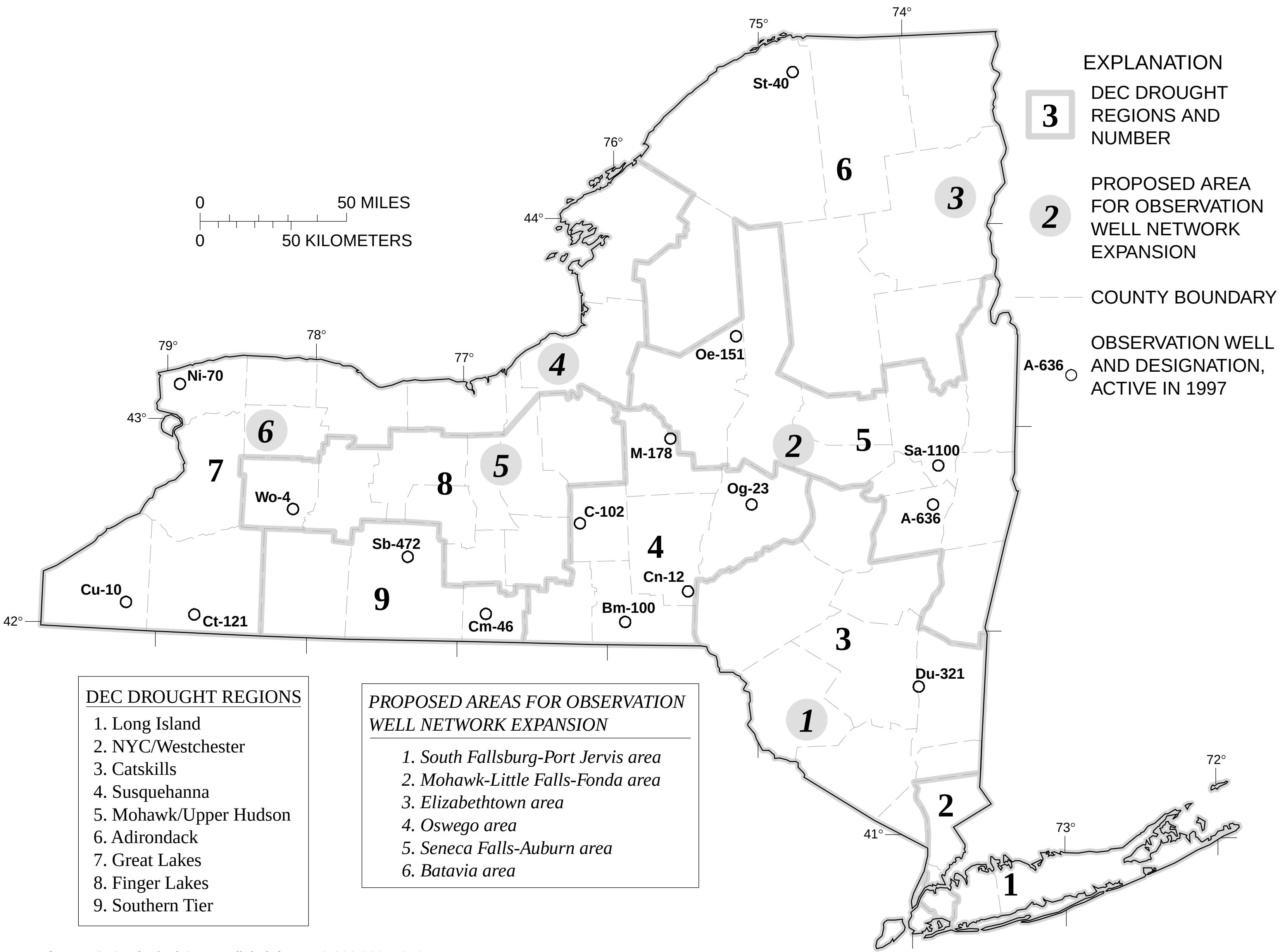
Water level data from the Statewide network are generally evaluated by NYSDEC staff on a monthly basis, whereas, water-level data from USGS recorder-equipped network wells are downloaded, evaluated, and made available to NYSDEC and the public on a 7-week basis. During periods of drought, however, changes in ground-water levels need to be monitored more frequently by the NYSDEC, perhaps on a weekly basis. These ground-water level data are an important basis for NYSDEC decisions as to whether conditions warrant the declaration of a drought “watch”, drought “warning”, or drought “emergency”.

Ground-water data could be made available to NYSDEC on an as-needed basis if recorder wells that are not equipped with electronic data loggers were so equipped, and if wells that are measured manually were automated with electronic data loggers. Regional NYSDEC staff in each of the State drought regions could then be instructed how to retrieve the most recent water-level reading that was logged, this would allow a team of NYSDEC regional observers to relay water-level data to NYSDEC headquarters during critical drought periods on a weekly or even daily basis.

SUMMARY AND CONCLUSIONS

Immediate efforts and continued long-term efforts are needed to reactivate key discontinued wells and to improve the overall quality and distribution of the Federal-State cooperative observation-well network in upstate New York, if the network is to enable Federal, state, and local water agencies to assess the effect of short- and long-term drought conditions, as well as ground-water pumping, on ground-water storage. A total of six selected observation wells in the “baseline” and “management” subnetworks warrant reactivation as soon as funding permits. Long-term objectives for improving the network include (1) replacing wells of inadequate construction with 6-inch-diameter drilled wells equipped with appropriate screens, (2) replacing “water-management” wells that are screened within cones of depression with wells farther from pumping centers, and (3) installing new “baseline” wells in six areas of the State to monitor ground-water levels in stratified-drift aquifer within several NYSDEC Drought Management Regions. In addition, at least one observation well is needed in both the “baseline” and “management” networks for each State-designated primary aquifer to allow continual assessment of natural and pumping-induced changes in ground-water storage.

New wells need to be carefully sited and constructed to ensure that the resulting water-level data accurately represent fluctuations in ground-water storage in the aquifer in which they are screened. Water level data from regional sandstone and limestone aquifers in the northern part of New York are lacking; therefore, future network-expansion plans ideally would include new “baseline” wells in aquifers in this part of the State. Timely reporting of data from the upgraded network could be enhanced by selectively training Regional NYSDEC



Base from U.S. Geological Survey digital data, 1:2,000,000, 1972
Albers Equal-Area Conic projection
Standard parallels 29°30' and 45°30', central meridian -96°00'

Figure 7. Drought Regions in New York State and proposed areas for expansion of observation well network.

observers to access recorder-equipped observation wells in their respective Regions and thereby provide water-level data on a weekly or daily basis during critical drought periods.

SELECTED REFERENCES

Busciolano, Ronald, Monti, Jack Jr., and Chu, Anthony, 1998, Water-table and potentiometric-surface altitudes of the upper glacial, Magothy, and Lloyd aquifers on Long Island, New York, in March-April, 1997, with a summary of hydrogeologic conditions: U.S. Geological Survey Water Resources Investigations Report 98-4019, 17 p.

Cullings, E.S., 1936, Fluctuations in ground-water at Woodgate, New York: Transactions, American Geophysical Union, pt. 2, 17th Annual Meeting, National Research Council, Washington, D.C., July 1936, p. 357-360.

Cosner, O.J., 1984, Atlas of four selected aquifers in New York: U.S. Environmental Protection Agency report, contract no. 68-01-6389, Norman, Oklahoma, Engineering Enterprises 102 p.

Emery, F.E., 1889, Notes on fluctuations in the height of water in an unused well: New York Agricultural Experiment Station, 8th Annual Report, p. 374-377.

Fenneman, N.M., 1938, Physiography of the eastern United States: New York, McGraw-Hill, 714 p.

Fisher, D.W., Isachsen, Y.W., and Rickard, L.V., 1970, Geologic map of New York: New York Museum and Science Service Map and Chart Series, No. 15, 5 sheets, 1:250,000 scale.

Harrington, A.W., 1935, Records of water levels in central New York, in Meinzer, O.E., and Wenzel, L.K., Water levels and artesian pressure in observation wells in United States, 1935: U.S. Geological Survey Water Supply Paper 777, p. 127-129.

Heath, R.C., 1976, Design of ground-water level observation well programs: Ground Water, v. 14, no. 2, p. 71-77.

Holland, W.T., and Jarvis, C.S., 1938, Inventory of unpublished hydrologic data: U.S. Geological Survey Water Supply Paper 837, 77 p.

New York State Department of Environmental Conservation and New York State Department of Health, 1982, New York State's framework for ground-water management—a program development strategy: mimeograph report, 17 p.

New York State Department of Health, 1981, Report on ground water dependence in New York State: New York State Department of Health, Bureau of Public Water Supply Report, 49 p.

Pack, A.B., 1972, The climate of New York, in Climates of the States, 1, Eastern States (plus Puerto Rico and the U.S. Virgin Islands): Syosset, N.Y., Water Information Center, p. 357-8.

Randall, A.D., 1996, Mean annual runoff, precipitation, and evapotranspiration in glaciated northeastern United States, 1951-80: U.S. Geological Survey Open-File Report 96-395, 2 sheets, scale 1:1,000,000.

Thompson, J.H., (ed.), 1966, Geography of New York State: Syracuse, N.Y., Syracuse University Press, 543 p.

Waller, R.M., and Finch, A.J., 1982, Atlas of 11 selected aquifers in upstate New York: U.S. Geological Survey Open-File Report 82-553, 255 p.

APPENDIXES

Appendix 1. Selected data on wells in U.S. Geological Survey Federal-State Cooperative observation-well network, fiscal years 1995 and 1997.

EXPLANATION OF COLUMN HEADINGS

County well no.: County well numbers are assigned by the USGS to each well in the USGS Ground water site Inventory (GWSI) data base. County well numbers are sequential within each county, and wells within each county are identified by a two letter prefix. Prefixes and their respective counties used here include:

A	Albany County	Oe	Oneida County
Bm	Broome County	Og	Otsego County
Ct	Cattaraugus County	Ot	Ontario County
Cy	Cayuga County	P	Putnam County
Cu	Chautauqua County	Re	Rensselaer County
Cm	Chemung County	Ro	Rockland County
Cn	Chenango County	St	St. Lawrence County
C	Cortland County	Sa	Saratoga County
D	Delaware County	Sb	Steuben County
Du	Dutchess County	Sn	Schenectady County
G	Greene County	U	Ulster County
H	Hamilton County	W	Washington County
M	Madison County	We	Westchester County
Mt	Montgomery County	Wo	Wyoming County
Ni	Niagara County		

Site Identifier: A unique 15-digit number that identifies each well within the GWSI database. It initially consists of the latitude and longitude of the well location, followed by a two-digit sequence number; subsequent revisions in latitude-longitude of the well are not reflected in the site identifier, but rather in its latitude and longitude. Wells that share essentially the same location are distinguished by sequential numbers.

Period of record: The period(s) of time over which water-level data were collected at the well on a continual basis.

Aquifer material: Lithology of the aquifer material in which the well is completed.

Aquifer code: An eight-character code from the USGS GWSI database that indicates the primary aquifer in which the well is completed. Aquifer codes used here include:

112SAND	Pleistocene-age sand deposits (undifferentiated)
112ICNC	Pleistocene-age ice-contact (kame) deposits
112SDGV	Pleistocene-age sand and gravel deposits (undifferentiated)
112TILL	Pleistocene-age till deposits
112GLCD	Pleistocene-age glaciolacustrine deposits
112KMTC	Pleistocene-age kame-terrace deposits
112OTSH	Pleistocene-age outwash deposits
112GRVL	Pleistocene-age gravel deposits (undifferentiated)
351CMLS	Upper Silurian-age Camillus Shale
355LCKP	Middle Silurian-age (Niagran) Lockport Dolomite
367BKMN	Lower Ordovician-age Beeckmantown Group
400BCPX	Precambrian-age basement complex
BEDROCK	Undifferentiated bedrock

Aquifer type:	Water table - Water in this aquifer is primarily under unconfined (at atmo spheric pressure) conditions. Confined - Water in this aquifer is under confined (artesian, or greater than atmospheric pressure) conditions.
Well type	Refers to the method of well construction, as follows: drilled - installed by conventional drilling methods such as air-rotary, hydrau lic-rotary, reverse-rotary, or cable-tool drilling. Drilled wells are generally 6 to 8 inches in diameter. dug - large-diameter, hand-dug wells of walled, tile, or stone construction. augered - Small-diameter (less than 4 inches) well installed with a hollow-stem auger drill rig. driven - generally refers to small-diameter (less than 2 inches) wells equipped with a well point and are hand-driven into the aquifer. May also include some 6-inch-diameter wells driven by cable-tool equipment.
Well depth:	Depth of completed well, in feet below land surface
Well diameter:	Nominal inside diameter of largest casing used in well, in inches
Screened zone:	Depth to the top and bottom of the well interval open to the aquifer, in feet below land surface.
Physiographic region:	One of the nine physiographic provinces in New York in which the well is located. (See fig. 3.)
Climatic zone:	One of the 10 climatic zones in New York in which the well is located. (See fig. 2.)
Average annual precipitation:	Estimated average annual precipitation near each well location. (Data from Randall, 1996).
Topographic setting:	A general description of the topographic setting of the well location.
Annual water-level range:	Average annual range in water-level fluctuation in the well.
Network:	One of two networks—“baseline” or “water management” to which the well belongs
Lowest water level:	The lowest water level recorded in the well during the period of record, in feet below land surface.
Remarks:	Miscellaneous information about the well or its performance, or suggestions for improvement or replacement.

Appendix 1. Selected data for wells in the U.S. Geological Survey Federal-State cooperative observation- well network in New York, fiscal years 1995 and 1997.*

[Wells in boldface indicate reactivated wells currently funded in FY97. Average annual precipitation data from Randall (1996).]

A. EASTERN NEW YORK

County well no.	Site no.	Period of record	Aquifer material	Aquifer code	Aquifer type	Well type	Well depth (ft)	Well diam (in)	Screened (open) zone	Physiographic region
A-636	424114073495402	5/74-8/95	sand	112SAND	water table	drilled	24	6	22-24	Hudson-Mohawk Lowland
A-637	420440073535101	8/76-8/95	sand and gravel	112ICNC	confined	drilled	198	6	193-198	Hudson-Mohawk Lowland
D-492	420748075043101	9/77-8/83 10/84-8/95	shale and sandstone	BEDROCK	confined	drilled	180	6	30-180	Appalachian Upland
Du-321	414737073563301	9/48-4/50 4/53-9/97	shale	BEDROCK	confined	drilled	127	6	unknown	Appalachian Upland
Du-1009	414128073475201	10/65-4/69 6/71-7/89 12/91-9/93	sand and gravel	112SDGV	water table	augered	27	2.5	25-27	Appalachian Upland
G-1	422319073482001	12/45-8/95	till	112TILL	water table	dug	17	36	2-17	Appalachian Upland
H-3	432832074122201	11/65-8/95	sand	112SAND	water table	augered	19	2.5	16-19	Adirondack Uplands
Mt-1	430141074423501	10/42-8/95	till	112TILL	water table	dug	12	24	0-12	Hudson-Mohawk Lowland
Oe-151	433112075091501	7/26-8/45 10/48-present	sand	112SAND	water table	dug	31	36	0-31	Adirondack Uplands
Oe-766	433012075134202	11/68-8/95	sand	112SAND	water table	driven	33	6	open end	Adirondack Uplands
P-609	412450073413101	1/35-9/45 9/50-8/95	till	112TILL	water table	dug	16.1	36	0-16	New England Upland
Re-700	423834073391001	9/54-8/95	sand and gravel	112SDGV	water table	dug	15.9	48	0-16	New England Upland
Re-703	423534073423401	10/82-8/95	sand and gravel	112SDGV	confined	drilled	80	6	78-80	New England Upland
Ro-18	411802073593001	7/49-9/90 11/91-9/93	granite	400BCPX	confined	drilled	60	6	53-60	New England Upland
St-40	444904074455201	5/53-8/95	sand	112SAND	water table	dug	11.3	36	0-11.3	St. Lawrence Lowland
St-404	445216074593001	6/58-11/64 11/85-8/95	dolomite	367BKMN	confined	drilled	178.9	6	54-179	St. Lawrence Lowland
Sa-529	430327073475401	5/49-11/61 8/64-8/95	dolomite	BEDROCK	confined	drilled	288	6	189-288	Hudson-Mohawk Lowland
Sa-1072	430013073370401	7/59-8/95	sand	112SAND	water table	drilled	24	6	21-24	Hudson-Mohawk Lowland
Sa-1100	425242073473201	4/83-present	sand and gravel	112ICNC	confined	drilled	180	6	open end	Hudson-Mohawk Lowland
Sn-363	424910073591401	6/60-8/95	sand and gravel	112SDGV	water table	drilled	57	6	open end	Hudson-Mohawk Lowland
U-204	414425074213601	10/54-9/87 1/90-8/95	till	112TILL	water table	drilled	67	8	open end?	Appalachian Upland
U-405	414948074035101	10/64-7/65 3/66-12/74 4/76-8/95	sand	112SAND	water table	augered	36	2.5	34-36	Hudson-Mohawk Lowland
W-533	431030073192101	3/74-8/95	sand and gravel	112SDGV	water table	drilled	16	6	open	New England Upland
We-3	411421073481201	4/34-9/37 4/38-8/45 3/51-8/95	sand	112SAND	water table	dug	18.2	36	0-18.2	New England Upland

* Fiscal year (FY) is from October 1 through September 30; thus, FY 1995 began on October 1, 1994.

Appendix 1. Selected well data for U.S. Geological Survey Federal-State cooperative observation- well network in New York, fiscal years 1995 and 1997 (continued)

A. EASTERN NEW YORK

County well no.	Climatic Zone	Avg. annual precip (inches).	Topo-graphic setting	Annual water-level range	Network	Lowest water level (ft)	Remarks
A-636	Hudson Valley	38	upland plain	7	baseline	13.13	Replaced A-635 in 1965. Discontinued in 1995. Reactivated in 1997.
A-637	Hudson Valley	40	upland plain	14	water mgmt.	132.44	Confined channel aquifer. Discontinued in 1995.
D-492	Eastern Plateau	45	hilltop	60+	baseline	180	Affected by pumping? Responds rapidly to recharge. Discontinued in 1995.
Du-321	Hudson Valley	38	hilltop	8	baseline	73.85	Casing depth unknown. Responds to semidiurnal earth tides (0.05 feet).
Du-1009	Hudson Valley	40	valley floor	9	baseline	20.6	Discontinued in 1993. Stream control? Reactivated in 1997.
G-1	Hudson Valley	36	upland plain	10	baseline	15.56	Discontinued in 1995.
H-3	Northern Plateau	46	valley terrace	9	baseline	16.19	Lowest water level below top of screen. Discontinued in 1995
Mt-1	Mohawk Valley	40	upland	3	baseline	9.99	Discontinued in 1995.
Oe-151	Northern Plateau	48	upland plain	19	baseline	30.31	Federal network well until 1996. Lowest water level within 1 foot of well bottom.
Oe-766	Northern Plateau	48	upland plain	9	baseline	23.58	Discontinued in 1995. Candidate replacement well for Oe-151.
P-609	Hudson Valley	48	hillside	16	baseline	dry	Well goes dry frequently in fall. Discontinued in 1995.
Re-700	Hudson Valley	36	upland	6	baseline	15.49	Lowest water level within 1/2 foot of bottom. Discontinued in 1995
Re-703	Hudson Valley	36	upland plain	9	water mgmt.	41.93	Replaced Re-701 in 1982. May be affected by pumping. Discontinued in 1995.
Ro-18	Hudson Valley	48	hillside	18	baseline	33	Discontinued in 1993.
St-40	St. Lawrence	33	plain	6	baseline	9.38	Discontinued in 1995. Reactivated in 1997.
St-404	St. Lawrence	33	plain	5	baseline	16.77	Discontinued in 1995.
Sa-529	Hudson Valley	37	upland plain	16	baseline	56.2	Water level affected by earthquakes and distant pumping. Discontinued in 1995.
Sa-1072	Hudson Valley	36	upland plain	8	water mgmt.		Well filled in to 19.6 feet. Affected by nearby pumping. Discontinued in 1995.
Sa-1100	Hudson Valley	36	upland plain	85	water mgmt.	107.38	Well in cone of depression of nearby supply well. Suggest replacement with another well in Clifton Park.
Sn-363	Mohawk Valley	36	valley floor	27	water mgmt.	31.27	Located within municipal well field cone of depression. Also affected by stage of Mohawk River. Discontinued in 1995. Recommend replacement with I-890 loop well.
U-204	Eastern Plateau	45	Alluvial fan	10	baseline	26.9	Filled-in to 45.6 feet. Aquifer and open interval unknown. Suggest geophysical logging to confirm aquifer and construction. Discontinued in 1995.
U-405	Hudson Valley	42	valley floor	7	baseline	20.7	Filled-in to 33.3 feet. Installed within a pre-existing dug well. Discontinued in 1995.
W-533	Hudson Valley	38	valley floor	4	baseline	7.77	Filled-in to 15.2 feet. Replaced nearby well W-532 in 1974. Discontinued in 1995.
We-3	Hudson Valley	47	hillside	15	baseline	dry	Located 500 ft from New Croton Reservoir. Frequently goes dry in autumn. Discontinued in 1995. Filled-in to 17 feet.

Appendix 1. Selected data for wells in the U.S. Geological Survey Federal-State cooperative observation- well network in New York, fiscal years 1995 and 1997.*

[ft, feet, in, inches, mi, mile. Wells in boldface indicate reactivated wells funded in Fiscal Year 97. Average annual precipitation data from Randall (1996).]

B. WESTERN NEW YORK

County well no.	Site no.	Period of record	Aquifer material	Aquifer code	Aquifer type	Well type	Well depth (ft)	Well diam (in)	Screened (open) zone	Physiographic Region
Bm-100	420646075531201	10/46-7/55 4/66-8/95	sand-gravel	112SDGV	water table	drilled	52	6	40-45	Appalachian Upland
Bm-121	420657075583501	3/47-8/95	sand	112SDGV	water table	drilled	53	6	open end	Appalachian Upland
Bm-128	421138075511301	9/80-8/95	sand-gravel	112ICNC	water table	drilled	53	6	48.5-53	Appalachian Upland
Bm-129	421157075535401	11/85-8/95	shale	BEDROCK	confined	drilled	252	6	?	Appalachian Upland
Ct-121	420530078445201	9/50-present	sand-gravel	112SDGV	confined	drilled	53	6	open end	Appalachian Upland
Cy-7	424158076251901	12/65-8/95	gravel	112SDGV	water table	drilled	28	2.5	26-28	Appalachian Upland
Cu-5	420326079295801	5/49-8/95	till	112TILL	water table	dug	33	36	0-33	Appalachian Upland
Cu-10	420815079121401	11/39-9/43 8/46-8/95	sand-gravel	112GLCD	confined	drilled	232	12/10	130-144	Appalachian Upland
Cu-104	420748079062701	9/62-10/62 3/83-8/95	sand-gravel	112GLCD	confined	drilled	79	6	69-79	Appalachian Upland
Cm-46	420829076484801	10/55-present	sand-gravel	112SDGV	water table	drilled	34	6	open end	Appalachian Upland
Cn-12	421556075281602	4/75-present	gravel	112SDGV	water table	drilled	13	6	open end	Appalachian Upland
Cn-13	423849075315701	4/84-4/94	sand-gravel	112KMTC	confined	drilled	125	6	121-125	Appalachian Upland
C-102	423541076114701	10/75-present	gravel	112OTSH	water table	driven	45	1.25	43-45	Appalachian Upland
M-178	430056075354102	4/75-8/95	gravel	112GRVL	water table	drilled	16	6	open end	Appalachian Upland
Ni-69	430655079022001	10/58-8/95	dolomite	355LCKP	confined	drilled	36	8/6	17-36	Erie-Ontario Lowland
Ni-70	431308078544501	8/72-present	sand	112SAND	water table	dug	24	48	0-24	Erie-Ontario Lowland
Ot-900	425840077133901	5/55-8/95	shale	351CMLS	confined	drilled	139	6	11-139	Appalachian Upland
Og-23	424136075025101	5/53-8/95	till	112TILL	water table	dug	15	36	0-15	Appalachian Upland
Sb-472	422445077203301	11/65-present	gravel	112SDGV	water table	driven	18	2.5	16-18	Appalachian Upland
Sb-473	420811077021501	9/89-8/95	sand-gravel	112OTSH	water table	drilled	83	6	open end	Appalachian Upland
Wo-1	423739077595501	11/42-present	till	112TILL	water table	driven	15	2	13-15	Appalachian Upland
Wo-4	423743078070802	5/74-present	sand	112SAND	water table	drilled	20	6	open end	Appalachian Upland

* Fiscal year (FY) is from October 1 through September 30; thus, FY 1995 began on October 1, 1994.

Appendix 1. Selected well data for U.S. Geological Survey Federal-State cooperative observation- well network in New York, fiscal years 1995 and 1997 (continued)

B. WESTERN NEW YORK

County well no.	Climatic Zone	Avg. annual precip. (inches)	Topo-graphic setting	Annual water-level range	Network	Lowest water level (ft)	Remarks
Bm-100	Eastern Plateau	38	valley floor	4	baseline/ mgmt	13.2	Affected by nearby pumping? Discontinued in 1995.
Bm-121	Eastern Plateau	38	valley floor	24	mgmt	29.4	Water level affected by high stages of Susquehanna River and by pumping from wellfield 1100 ft south. Discontinued in 1995; reactivated in 1997.
Bm-128	Eastern Plateau	36	valley floor	13	baseline/ mgmt	32.8	Water level may be affected by school supply well 300 ft west and public supply well to the east. Discontinued in 1995.
Bm-129	Eastern Plateau	36	hillside	9	baseline	75.8	Length of open bore unknown. Discontinued in 1995.
Ct-121	Western Plateau	44	upland valley	7	baseline	34.8	Water levels affected by local pumping 1969-79.
Cy-7	Central Lakes	38	valley floor	8	baseline	25	Lowest water level within 1 ft of top of screen. Discontinued in 1995.
Cu-5	Great Lakes	44	upland	9	baseline	9.4	NYSDEC owned. Discontinued in 1995. Poor record except for digital recorder record, 4/90-9/92.
Cu-10	Great Lakes	44	valley floor	38	mgmt	66.6	Affected by pumping from municipal well field. Long period of record. Discontinued in 1995; reactivated in 1997. Within well field.
Cu-104	Great Lakes	44	valley floor	24	mgmt	21.3	Water level reflects pumping from Jamestown wellfield & stage of nearby Conewango Creek. Discontinued in 1995.
Cm-46	Western Plateau	34	valley floor	7	baseline	26.3	Water level affected by stage of Newtown Creek. Federal network well, in 1997.
Cn-12	Eastern Plateau	42	valley floor	9	baseline	11.8	Replaced nearby well Cn-11 (10/65-9/72) in 1974. Lowest water level close to bottom of well. 0.5 mi southeast of Susquehanna River.
Cn-13	Eastern Plateau	40	valley floor	6	baseline	10.17	Installed in 1980 as observation well for Statewide network. Water levels may reflect barometric effects and (or) slight pumping effects from nearby domestic well. Discontinued in 1994. Suggest reactivation.
C-102	Eastern Plateau	42	valley floor	11	mgmt	14.5	Too close to well field? Baseline well is needed in this primary aquifer. This well replaced C-19 (2/47-5/76).
M-178	Eastern Plateau	40	valley floor	8	baseline	10.97	Replaced well M-177 (10/65-9/73) in 1974. Discontinued 1995
Ni-69	Great Lakes	33	plain	6	baseline	22.3	Open to confined and unconfined zones. Discontinued in 1995.
Ni-70	Great Lakes	32	plain	13	baseline	13.88	Federal network well in 1997.
Ot-900	Central Lakes	32	plain	7	baseline	+4.4	Artesian well; water level always above land surface. Casing is 11.6 ft above surface. Discontinued in 1995.
Og-23	Eastern Plateau	41	upland	10	baseline	12.66	Good annual response to precipitation. No long-term changes in storage noted. Discontinued in 1995.
Sb-472	Western Plateau	34	valley floor	7	baseline	10.8	Good annual response to precipitation. No long-term changes in storage noted. Screen partly filled in; well depth 17 ft.
Sb-473	Western Plateau	33	valley floor	8	baseline	9.42	Water levels affected by stage of Chemung River. Discontinued in 1995.
Wo-1	Western Plateau	33	upland	13	baseline	dry	Went dry for the month of December 1964. NYSDEC owned. Discontinued in 1995.
Wo-4	Western Plateau	37	upland	7	baseline	14	Replaces well Wo-2 (11/65-5/74).

Appendix 2. Ten-year hydrographs (1986-96) of water levels at 46 observation wells in the U.S. Geological Survey Federal-State Cooperative observation-well network in upstate New York, 1995 and 1997, and boxplots showing median monthly water levels and monthly percentile statistics (in alphabetical order by county)

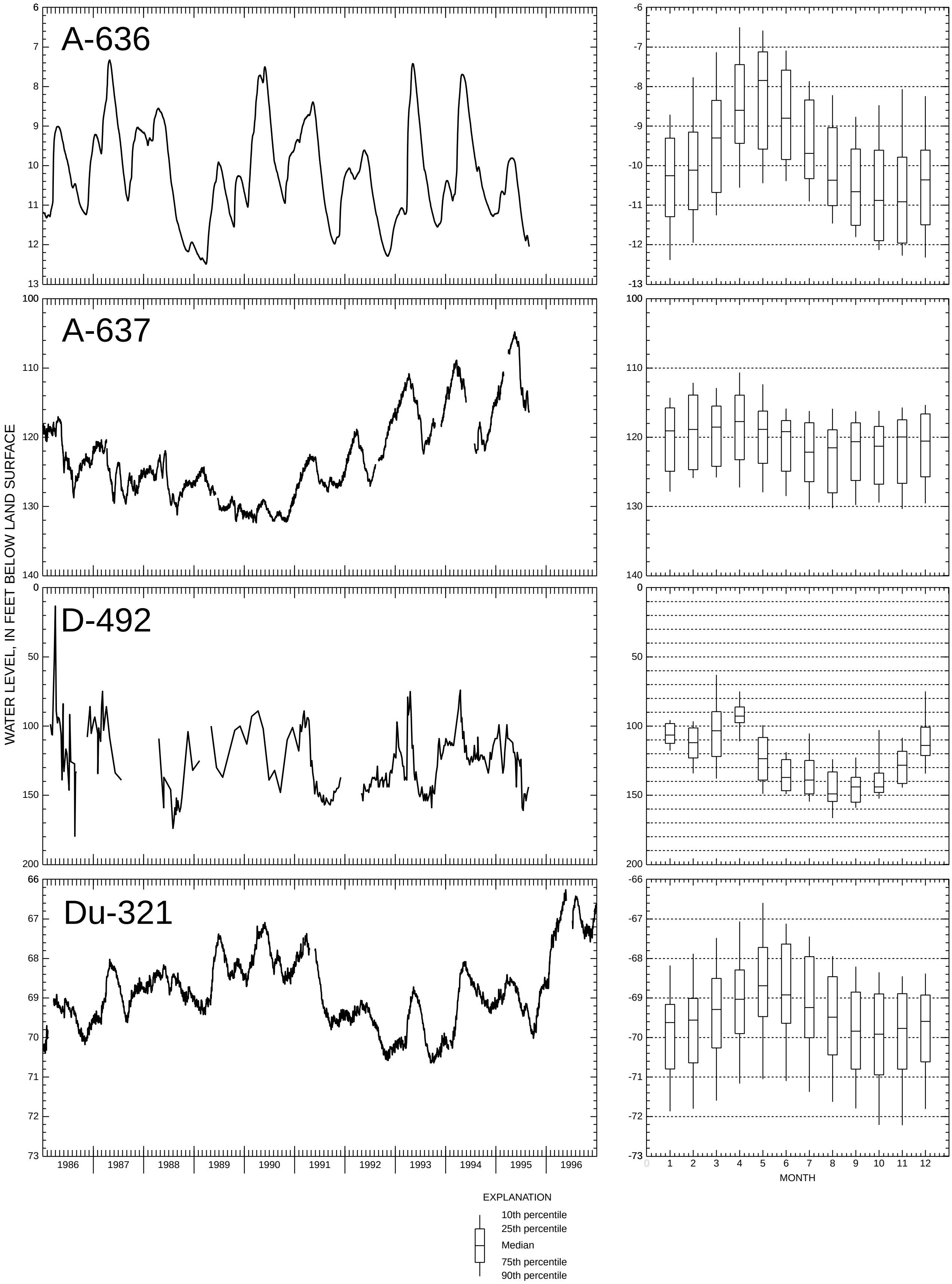


Figure A1. Ten-year hydrographs (1986-96) and boxplots showing median monthly water levels and monthly percentile statistics for observation wells A636 (Albany County), A637 (Albany County), D492 (Delaware County), and Du 321 (Dutchess County).

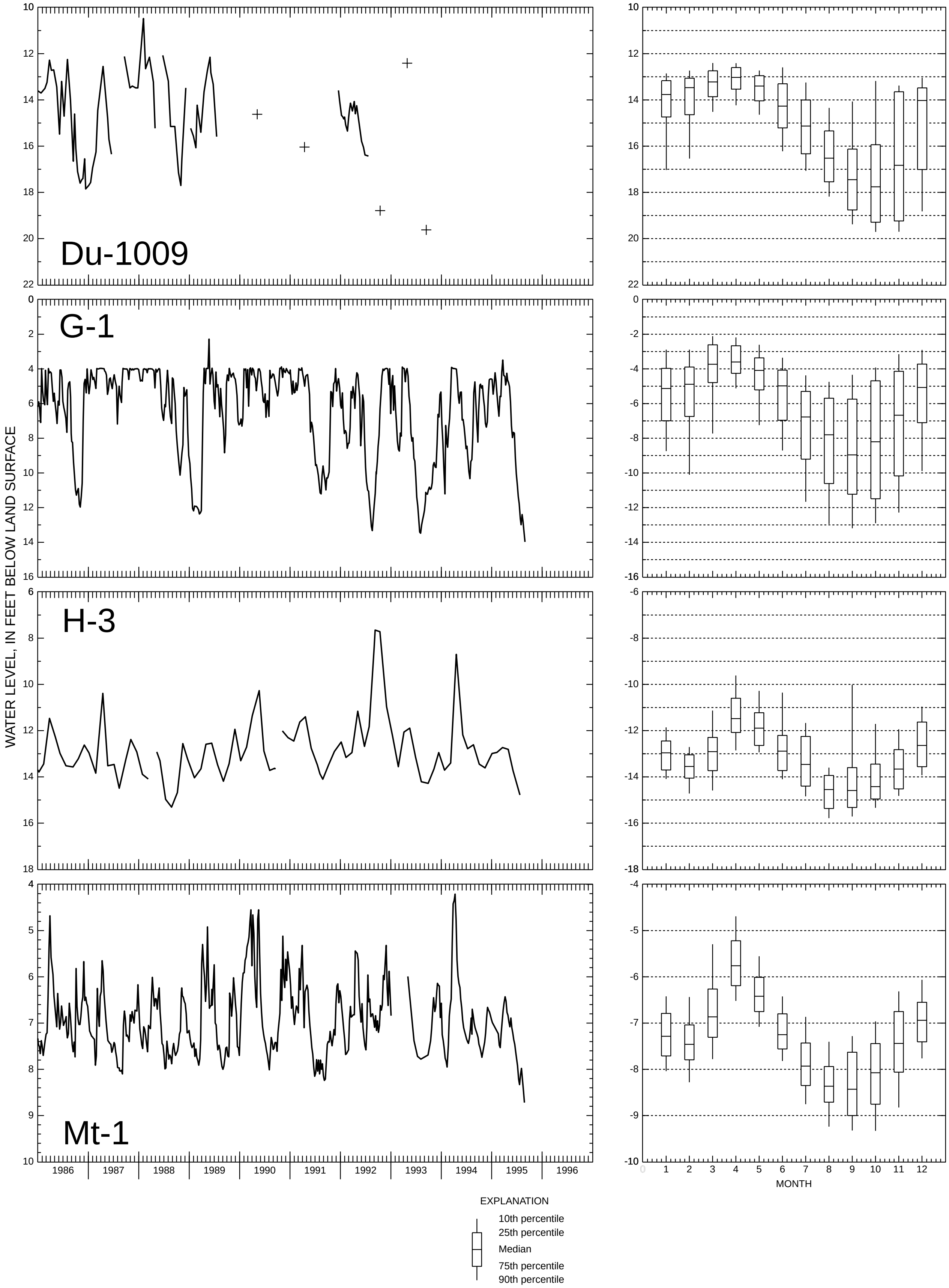


Figure A2. Ten-year hydrographs (1986-96) and boxplots showing median monthly water levels and monthly percentile statistics for observation wells Du-1009 (Dutchess County), G-1 (Greene County), H-3 (Hamilton County), and Mt-1 (Montgomery County).

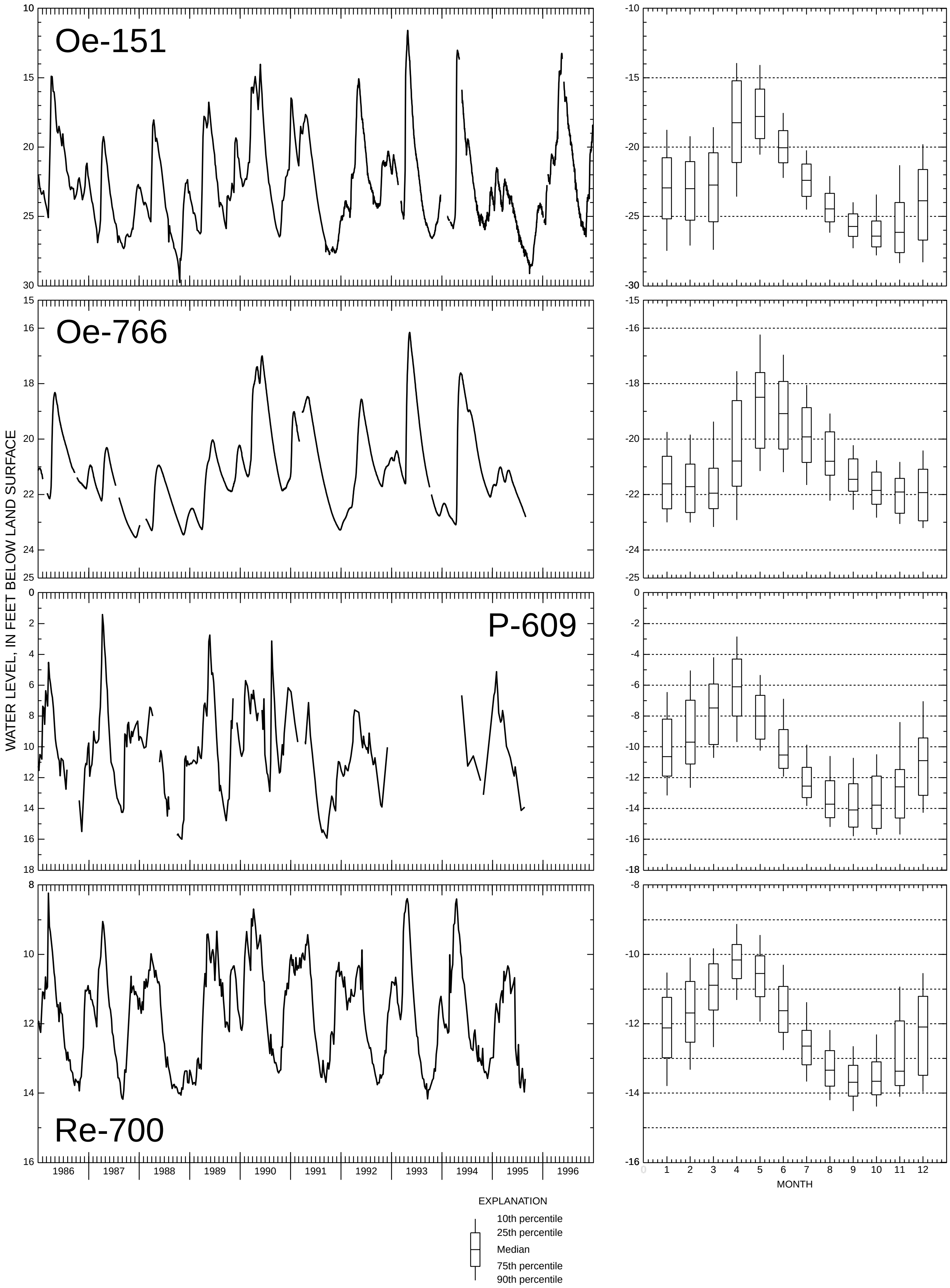


Figure A3. Ten-year hydrographs (1986-96) and boxplots showing median monthly water levels and monthly percentile statistics for observation wells Oe-151 (Oneida County), Oe-766 (Oneida County), P-609 (Putnam County), and Re-700 (Rensselaer County).

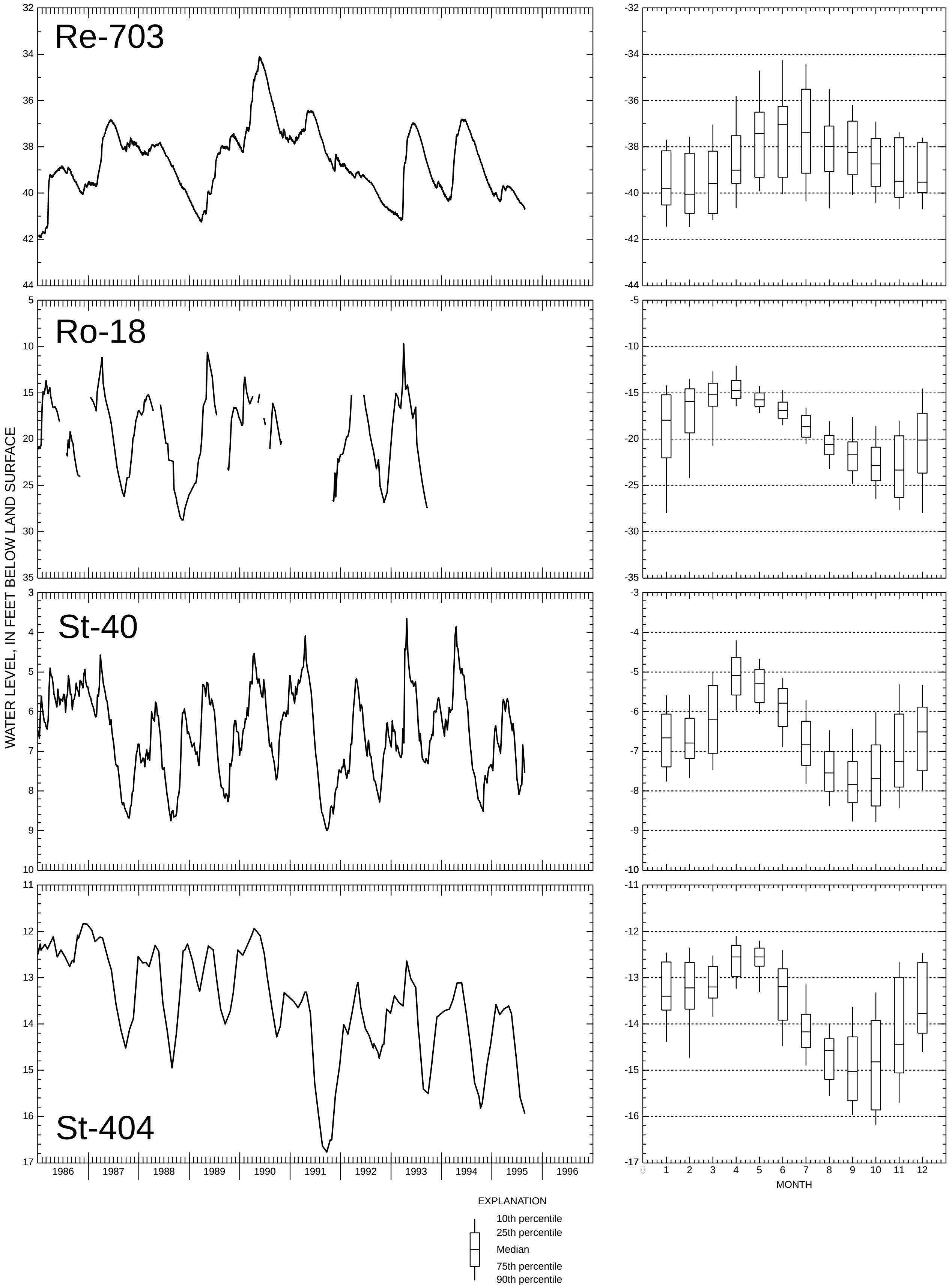


Figure A4. Ten-year hydrographs (1986-96) and boxplots showing median monthly water levels and monthly percentile statistics for observation wells Re-703 (Rensselaer County), Ro-18 (Rockland County), St-40 (St. Lawrence County), and St-404 (St. Lawrence County).

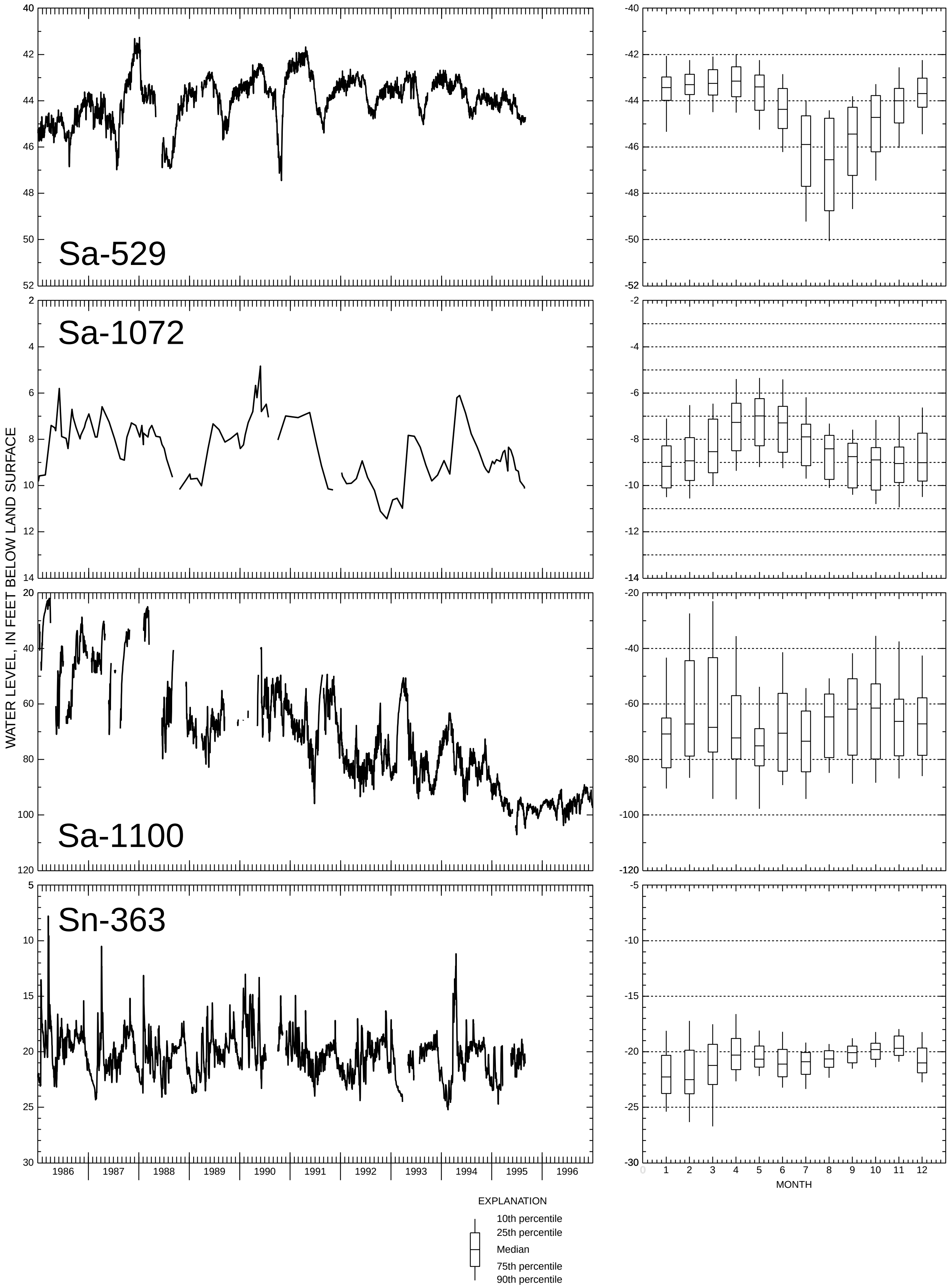


Figure A5. Ten-year hydrographs (1986-96) and boxplots showing median monthly water levels and monthly percentile statistics for observation wells Sa-529 (Saratoga County), Sa-1072 (Saratoga County), Sa-1100 (Saratoga County), and Sn-363 (Schenectady County).

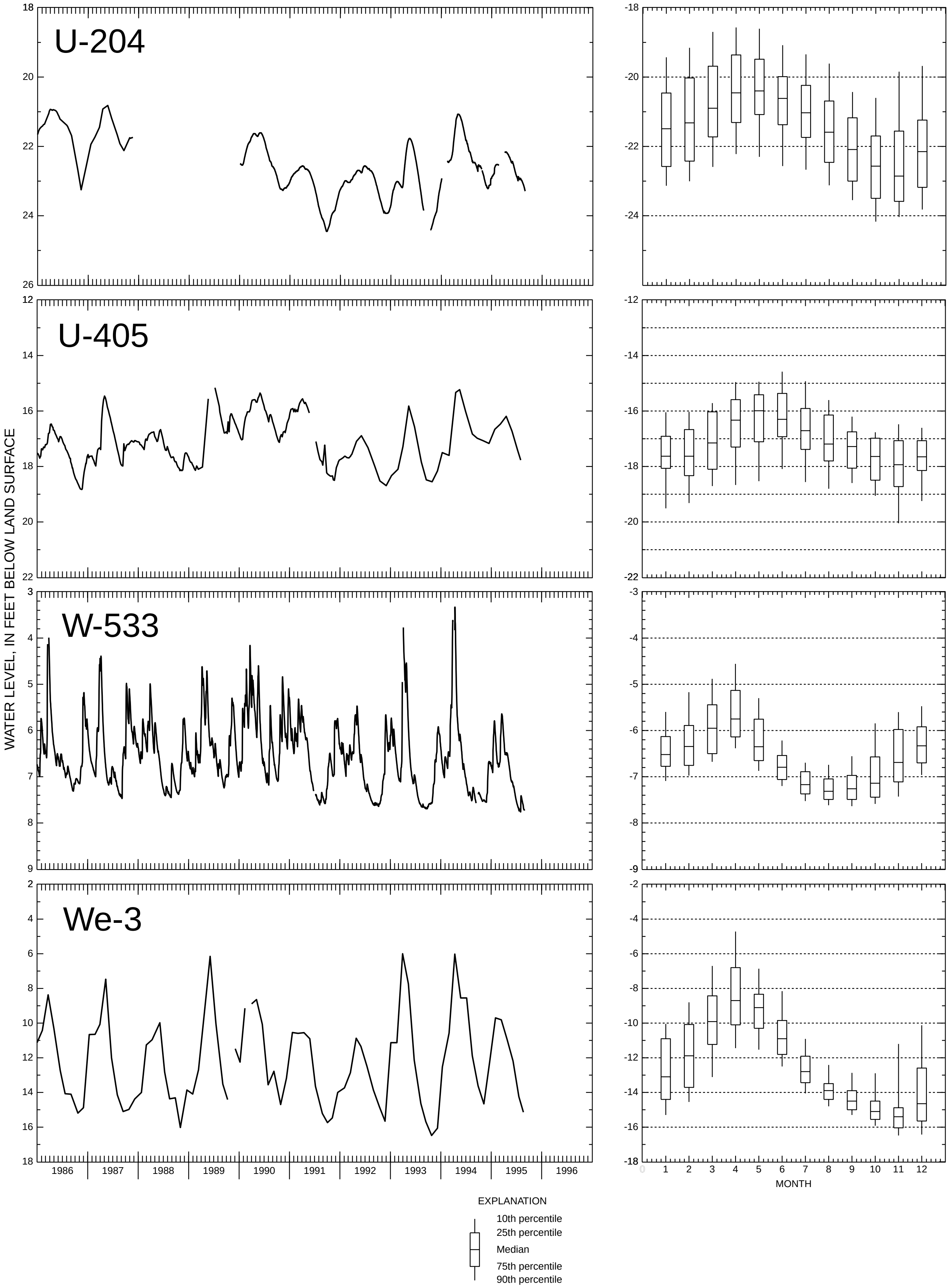


Figure A6. Ten-year hydrographs (1986-96) and boxplots showing median monthly water levels and monthly percentile statistics for observation wells U-204 (Ulster County), U-405 (Ulster County), W-533 (Washington County), and We-3 (Westchester County).

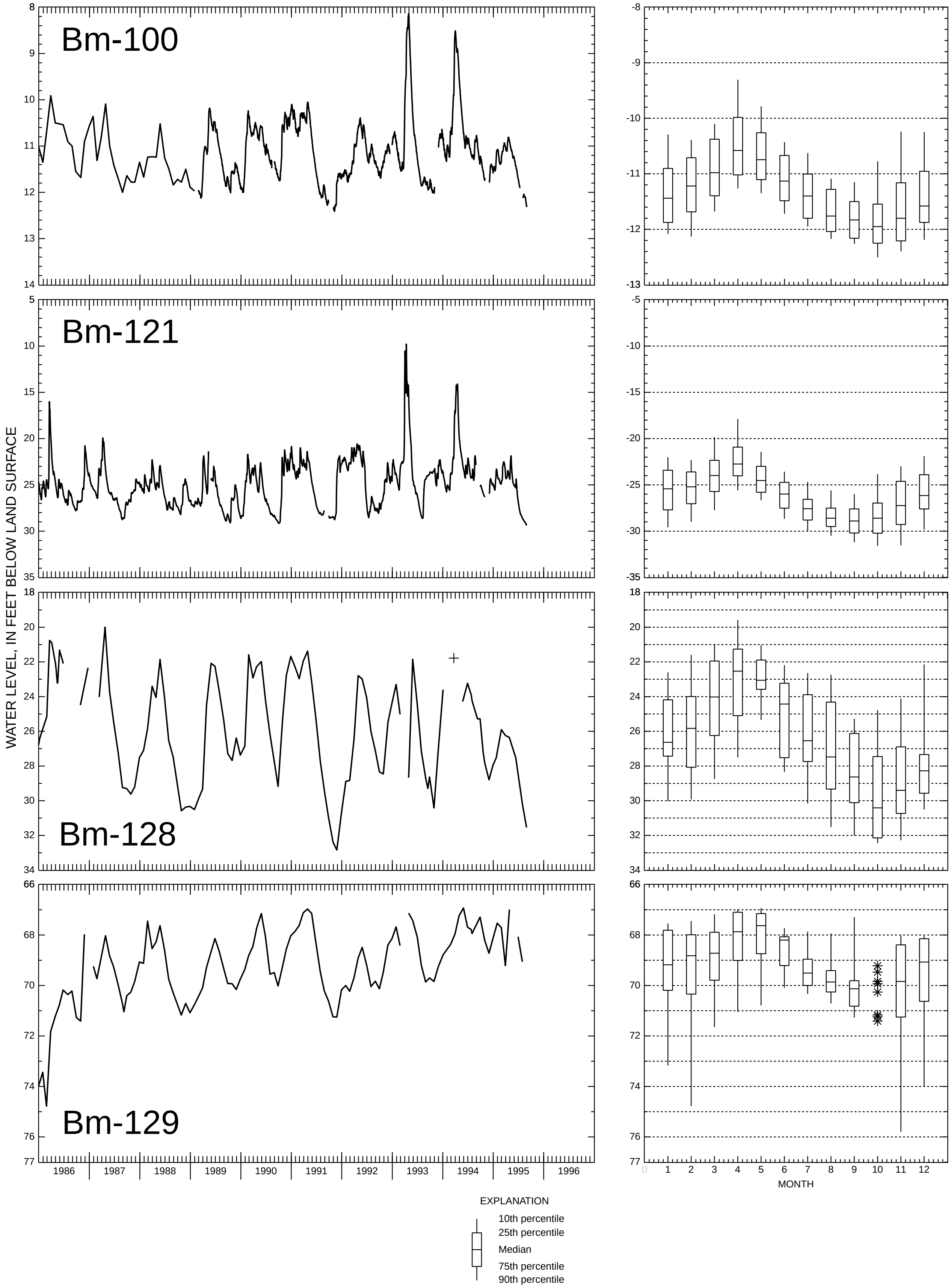


Figure B1. Ten-year hydrographs (1986-96) and boxplots showing median monthly water levels and monthly percentile statistics for observation wells Bm-100 (Broome County), Bm-121 (Broome County), Bm-128 (Broome County), and Bm-128 (Broome County).

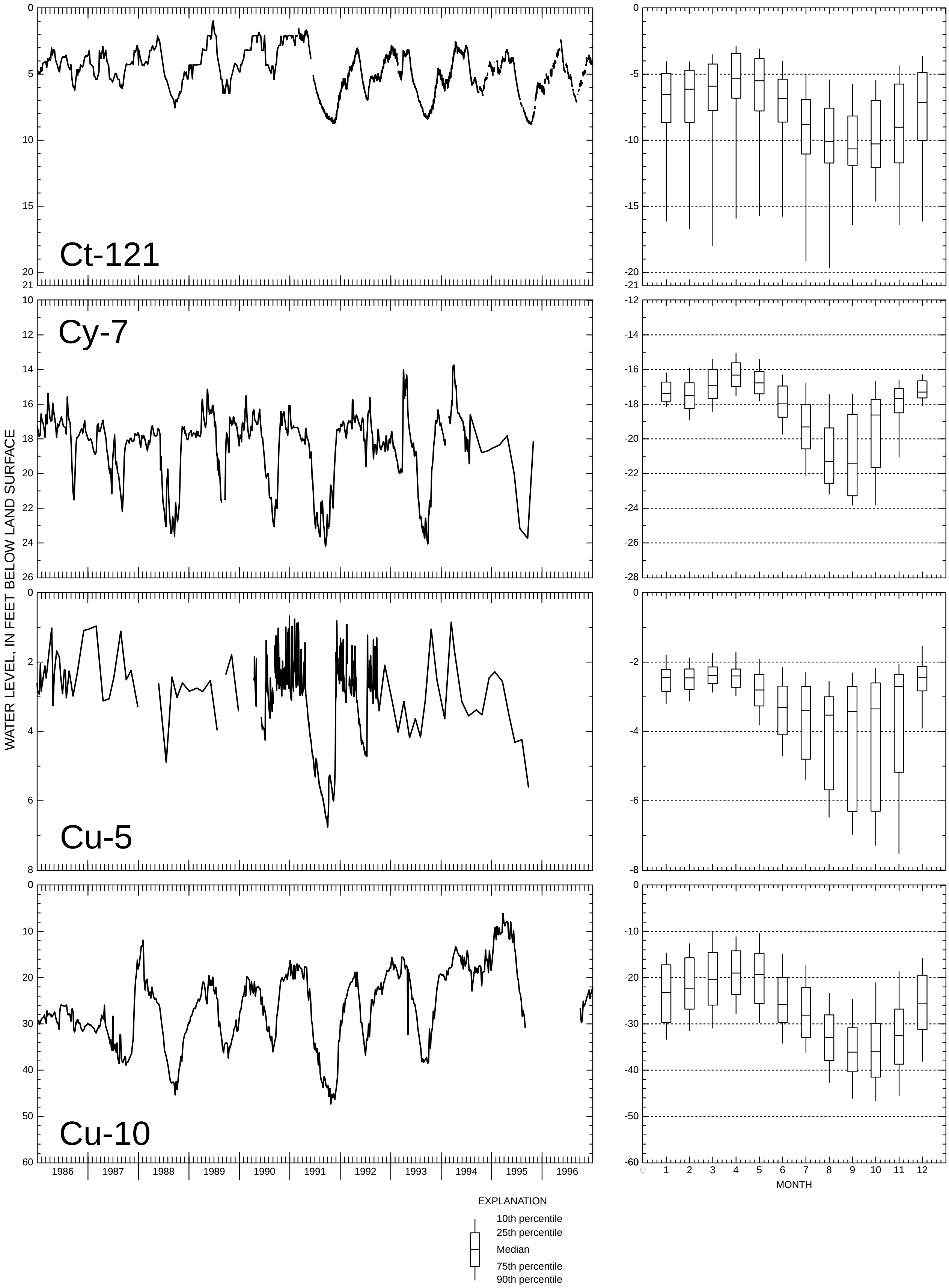


Figure B2. Ten-year hydrographs (1986-96) and boxplots showing median monthly water levels and monthly percentile statistics for observation wells Ct-121 (Cattaraugus County), Cy-7 (Cayuga County), Cu-5 (Chautauqua County), and Cu-10 (Chautauqua County).

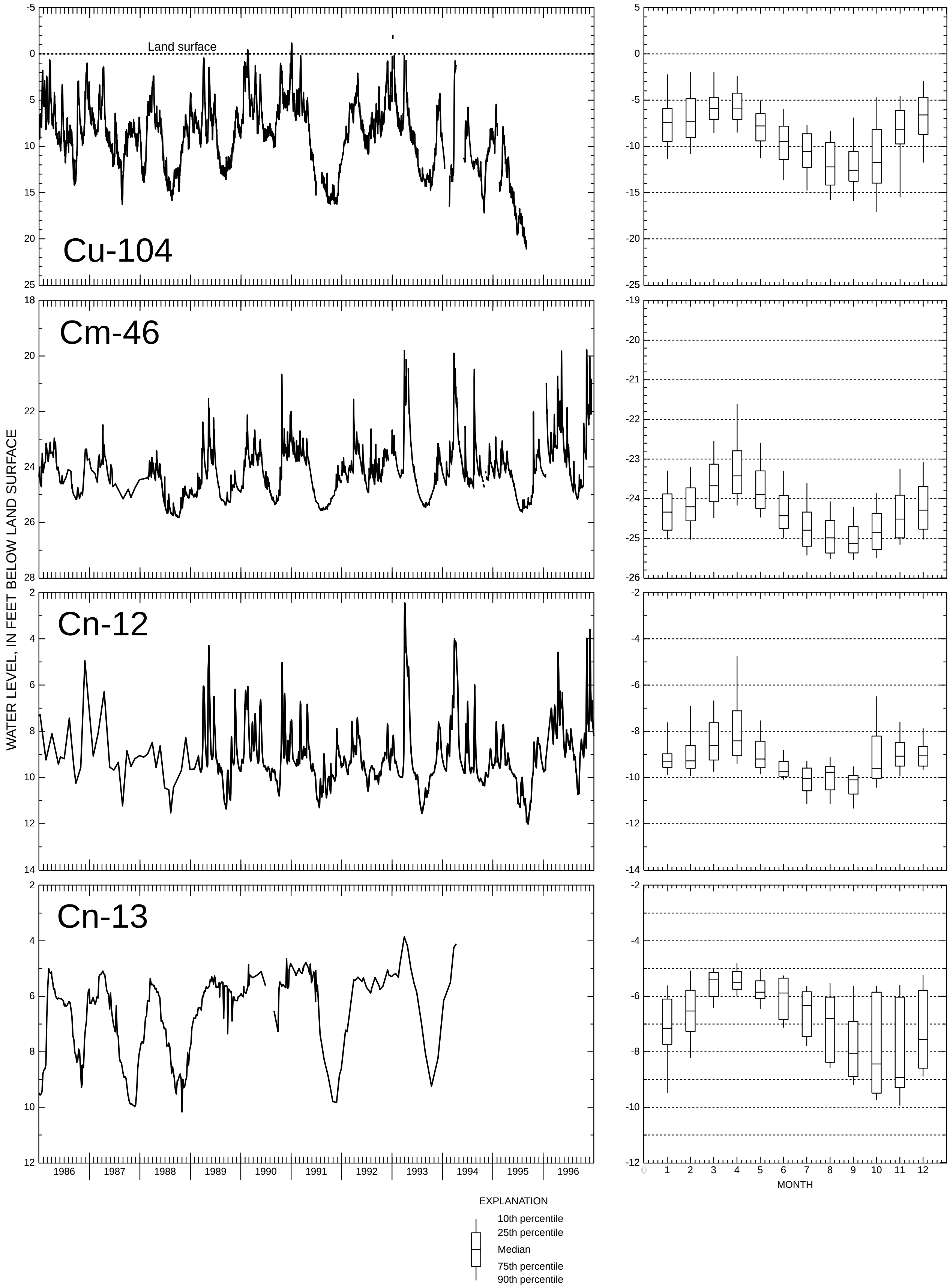


Figure B3. Ten-year hydrographs (1986-96) and boxplots showing median monthly water levels and monthly percentile statistics for observation wells Cu-104 (Chautauqua County), Cm-46 (Chemung County), Cn-12 (Chenango County), and Cn-13 (Chenango County).

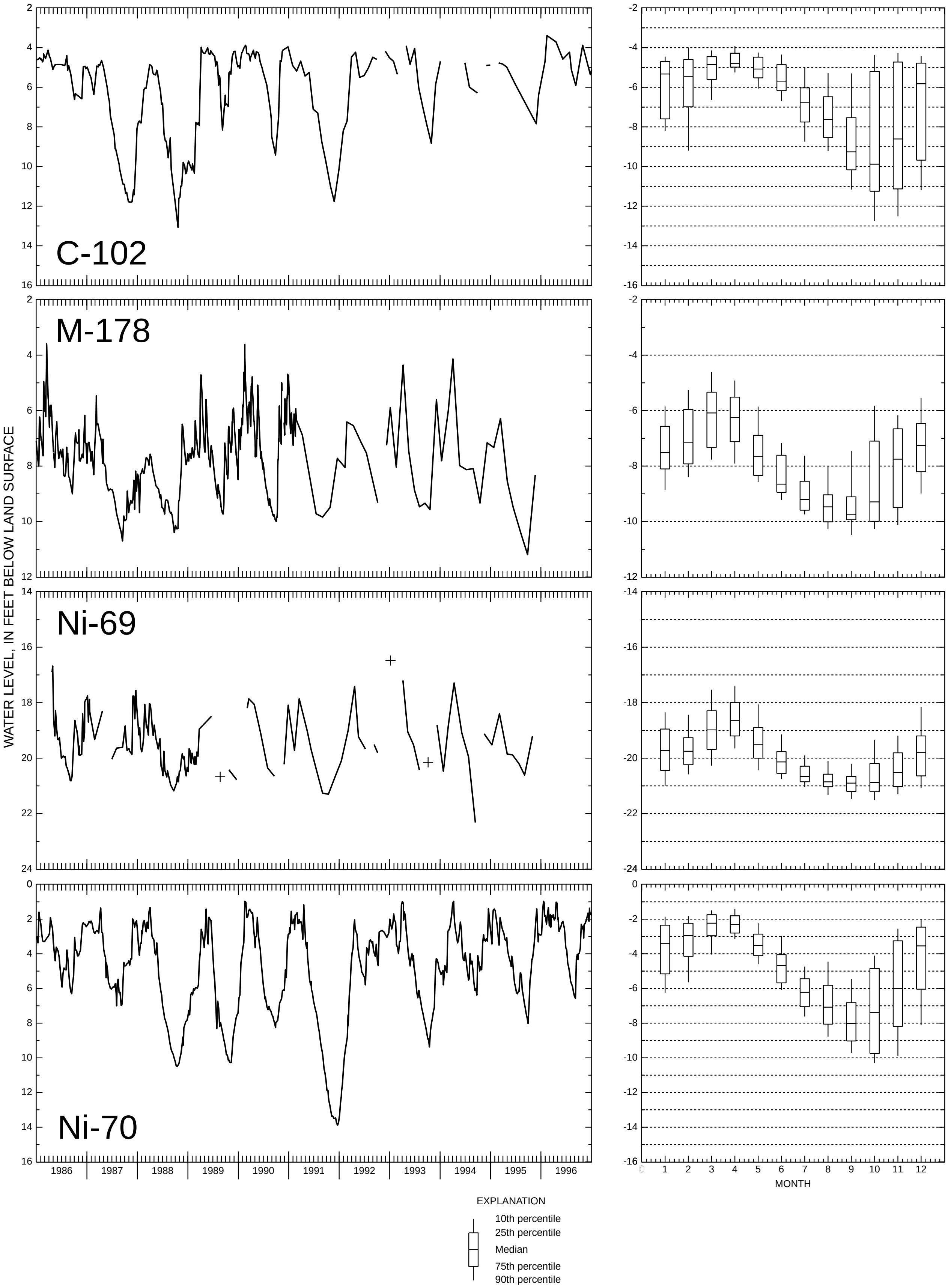


Figure B4. Ten-year hydrographs (1986-96) and boxplots showing median monthly water levels and monthly percentile statistics for observation wells C-102 (Cortland County), M-178 (Madison County), Ni-69 (Niagra County), and Ni-70 (Niagra County).

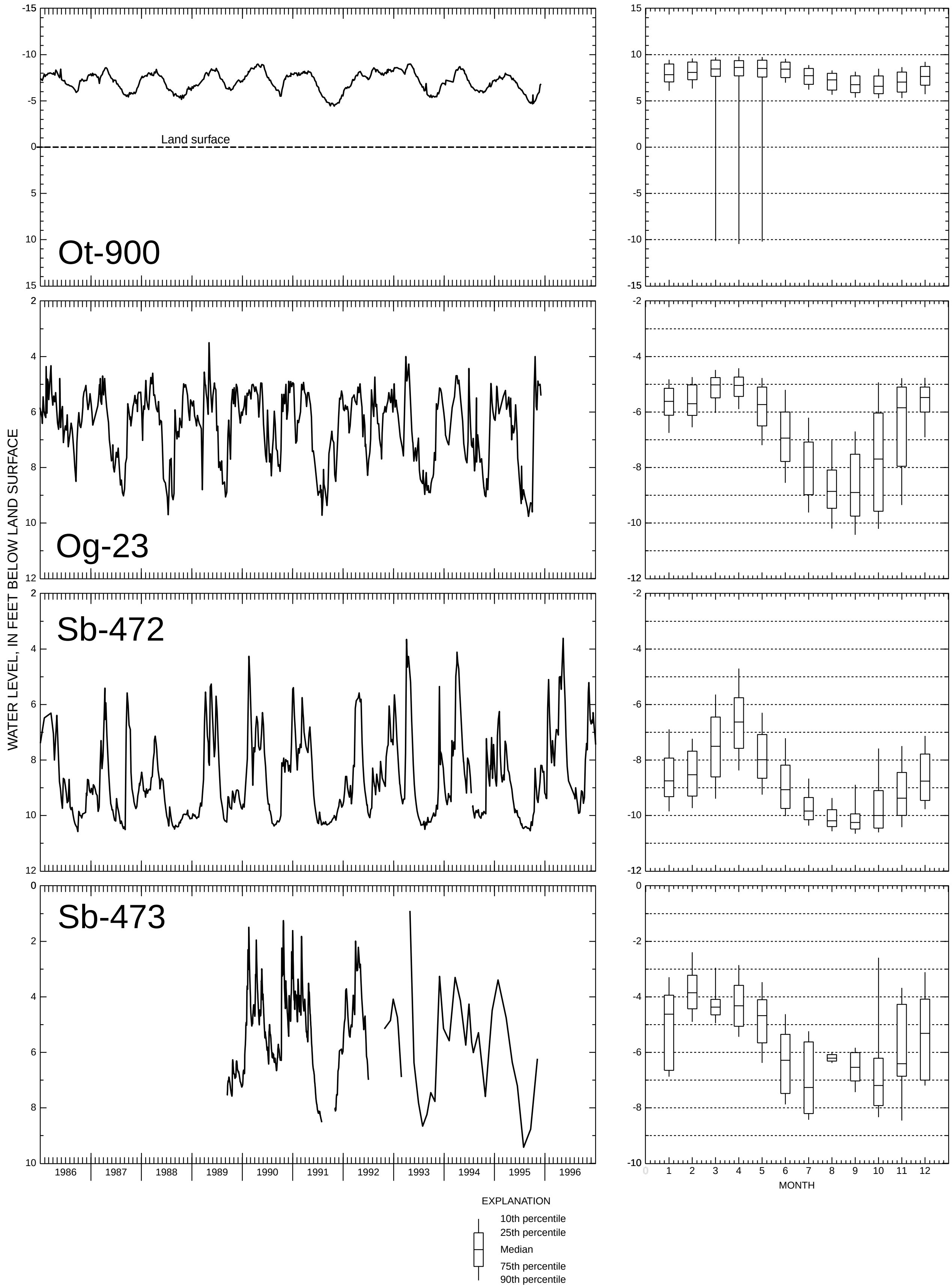


Figure B5. Ten-year hydrographs (1986-96) and boxplots showing median monthly water levels and monthly percentile statistics for observation wells Ot-900 (Ontario County), Og-23 (Otsego County), Sb-472 (Steuben County), and Sb-473 (Steuben County).

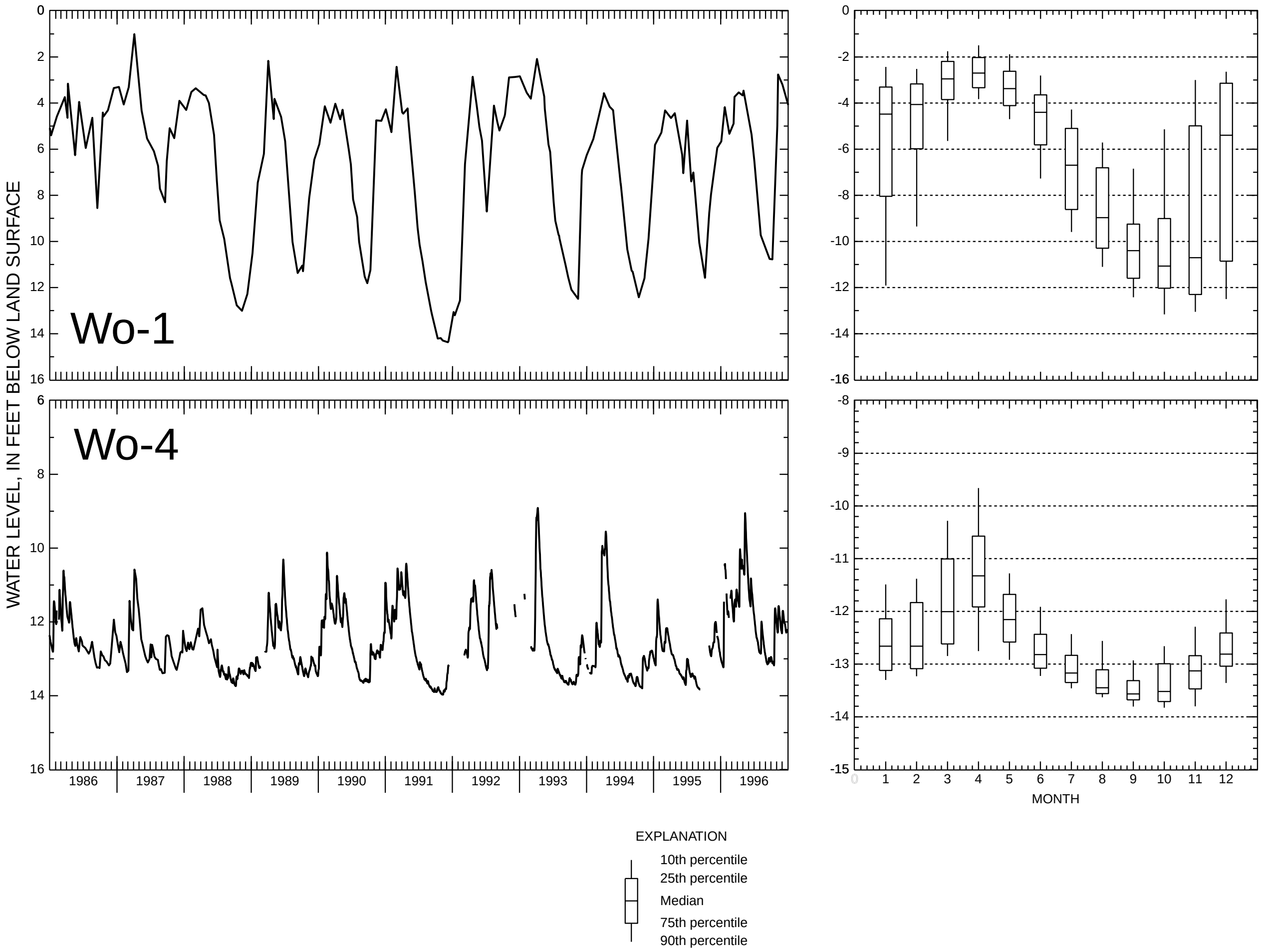


Figure B6. Ten-year hydrographs (1986-96) and boxplots showing median monthly water levels and monthly percentile statistics for observation wells Wo-1 (Wyoming County) and Wo-4 (Wyoming County).