GROUNDWATER HEAD MEASUREMENTS IN SOUTH-CENTRAL SUFFOLK COUNTY, NY, 1975 – 2001

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Abstract:
Twenty-five years of head data from a network of 133 wells and two stream gages are discussed. Maps of the water table, Upper Glacial-Magothy aquifers head differentials, and areal head fluctuations over time are presented, along with time series of water table measurements at several wells. The data show that local flow fields, generated either by models or other means, and which are based on head relations over time and space, should to be based on long-term, multi-well head data sets rather than single-well data or one-time synoptic surveys.

Introduction

In 1974, the New York State Environmental Facilities Corporation constructed a landfill in the Town of Brookhaven in the south-central portion of Suffolk County (Figure 1). Ownership of the landfill was later transferred to the Town of Brookhaven. The landfill was coincidentally located near a United States Geological Survey (USGS) monitoring well (S3529). The well, which was relocated in 1975, has been used by both the USGS and the Suffolk County Department of Health Services as an element in groundwater elevation mapping programs.

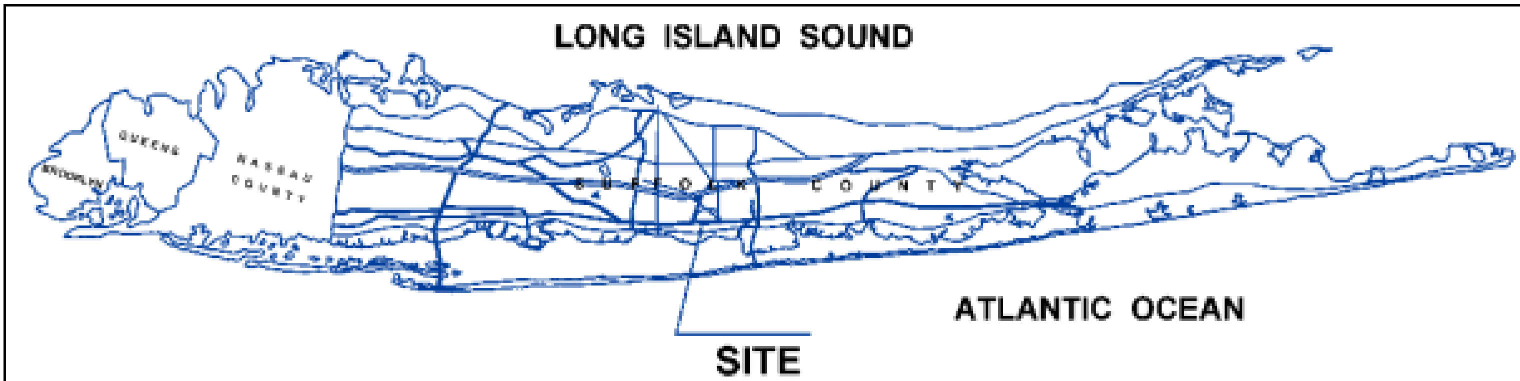


FIGURE 1
STUDY LOCATION

The landfill site is on the outwash plain south of the Ronkonkoma moraine, and the deep recharge zone has been mapped as lying north of the site. The landfill is found at the head water region of a locally important stream, Beaverdam Creek, and near to Carmans River. Leachate releases from the landfill have contaminated local groundwater, resulting in monitoring and modeling programs. Some of these programs collected measurements of groundwater heads in the growing monitoring network near the landfill. The Town expanded the landfill in the 1990s; that permit process required monthly head measures at a series of wells. Sporadic synoptic surveys of the entire well network, begun in the mid-1990s, culminated in monthly surveys at more than 100 monitoring points from 1999 – 2001.

This extensive data set allows for:

1) the construction of areal water table maps;
2) plots of trends of head changes over several decades;
3) discussion of interactions between the Upper Glacial and Magothy aquifers in the transition zone between deep recharge and discharge; and,
4) discussion of differences in responses to recharge in different sections of the Upper Glacial aquifer.

Water Table Maps

The possession of synoptic head data from many wells seems to require mapping potentiometric surfaces. Only four of the 133 wells in the monitoring network with head data are clearly logged as screened in the Magothy aquifer. Two wells were intentionally installed in the confining layer between the aquifers, and field observations at two other wells suggest they too are screened in the confining layer. However, this means that 125 wells at 65 distinct sites in the network are screened in the Upper Glacial aquifer.

With one exception, all of the clustered Upper Glacial wells show no head variation greater than 0.1 ft between wells on any particular date. This suggests that any well, no matter the screened depth, can serve as a measure of the water table elevation for the unconfined Upper Glacial aquifer. This is because 0.1 ft seems to be approximately the limit of other errors associated with head measurements. For instance, the water level meters were marked at 0.01 ft intervals, but because of sampler choice in comparing well casing marks and the onset of the meter signal of water, the precision of the measurements can be said to be approximately 0.02 ft. Accuracy in surveying data may be less, although those data too are reported to a precision of 0.01 ft. Repeated surveys of wells resulted in measuring point elevation variations of as much as 0.06 ft. This could be due to subsidence (either at the well or at the monument), or surveyor error, or perhaps instrument precision difficulties. Therefore, variations of head of 0.1 ft do not seem to be very much different than inherent errors associated with the measurements.

This assumption allows for a network of 65 sites to be used to develop water table maps (67 sites in total, assuming that the surface of Beaverdam Creek reflects the local water table). Drawing these maps is not a simple task, however.

1) Conflicts arise in developing consistent contours. Linear interpolations between multiple pairs of points can locate the same foot-contour line several hundred feet apart. The most obvious resolution of this problem is to determine if a data consensus leads to clustering for one choice rather than another. However, if the cause of the difficulty is truly an unusual head feature on the water table, then it is most appropriate to use the anomalous datum and its resultant contours.
2) Accurately defining the impact of particular head relations between two points can be difficult. It is assumed that linear relations hold between the measuring points, but a fair question is whether

the water table slope described between the points also extends up- or downgradient. If the linear relations hold outside of the two points, the question can then be asked: how far do the relations hold?

3) Finally, how should a map address features that are assumed to impact the water table, but where the data do not show impacts. This, predominantly, concerns the sections of Beaverdam Creek that are obviously gaining (as flow in the creek increases over distance), but, due to no appropriate measuring points (no surveyed elevations for the creek itself, and no immediate wells), show no associated deflections in the water table. Recharge basins that hold perennial water also are often assumed to be associated with water table mounding.

We side-stepped these issues by having a CAD elevation-contouring tool draw the potentiometric surfaces (Eagle Point Software, 2001). This program uses a triangulation algorithm. Generally, the results for this process were acceptable, although isoclines near Beaverdam Creek seem to be distorted from perceived groundwater head elevations.

Several examples of water table maps are shown (Figures 2- 5), covering a range of conditions:

Figure 2: July 2001 (rather typical conditions),

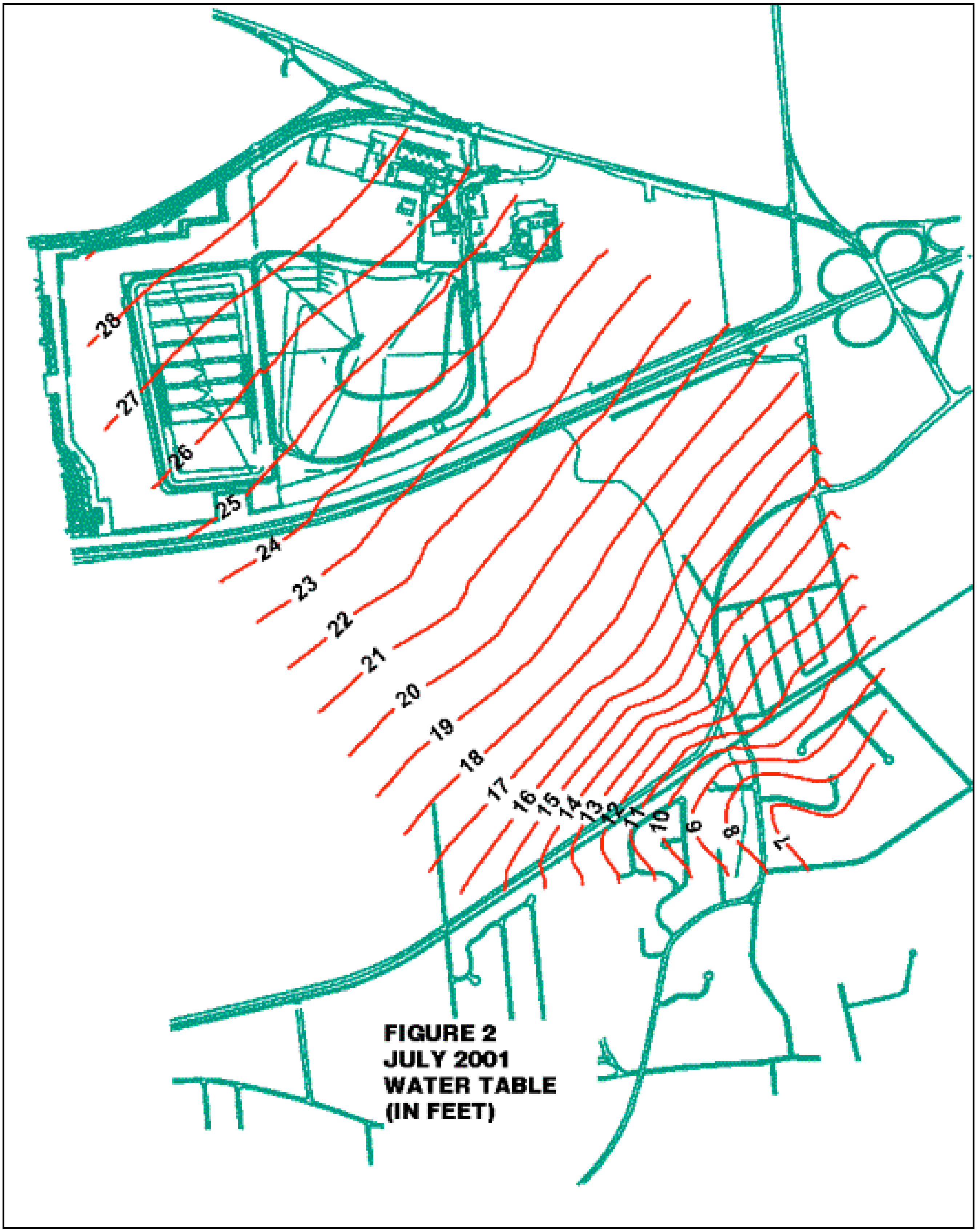


Figure 3: June 1998 (a particularly high stand for the aquifer)

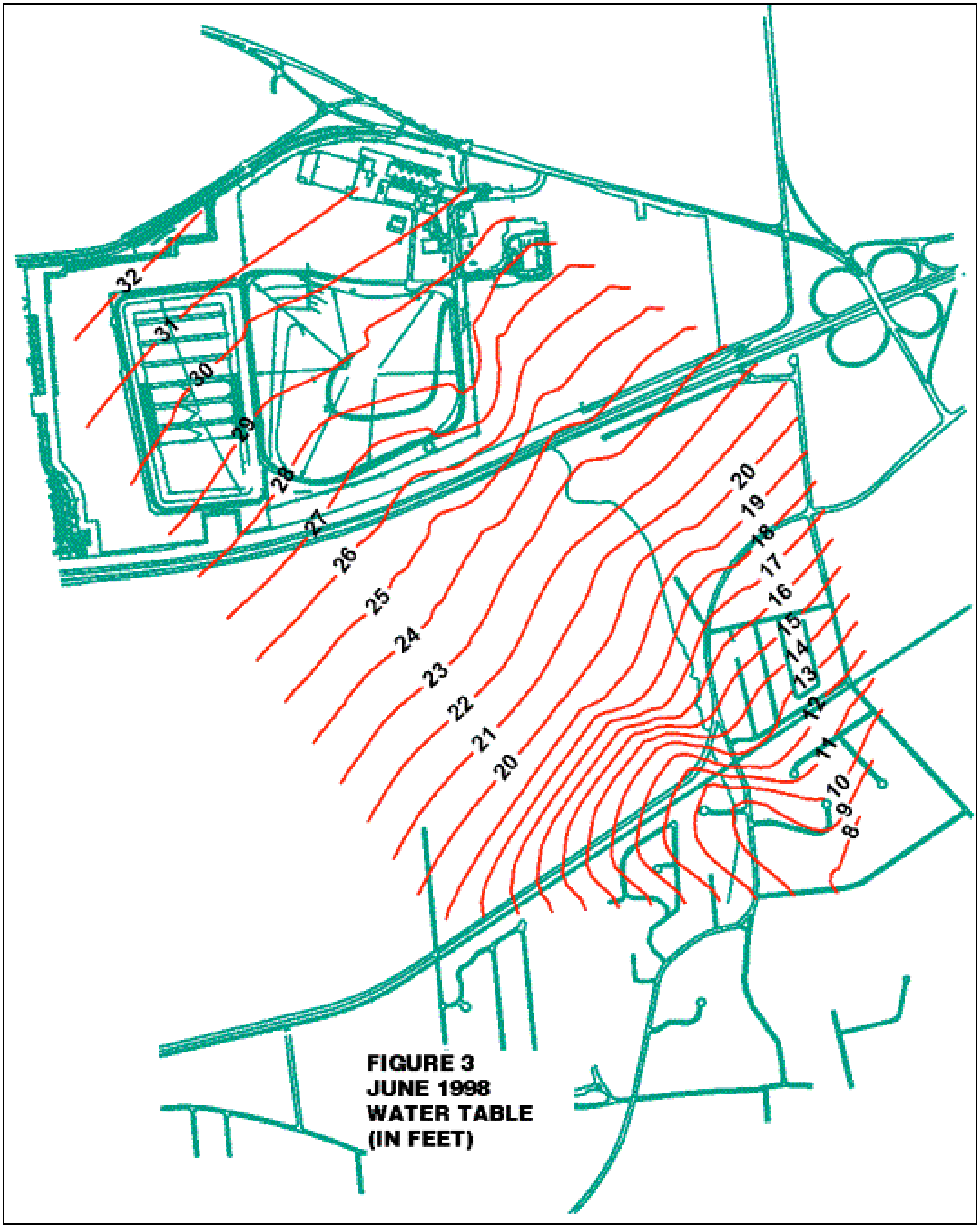


Figure 4: October 1995 (a low water stand)

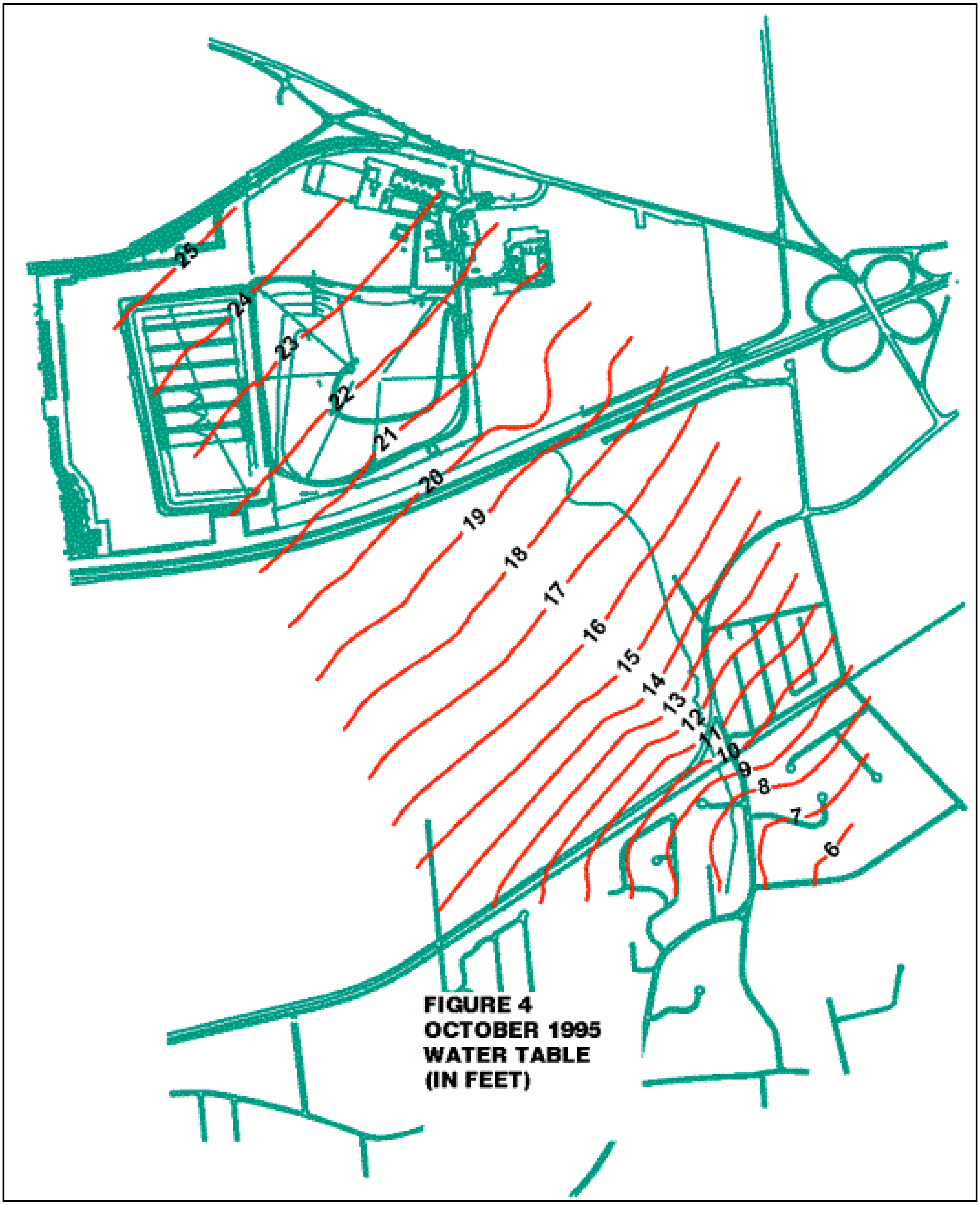


Figure 5: June 2000 (a hand-drawn map found evidence of water table mounding near a recharge basin)

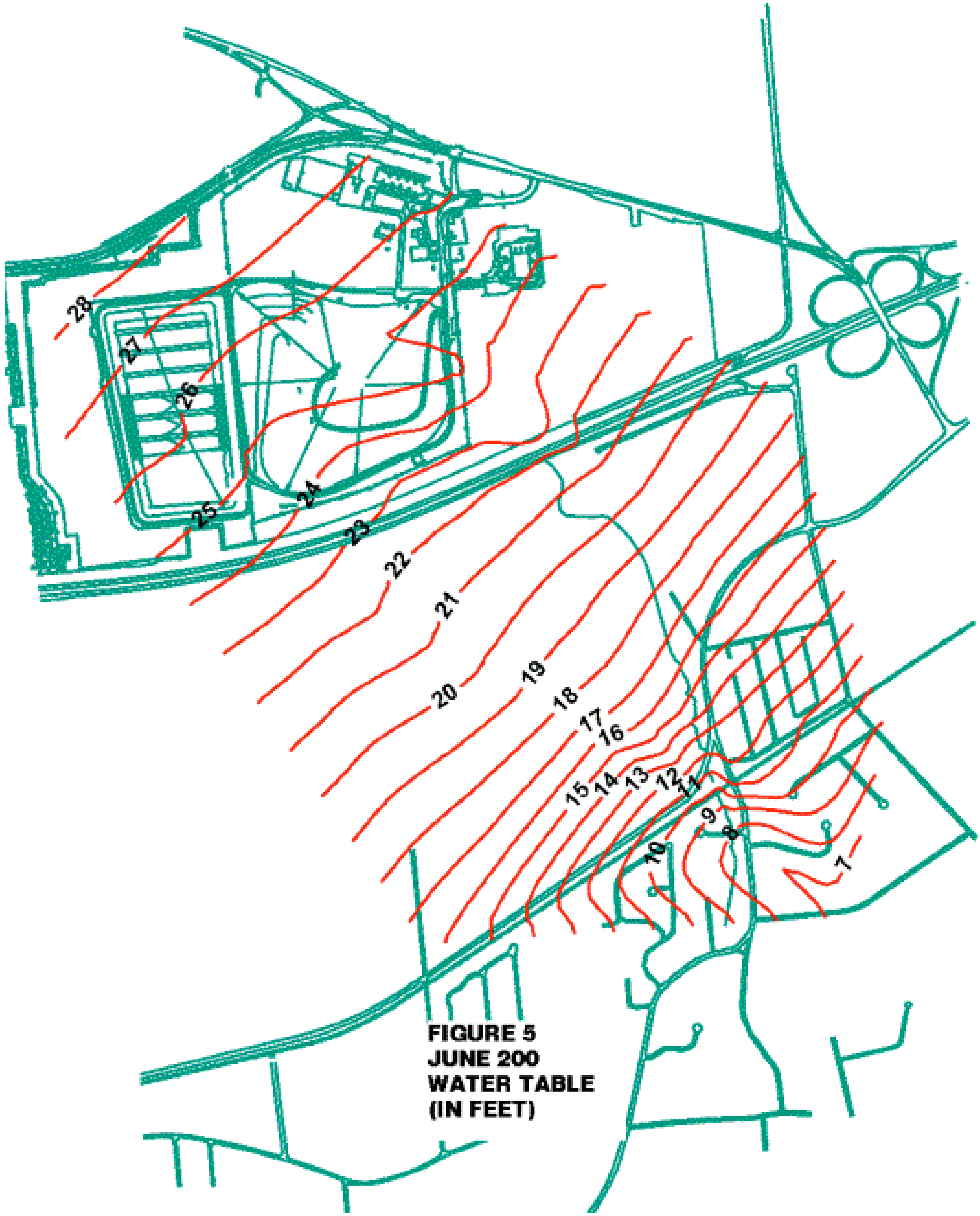


FIGURE 5
JUNE 200
WATER TABLE
(IN FEET)

The basic pattern of the water maps is the same in each case. Flow is from the northwest to the southeast. The gradient of the water table appears to increase from approximately 1.3 x 10^{-3} ft/ft in the vicinity of the landfill to 3.0 x 10^{-3} ft/ft in the far downgradient area of the network (Table 1). Beaverdam Creek appears to cause some perturbations in the water table, serving as a local discharge point for the aquifer. The Carmans River, a more substantial aquifer discharge point, may be causing a general easterly trend in the isopleths in the southeastern portion of the network.

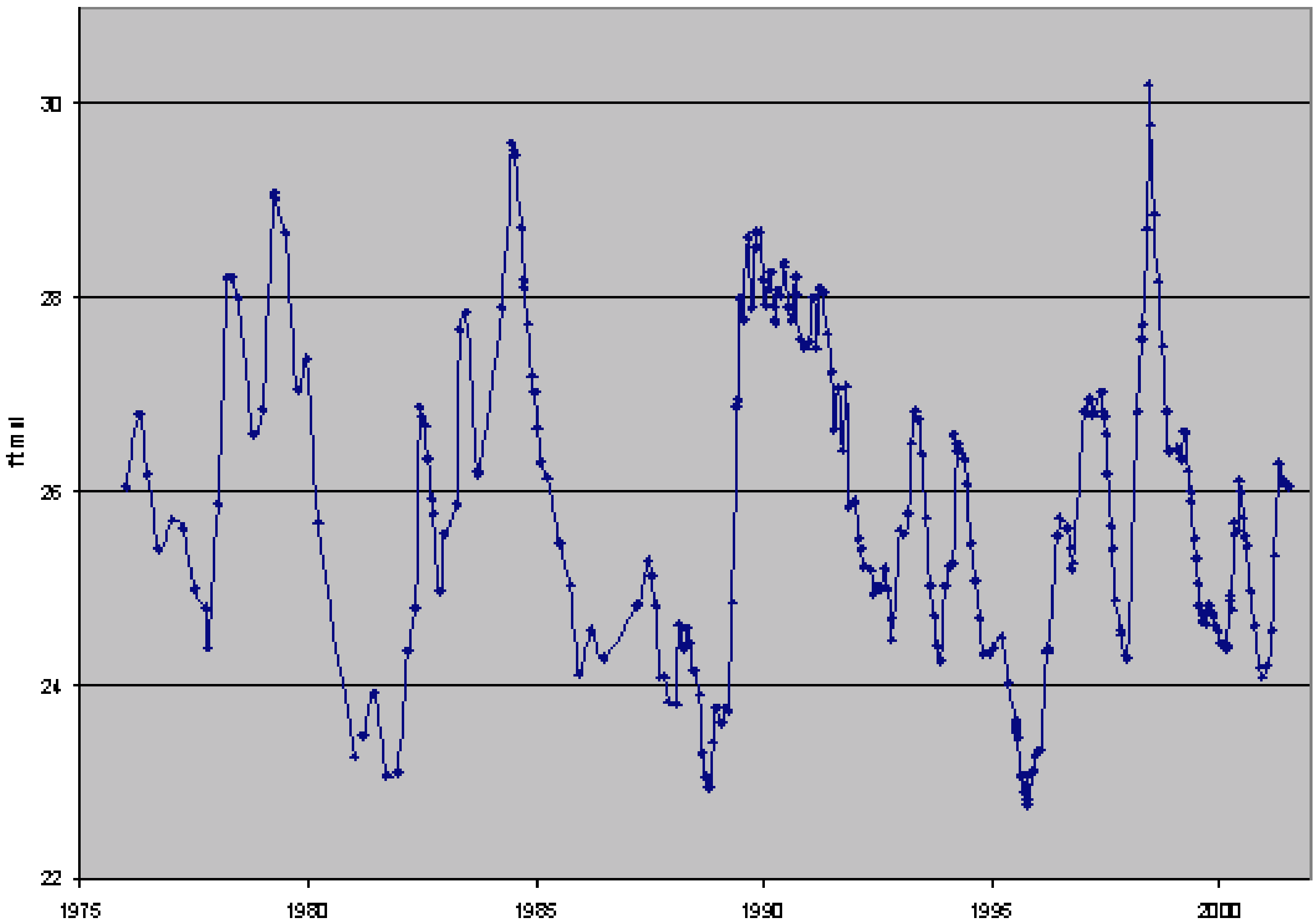
Table 1. Water table gradients (based on synoptic measurements)
all data in ft

Well Pair	MW5-S – MW10-S	S95323 – S95324
Separation distance	3000	1025
Number of Readings	117	57
Maximum Difference	4.89	3.29
Minimum Difference	3.48	2.75
Mean Difference	4.00	3.05
Standard Deviation	0.24	0.12
Mean Gradient (ft/ft)	0.0013	0.0030

Water Table Trends Over Time

Well S3529 has been monitored for over 25 years. The data set for the well has been mapped in Figure 6. It shows irregular patterns of increases and decreases. Mostly, the water table rises in the early part of the year, and declines from July onwards. Highest water levels are most often found in June, and the lowest tend to be measured in November – January. Recharge is the dominant control on the water table, and it is directly related to precipitation and indirectly related to evapotranspiration (Steenhuis and van der Molen, 1986). It is notable that the water table at S3529 reached a low during the dry period in the summer-fall of 1995, and a maximum following heavy rains in the winter and spring of 1998. Both weather patterns reinforced the usual seasonal trends of the water table, creating unusual conditions. The water table quickly recovered back to more typical elevations in both cases.

Figure 6. S3529 Heads



Recharge-Discharge Zones

The "208 Study" (Koppelman, 1978) mapped the extent of the deep recharge zones on Long Island, using head differentials between the Upper Glacial and Magothy aquifers to define where recharge might be transmitted into the deeper two aquifers (deep recharge), and where it would stay in the shallow-flow regime of the Upper Glacial aquifer. The landfill and its environs were mapped into Hydrogeological Zone 6, a shallow-flow zone (although the line of demarcation was only ½ mile to the west and north).

Head differences between the Upper Glacial and Magothy aquifers indicate there is a consistent positive difference (downward potential flow) in the northern and western portion of the network. It changes to a transition zone at or about the southern edge of the landfill. The head differences are several feet upwards in the southern portion of the network. Figure 7 maps the head differentials for the July 2001 data (which is rather typical for the recent past). Table 2 gives some statistics for the comparative data. A flow-net constructed for the Town's Cell 5 application (Dvirka and Bartilucci, 1994) indicated that the lower portion of the Upper Glacial aquifer might be discharging into the shallow Magothy aquifer in the near vicinity of the landfill, but that it was unlikely that any flow lines could be drawn from the water table into the Magothy aquifer. Although well logs suggest the presence of the Gardiners Clay (or equivalent) in the downgradient portion of the network (Wexler, 1988), the head differentials can support calculations that this area is a discharge zone for the Magothy aquifer, and that up to half of the groundwater in the Upper Glacial aquifer in the southern part of the network may have originated in the Magothy aquifer (Tonjes, 1999).

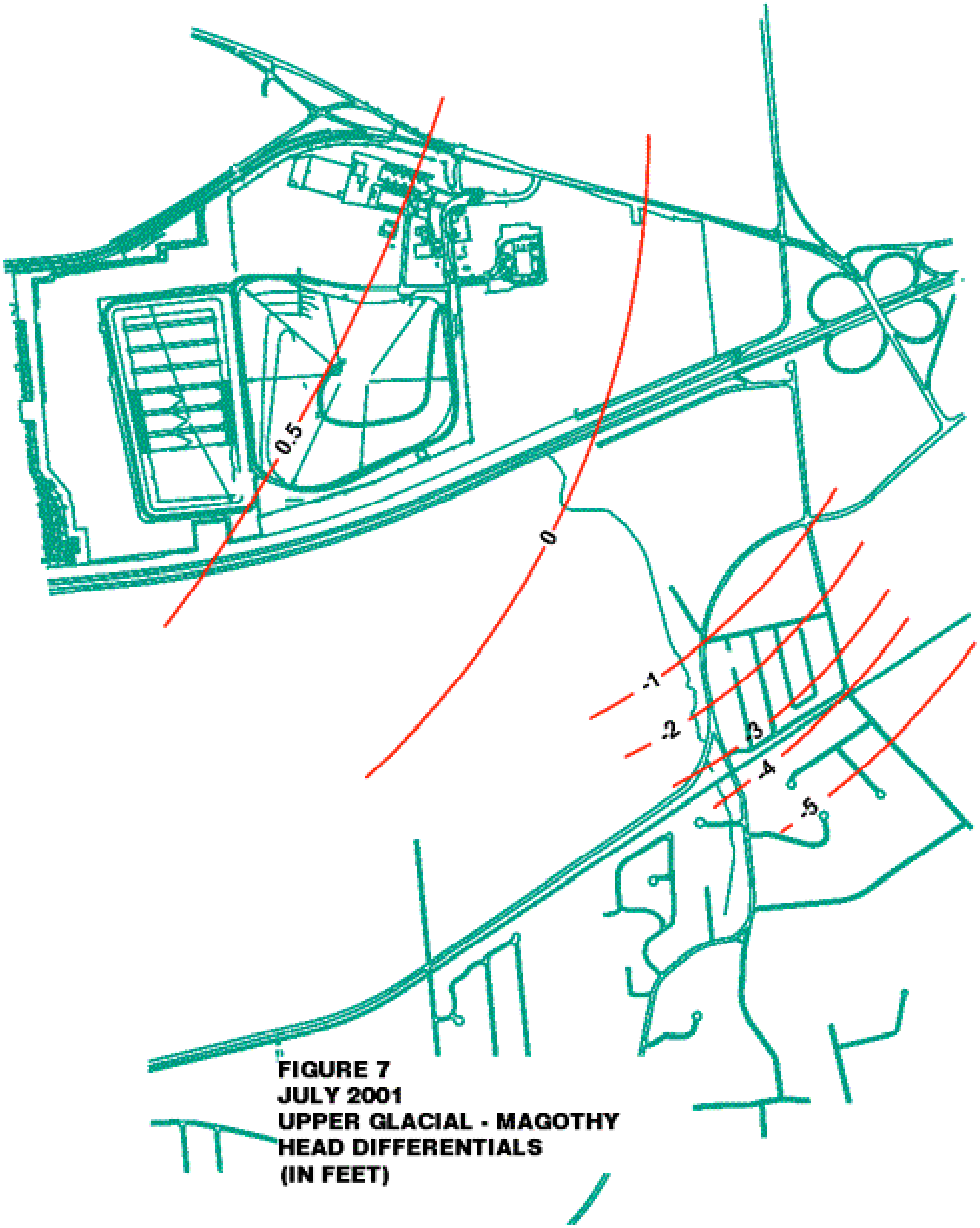


FIGURE 7
JULY 2001
UPPER GLACIAL - MAGOTHY HEAD DIFFERENTIALS (IN FEET)

Table 2. Head differences between Upper Glacial aquifer wells and Magothy aquifer wells (based on synoptic measurements)

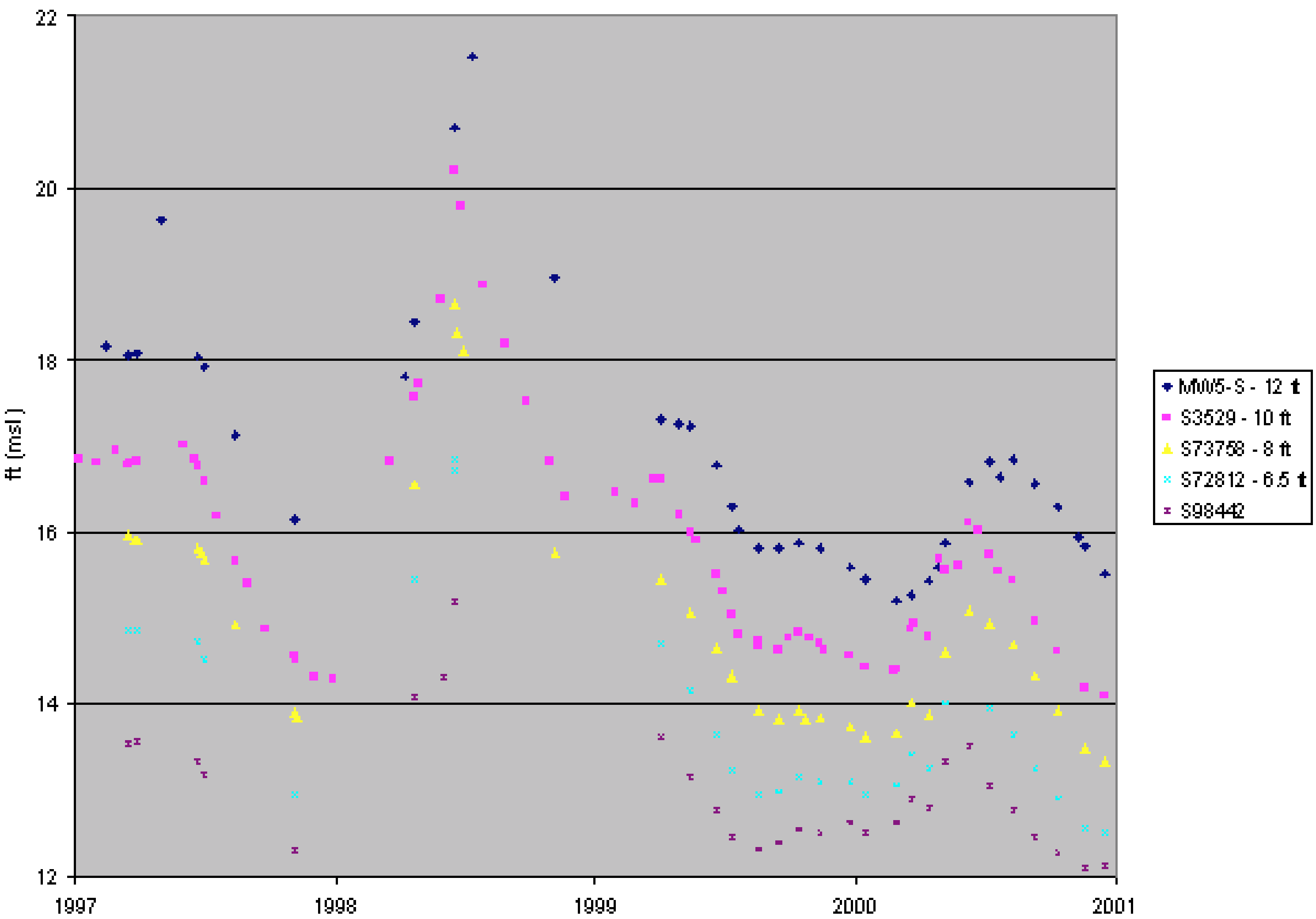
Upper Glacial well	Magothy well	Number of Readings	Mean difference (ft)	Standard deviation
MW2-S	MW11-M	116	+0.46	0.14
S3529	S72812M	78	+0.30	0.13
S73760	S72813M	95	-0.01	0.14
S72827	S95310*	64	-0.13	0.05
S95323	S72151M	63	-3.49	0.21
S98434	S95202*	63	-4.70	0.28

* well screened in the confining layer

Geographical Patterns in Water Table Fluctuations

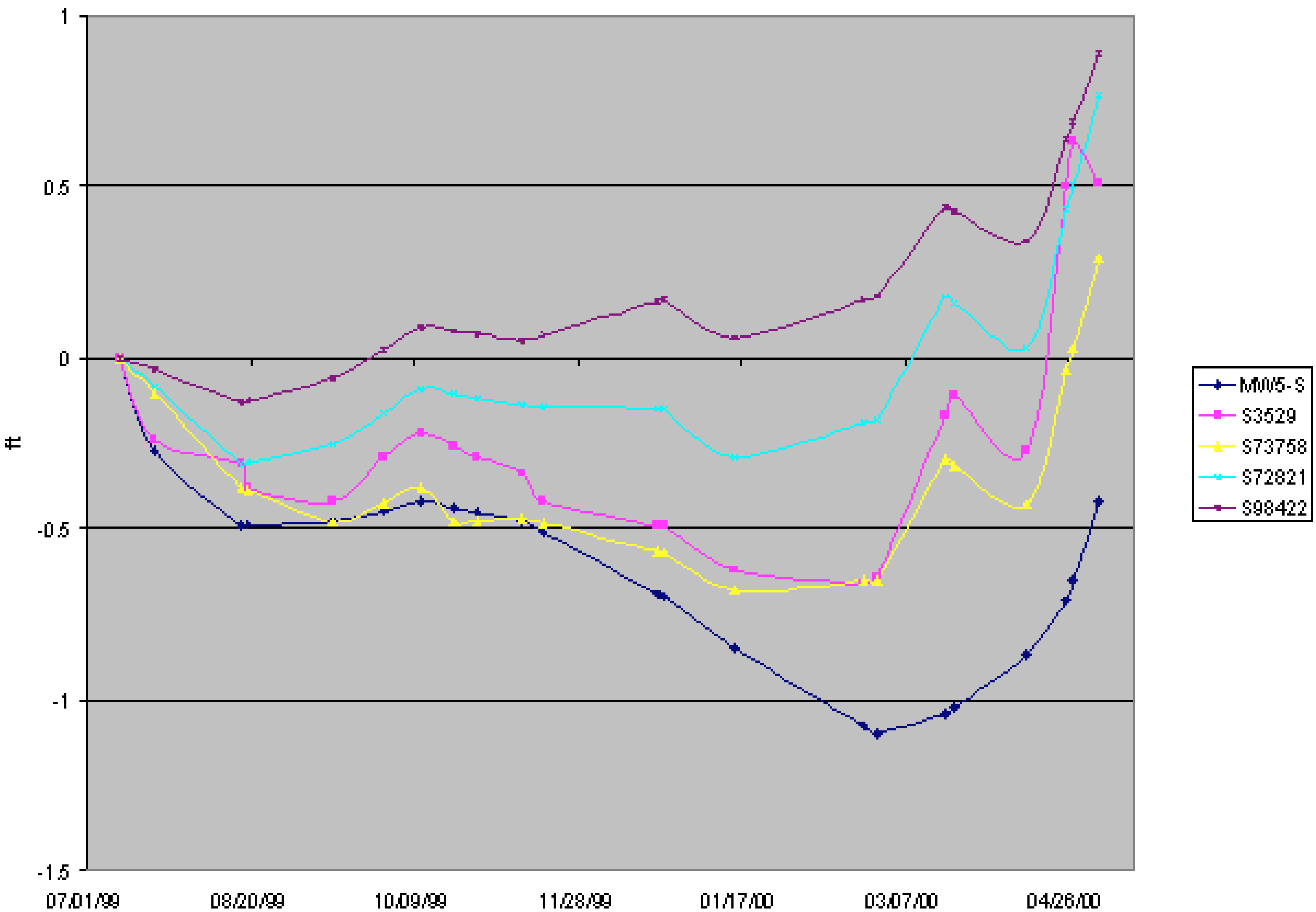
On the whole, head fluctuations throughout the network tend to be similar from month to month. Figure 8 compares five wells located throughout the network (the data are compressed to simplify comparisons). The four-year pattern appears to show the heads rising and falling synchronously.

Figure 8. Relative Head Measurements



However, over shorter periods of time, and when the data are examined more closely, variations can be detected. Figure 9 shows the same set of wells, mapped showing changes from a base elevation (July 1999). It is clear that the amplitude of head change varies for different wells in different months. In addition to variations in magnitudes of head changes, the sign of the change can also vary. Thus, over some measurement periods, heads rise for some wells and fall for others.

Figure 9. Relative Changes in Head (July 11, 1999 = 0)



The wells in the northern portion of the network seem to react more synchronously than with the wells in the southern portion of the network. In the southern portion of the network, the Upper Glacial aquifer is discharging into Beaverdam Creek, and, potentially, having Magothy aquifer waters discharge into it. This could result in differences in water table fluctuations in such a region, compared to an area where recharge is a more dominating control on head elevations.

The geographical variability in head changes over time periods can be shown as in Figure 10, which graphs the head changes from July 1999 to March 2000. A negative number indicates a falling water table, and a positive number a rising water table. In northern portions of the network, the water table fell by as much as 1 ft in eight months; at the southernmost well, the water table rose over 0.5 ft in the same time period.

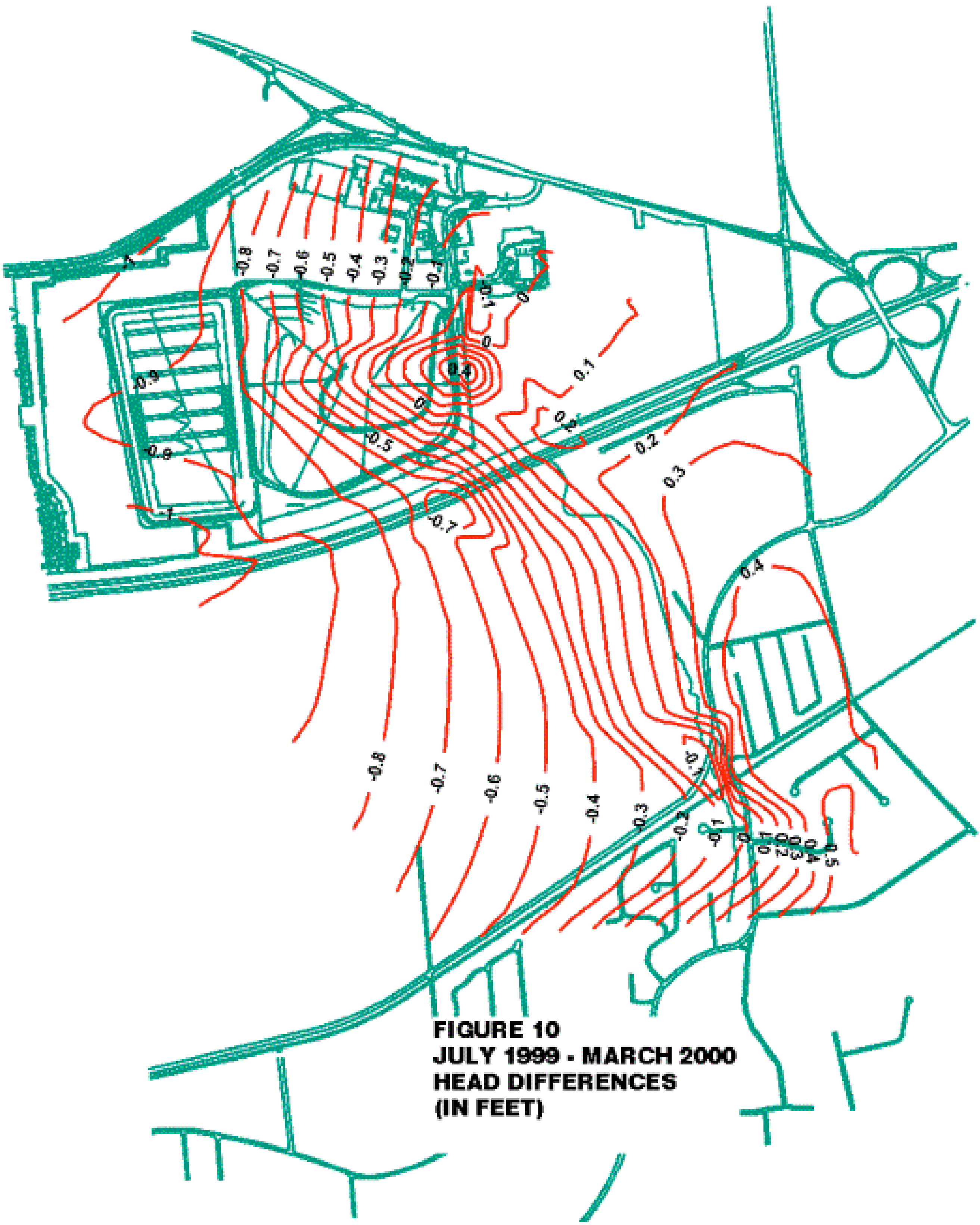


FIGURE 10
JULY 1999 - MARCH 2000
HEAD DIFFERENCES
(IN FEET)

Conclusions

Close examination of a long and robust head data set from a 100+ well network in the vicinity of the Town of Brookhaven landfill shows the patterns of head variation and variability have certain complications that might not be ascertained by either a single-well long-term data set, or a single survey of a large well network. This suggests that clear understanding of heads (and flows) in Long Island aquifers should be based on long-term, multi-well data sets. Important variations from expected responses may be missed if only one well is observed (no matter how long and detailed its data set may be) or through a single round of water level measurements (no matter how many wells are included in the sample set).

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