KEYSPAN

VILLAGE OF HEMPSTEAD WATER SUPPLY WELLS CAPTURE ZONE ANALYSIS REPORT

Assessment of Hempstead Intersection Street Former MGP Site Related Impacts

H2M PROJECT NO.: KEYS 04-05

OCTOBER 2006

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VILLAGE OF HEMPSTEAD WATER SUPPLY WELLS

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EXECUTIVE SUMMARY

On behalf of KeySpan, Holzmacher, McLendon & Murrell, P.C. (H2M) analyzed ground water flow in the vicinity of the former Hempstead Intersection Street Manufactured Gas Plant (MGP) site and the Village of Hempstead's public water supply wells located on Clinton Street approximately 4,000 feet east of the former MGP site. The analysis was conducted using data from the March 2006 Paulus, Sokolowski & Sartor Engineering, P.C, Final Remedial Investigation Report, which describes the groundwater conditions and impacts from the former MGP site.

H2M performed computer modeling to simulate groundwater flow in the aquifer system, which is the source for the public water supply wells. The modeling results indicate the former MGP site is outside the groundwater capture zone for the water supply wells, assuming normal pumping rates based on historical data. Under the theoretical maximum pumping conditions the capture zones move closer to the area of the former MGP site. However, this scenario is very conservative in nature and the maximum pumping scenario is unlikely to occur for an extended time period due to the following:

- The possibility of the Village of Hempstead requiring the maximum pumping rates necessary to create the worst-case scenario is very remote since the residential and commercial community served by these wells is at or near maximum growth potential and local water supply demand is therefore not expected to increase significantly over time.

- Good engineering practice and applicable guidance documents for the water supply industry call for redundancy in water supply systems which would reduce the likelihood of any one system operating at full capacity for more than a few years time.
- There is little known precedent for water purveyors in the local region to operate a given pumping system at maximum output for the timeline required to create the worst-case scenario.
- In addition, the model focuses on groundwater flow instead of contaminant migration and does not account for natural contaminant attenuation factors such as dispersion, advection, and adsorption, which can significantly limit contaminant mobility through the subsurface environment.

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1.0 INTRODUCTION

1.1 PURPOSE

In order to assess the potential impacts of the Hempstead Intersection Street former manufactured gas plant (MGP) site on the Village of Hempstead public supply wells, KeySpan Corporation retained Holzmacher, McLendon & Murrell, P.C. (H2M) to prepare this capture zone analysis.

Review of the Contaminant Fate Report - Hempstead Gas Plant, May 1995 as prepared by P.W. Grosser Consulting Engineer & Hydrogeologist, P.C., indicated that improvements could be made to several general assumptions in that report regarding groundwater stratigraphy and conductivity rates. The new groundwater model includes more site-specific data and provides a more refined analysis of groundwater flow.

H2M constructed a groundwater flow model to define the potential capture zones of the Village of Hempstead supply wells N-00079, N-00080, N-00082, N-00083, N-04425 and N-07298, which are located approximately 4,000 feet east of the former MGP site. The groundwater flow model was created using Visual ModFlow 4.0, a hydrogeologic software program developed by Waterloo Hydrogeologic, Inc. This software program simulates steady state and transient conditions for a three-dimensional, finite difference groundwater flow model. The Visual ModFlow software solves the fundamental partial differential equation of Darcy's Law for groundwater flow, and generates output data that is used to analyze specific scenarios of interest. The modeling effort was conducted in accordance with standard and accepted scientific and engineering practices for the development of groundwater flow models including applicable ASTM standards. The groundwater model was prepared in accordance with applicable provisions of ASTM Standard D5718-95 Standard Guide for Documenting a Ground-Water Flow Model Application.

1.2 SITE BACKGROUND

The Hempstead Intersection Street former MGP site is located in Garden City, New York in Nassau County. The site was used as a gas manufacturing plant from the early 1900's until the mid-1950's, when it was retired by the Long Island Lighting Company (LILCO). In 1998, LILCO merged with Brooklyn Union Gas to form KeySpan Corporation. KeySpan now owns the site and uses it as a natural gas regulator station. According to the February 2005 Paulus, Sokolowski & Sartor Engineering, P.C *Draft Final Remedial Investigation Report*, on-site sampling results indicate the presence of non-aqueous phase liquids (NAPL), BTEX (benzene, toluene, ethylbenzene and total xylenes) and polycyclic aromatic hydrocarbons (PAH) in soil and groundwater.

This capture zone analysis focused on the six (6) public supply wells located east of the former MGP site. These wells are identified as N-00079, N-00080, N-00082, N-00083, N-04425 and N-07298, otherwise known as Village of Hempstead Well Nos. 2, 3, 5, 6, 1 and 8 respectively.

2.0 HYDROGEOLOGY

2.1 REGIONAL HYDROSTRATIGRAPHY

Three major aquifers, the Upper Glacial, the Magothy and the Lloyd, comprise the hydrogeologic layered formations that underlie the region surrounding the former MGP site. Located a short depth below the ground surface, the Upper Glacial aquifer ranges in thickness from 50 to 100 feet, and consists of medium-to-course grained Pleistocene deposits. Proceeding deeper, the Magothy aquifer is approximately 400 to 600 feet thick, and it includes the Upper Magothy and Lower Magothy. The Upper Magothy typically contains fine-to-medium sand, while the Lower Magothy consists of coarser material. The Hempstead public water supply wells, N-10033 and N-10034, withdraw water from the Lower Magothy. A 100 to 200-foot thick confining layer of clay, known as the Raritan Formation, separates the Lower Magothy from the Lloyd aquifer. The deepest layer, known as the Lloyd aquifer, ranges in thickness from 200 to 300 feet, and consists of coarse to fine sands on top of the underlying bedrock formation. The bedrock formation has a low permeability and is considered the base of the groundwater system.

The ground surface, the underlying layered aquifers, and the bedrock generally have a southeastward slope, which contributes to the horizontal groundwater flow direction. Additionally, groundwater flow is typically greater in the horizontal direction than in the vertical direction. Groundwater contours for this model were generated using data tables from the Nassau County Regional Groundwater Model (NCRGM). The regional head contours (water level) that were generated at five foot intervals are presented in Figure 2-1.

2.2 WELL CHARACTERISTICS

The Village of Hempstead public supply wells, N-00079, N-00080, N-00082, N-00083, N-04425 and N-07298, are located approximately 4,000 feet from the MGP site. Characteristics of each well are presented in Table 2-1 below.

	N-00079	**N-00080**	**N-00082**	**N-00083**	**N-04425**	**N-07298**
Depth of Well	428 ft.	425 ft.	500 ft.	403 ft.	325 ft.	449 ft.
Pump Capacity (GPM)	1,240	1,200	1,200	800	1,200	1,200
Screen Interval	278' to 368'	368' to 418'	330' to 482'	303' to 343'	265' to 305'	334' to 384'
Aquifer Source	Lower Magothy	Lower Magothy	Lower Magothy	Lower Magothy	Lower Magothy	Lower Magothy

Table 2-1: Well Characteristics

3.0 GROUNDWATER MODEL INPUT PARAMETERS

A groundwater model is a computer simulation representing an approximation of groundwater flow in an aquifer. The aquifer is defined by its unique hydrogeological parameters. Visual ModFlow uses the MODFLOW groundwater flow code developed by McDonald and Harbough at the United States Geological Survey (USGS). MODFLOW is capable of simulating transient or steady state three-dimensional flow in porous media.

MODFLOW uses the finite difference method to solve a partial differential equation for three-dimensional groundwater flow in porous media. Visual ModFlow uses the same partial differential equation, which is mathematically derived from Darcy's Law. The equation is:

$$\frac{\partial}{\partial x}\left(K_{xx}\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_{yy}\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_{zz}\frac{\partial h}{\partial z}\right)+W=S_s\frac{\partial h}{\partial t}$$

Where,

$\frac{\partial}{\partial x}\left(K_{xx}\frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_{yy}\frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_{zz}\frac{\partial h}{\partial z}\right)$ = *Groundwater Flux in 3 dimensions*

K_{xx}, K_{yy}, K_{zz} = *Hydraulic Conductivity*

h = *Head*

W = *Sources/Sinks*

$S_s\frac{\partial h}{\partial t}$ = *Change in Storage (where S_s is Storage)*

The groundwater model was created to simulate the capture zone for the Village of Hempstead public water supply wells N-00079, N-00080, N-00082, N-00083, N-04425 and N-07298. The NCRGM was the source of many of the input parameters, and it is considered the conceptual starting point for the model. The groundwater model includes input parameters to define the model boundaries, including recharge and flow boundaries. Aquifer properties including hydraulic conductivity, porosity and storage, were input for the various hydrogeologic layers of the model. Also, initial conditions and field observations for groundwater heads and well pumpages were input to the model.

3.1 THREE DIMENSIONAL PARAMETERS

Conservative assumptions were made regarding the geographic extents of the model, with consideration for the project objectives. The model boundaries were set at 3.3 miles from East to West, and 4.3 miles from North to South. The model grid was established by setting the Village Of Hempstead public supply well cluster as the central point in the model. Boundary lines were then established to allow for influences from regional groundwater flow and pumpage from nearby public supply wells.

The groundwater model was dissected in the longitudinal and latitudinal directions, creating a grid using the mathematical optimization features of the Visual ModFlow software program. The model domain was divided into 54 rows, 42 columns and 7 layers of grid cells. Each grid cell is a three-dimensional, right-angled shape with an elemental volume that is input into the program's equation solver. A uniform grid was not used for the groundwater model.

Grid sizes are approximately 2.5 acres in areas surrounding the former MGP site and the grid sizes gradually enlarge to 4.5 acres on the edges of the model space. A grid smoothing algorithm was applied to optimize discretization and to maximize numerical and computational stability. The elevation of each corner of every grid cell in the model was obtained by interpolation of geographically referenced data points from the NCRGM. The three-dimensional model grid is shown on Figure 3-1.

Public supply well coordinate locations and screen elevations were also imported from the NCRGM. These parameters were verified or refined according to topographic mapping and well completion reports.

3.2 HYDROGEOLOGIC PARAMETERS

The groundwater model design and subsequent simulation efforts incorporated conservative considerations for system geometry and hydrogeologic parameters. The key hydrogeologic parameters that were tested for accuracy and consistency of results include; recharge, hydraulic conductivity, initial head and constant head. In addition, accepted regional values for effective porosity and specific storage were imported from the NCRGM data files.

Recharge is the amount of water returned to the ground after both runoff and evapotranspiration are subtracted from the total amount of precipitation. The sole source of groundwater replenishment for Long Island aquifers is precipitation, which averages 44 inches per year. The United States Geological Survey and the New York State Department of

Environmental Conservation estimate that about 50% of the average rainfall (22 inches) that falls on the land eventually percolates through the soil to the water table. The balance is returned to surface water via runoff and to the atmosphere via surface evaporation and transpiration of plants.

Hydraulic conductivity (K) is a measure of an aquifer's ability to transmit groundwater. By definition, water passes easily through the large pore spaces of a coarse material, thereby equating to a high K value. Similarly, a fine material, through which water flows slowly, has a low K value. The hydraulic conductivity of the Glacial, Magothy and Lloyd aquifers, ranges from 10 to 100 times greater in the horizontal direction than the vertical direction. It should be noted that hydraulic conductivity values used in the model were approximated for the entire thickness of each aquifer, however the natural stratification of the deposits in these formations results in variations of conductivities at different depths. Values for hydraulic conductivity were obtained from the NCRGM data files. A listing of hydraulic conductivities used in each layer of the groundwater model, with the corresponding geologic formation, is presented on Figure 3-2 and in Table 3-1 below.

Model Layer	Geologic Formation	K_x (ft/d)	K_y (ft/d)	K_z (ft/d)
1	Glacial	200	200	20
2	Upper Magothy 1	30	30	0.35
3	Upper Magothy 2	35	35	0.35
4	Lower Magothy 1	40	40	0.40
5	Lower Magothy 2	125	125	1.25
6	Raritan Clay	0.30	0.30	0.002
7	Lloyd	35	35	0.35

Table 3-1: Hydraulic Conductivities

Initial head is a measure of the pressure or head corresponding to the height to which water would rise in an observation well penetrating a specific aquifer. The initial heads for nodes within the groundwater model were imported from the NCRGM data files. Initial heads are used in the simulation process for calculation of drawdown, and the values are adjusted for each consecutive time iteration.

Constant head boundaries are assigned to the groundwater model to act as a fixed head source or sink. These groundwater system boundaries are necessary in order to completely enclose the region of interest. The northern boundary acts as an infinite source of water entering the system, and the southern boundary acts as an infinite sink for water exiting the system. For this groundwater model, constant head boundaries were assigned to their respective grid coordinates based on head values interpolated from the NCRGM data files.

4.0 MODEL SIMULATIONS

The three-dimensional groundwater flow model was used as a tool for evaluation of the following scenarios. A series of steady state scenarios were developed to determine the capture zones for the Hempstead public supply wells N-00079, N-00080, N-00082, N-00083, N-04425 and N-07298.

All groundwater modeling scenarios were run using the WHS Solver in Visual ModFlow. The WHS Solver uses a bi-conjugate gradient stabilized acceleration routine implemented with incomplete decomposition for preconditioning of the groundwater flow partial differential equations.

4.1 CAPTURE ZONE SCENARIOS

A capture zone is an estimated area that contributes water to a pumping well. Capture zone analysis is a technique used to predict the horizontal and vertical extent of groundwater that could be drawn into a well under specified pumping conditions. The use of capture zones is a conservative tool, because the calculation of a capture zone does not take into account interations of contamination attenuation processes known to exist in the real world, such as dispersion, adsorption and advection.

Visual ModFlow can generate capture zones using particle path lines. By running the numerical model in reverse and placing particles at the well screen, the resultant particle path lines provide a graphical representation of the area contributing to the respective pumping well. This process outlines the capture zone for a specific well.

To generate the capture zones for wells N-00079, N-00080, N-00082, N-00083, N-04425 and N-07298, an average and maximum condition were simulated in order to delineate a probable capture zone and a worst-case capture zone. The simulations were run with steady state conditions, whereby Visual Modflow runs numerous iterations until convergence occurs and calculated results are repeatable within an acceptable margin. The capture zone scenarios that were run are; Baseline Pumpage Scenario, which simulates average pumping rates for all public supply wells; and Maximum Pumpage Scenarios, which simulate maximum pumping rates for one of the six public supply wells, and average pumping rates for all other wells.

4.1.1 Baseline Pumpage Scenario

The baseline pumpage scenario was developed using actual Village well pumpage records from the last three years. The pumpage values were converted to average pumping rates by assuming the wells are in continuous operation for the purposes of the steady state simulation. The Baseline Pumpage Scenario simulates average pumping rates for all of the Village of Hempstead public supply wells N-00079, N-00080, N-00082, N-00083, N-04425, and N-07298. Based on the actual pumping data from 2003, supplied by the Village of Hempstead; Well N-00079 was assumed to pump 83 GPM; Well N-00080 was assumed to pump 1,090 GPM; Well N-00082 was assumed to pump 292 GPM, Well N-00083 was assumed to pump 153 GPM; Well N-04425 was assumed to pump 674 GPM; and Well N-07298 was assumed to pump 400 GPM.

It should be noted that the baseline scenario represents current public water supply withdrawal rates for a residential and commercial community at or near maximum growth potential. Therefore, local water supply demand should not increase significantly over time.

4.1.2 Maximum Pumpage Scenarios

The steady state maximum pumping scenarios simulate one of the six adjacent public supply wells operated at its maximum pumpage, while the other five remain at average pumpage. A total of six maximum pumpage scenarios were run, one scenario for each well set to its maximum pumping rate. In these scenarios all other public supply wells in the model are held to their average pumping rates. The pumping conditions simulated in the maximum scenarios are conservative, as they assume pumping rates as high as 1,400 GPM for 24 hours per day, 7 days per week, 365 days per year. Such a pumping condition is not in line with recent or past pumping rates for the Village of Hempstead wells. Furthermore, such a pumping condition is not reflective of how public supply wells are typically operated on Long Island, which depends on daily and seasonal water demand fluctuations. Hence, these maximum pumpage scenarios simulate worst case conditions for modeling purposes.

5.0 MODELING RESULTS AND ANALYSIS

Calibration of a groundwater flow model involves the process of obtaining a reasonable match between observed and simulated conditions. Regional groundwater elevations were used as a calibration tool since hydraulic head values at the water supply wells were unavailable. Model calibration was achieved by adjusting hydraulic parameters within reasonable ranges to obtain a match between accepted and simulated head potentials and groundwater contours. Accepted data was obtained from the NCRGM, the Paulus, Sokolowski & Sartor Engineering, P.C, *March 2006 Draft Final Remedial Investigation Report*, and the Village of Hempstead. The model was found to have an acceptable match between calculated groundwater elevation contours and observed groundwater elevation contours presented in the *March 2006 Draft Final Remedial Investigation Report* prepared by Paulus, Sokolowski & Sartor Engineering, P.C. The results of simulations were evaluated for their close agreement to the accepted data sources, and adjustments to the model parameters were made to calibrate the model.

5.1 BASELINE PUMPAGE SCENARIO

Figure 5-1 presents the estimated baseline pumpage capture zone area for the Village of Hempstead public supply wells. The furthest extents of the highlighted crescent shaped combined capture zone for the six Village of Hempstead wells are; a northern limit at 1,300 feet north of Old Country Road; a southern limit at 700 feet north of Hempstead Turnpike; an eastern limit at 3,500 feet west of the Meadowbrook Parkway; and a western limit at Franklin Avenue. The majority of the combined capture zone lies in the southern regions of the extents described above, with slender protrusions extending to the northern and eastern regions, caused by capture zones from more southerly supply wells.

5.2 MAXIMUM PUMPAGE SCENARIOS

Water particle tracking for maximum scenarios for the six Village of Hempstead wells was performed in an identical procedure as described for the baseline scenario. In Figures 5-2 through 5-7, the capture zone for the well under maximum pumping conditions is highlighted in yellow, while the capture zones for the remaining wells under average pumping conditions are shown in green. A description of the estimated capture zone areas for each of the six maximum pumpage scenarios follows:

- Figure 5-2 presents the estimated capture zone area for the Well N-00079 under maximum pumpage conditions. The approximate bounds of the crescent shaped maximum pumpage capture zone are; a northern limit at Stewart Avenue; a southern limit at Front Street; an eastern limit at Earle Ovington Boulevard; and a western limit at Hilton Avenue.

- Figure 5-3 presents the estimated capture zone area for the Well N-00080 under maximum pumpage conditions. The approximate bounds of the crescent shaped maximum pumpage capture zone are; a northern limit at Westbury Avenue; a southern limit at Hempstead Turnpike; an eastern limit 1,200 feet west of Earle Ovington Boulevard; and a western limit at Hilton Avenue. The majority of the capture zone for N-00080 lies in the southern and eastern regions of the extents described above, with a slender protrusion extending to the northeast region.

- Figure 5-4 shows the estimated capture zone areas for the Village of Hempstead wells under the maximum pumpage scenario for Well N-00082. The estimated capture zone area for Well N-00082 is located outside of the model domain, north of Old Country Road.

- Figure 5-5 shows the estimated capture zone areas for the Village of Hempstead wells under the maximum pumpage scenario for Well N-00083. The estimated capture zone area for Well N-00083 is located outside of the model domain, north of Old Country Road.

- Figure 5-6 presents the estimated capture zone area for the Well N-04425 under maximum pumpage conditions. The approximate bounds of the crescent shaped maximum pumpage capture zone are; a northern limit at Wyatt Road; a southern limit 500 feet north of Fulton Street; an eastern limit at Quentin Roosevelt Boulevard; and a western limit at Magnolia Avenue.

- Figure 5-7 shows the estimated capture zone areas for the Village of Hempstead wells under the maximum pumpage scenario for Well N-07298. The estimated capture zone area for Well N-07298 is located outside of the model domain, north of Old Country Road.

6.0 CONCLUSIONS

In conclusion, the capture zones for both current average pumping conditions and theoretical maximum pumping conditions for each of the public supply wells N-00079, N-00080, N-00082, N-00083, N-04425, and N-07298 are located in regions to the north and east of the former MGP site. Under each of the six maximum pumping scenarios, the capture zones shift closer to the former MGP site. The groundwater flow model showed some water particle path lines intersecting the former MGP site area at or below ground surface in all of the individual maximum pumping scenarios. The depth of these maximum pumpage path lines is within the same geologic zone as impacted groundwater observed from the former MGP site.

The baseline scenario indicates that under the groundwater conditions modeled, contamination originating from the former MGP site is very unlikely to reach the Village of Hempstead wells N-00079, N-00080, N-00082, N-00083, N-04425, and N-07298. If the Village changes their operation to the maximum pumpage levels described, it would be theoretically possible for groundwater in the area of the former MGP site to reach public supply wells N-00079, N-00080, N-00082, N-00083, N-04425 and N-07298. However, this scenario is very conservative in nature and the maximum pumping scenario is unlikely to occur for an extended time period due to the following:

- The possibility of the Village of Hempstead requiring the maximum pumping rates for the long time frames necessary to create the worst-case scenario is very remote since the residential and commercial community served by these wells is at or near maximum growth potential and local water supply demand is therefore not expected to increase significantly over time.

- Good engineering practice and applicable guidance[1] documents (Recommended Standards for Water Works) for the water supply industry call for redundancy in water supply systems which would reduce the likelihood of any one system operating at full capacity for more than a few years time.
- There is little known precedent for water purveyors in the local region to operate a given pumping system at maximum output for the timeline required to create the worst-case scenario.
- In addition, the model conservatively focuses on groundwater flow instead of contaminant migration and does not account for natural contaminant attenuation factors such as dispersion, advection, and adsorption, which can significantly limit contaminant mobility through the subsurface environment.

[1] Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, *Reccomended Standards for Water Works*, 2003 Edition.

7.0 REFERENCES

Historical information related to the Hempstead Intersection Street former MGP site was obtained from the following sources:

1. *Contaminant Fate Report – Hempstead Gas Plant*, May 1995, P.W. Grosser Consulting Engineer & Hydrogeologist, P.C.

2. *Final Remedial Investigation Report - Hempstead Intersection Street Former MGP Site*, February 2005, Paulus, Sokolowski & Sartor Engineering, P.C.

Both the Village of Garden City and the Village of Hempstead provided historical information on the pumpage rates and screen settings of their public supply wells. Water pumpage data for other public supply wells included in the model simulations was obtained from well completion reports for public supply wells in the West Hempstead Water District, Uniondale Water District, Garden City Park Water District, Carle Place Water District, Roosevelt Field Water District, East Meadow Water District, and the Village of Mineola.

Regional groundwater data, including topographic and stratigraphy data, and aquifer characteristics were taken from the Nassau County Regional Groundwater Model (NCRGM). The NCRGM was developed by the New York State Department of Health, the Nassau County Department of Health, the Suffolk County Department of Health Services, and the Suffolk County Water Authority, and was prepared by the engineering consultant Camp Dresser & McKee (CDM). The NCRGM was based on a group of existing three-dimensional finiteelement groundwater model codes developed by CDM. Each of the existing groundwater models had previously been calibrated and their accuracy has been documented in earlier studies.

The full color regional aerial mapping was obtained in a geographically referenced format from the New York State Statewide Digital Orthoimagery Program, circa 1999.

Background information on MODFLOW and mathematical equations used by Visual ModFlow were obtained from *Applied Groundwater Flow & Contaminant Transport Modeling*, June 2004, Waterloow Hydrogeologic, Inc.

FIGURES

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FIGURE 2-1

GROUNDWATER CONTOURS (5 FT. INTERVALS)

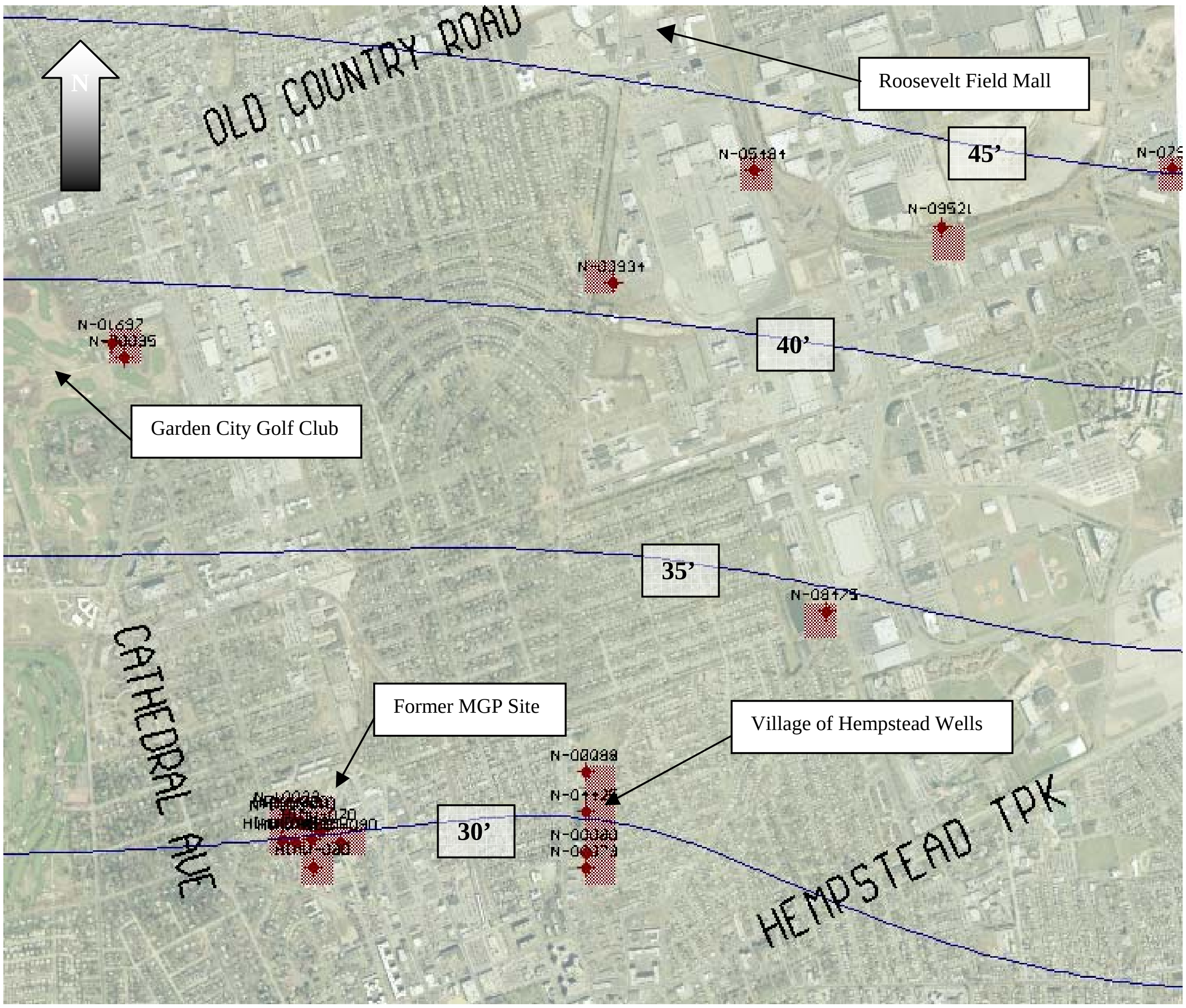

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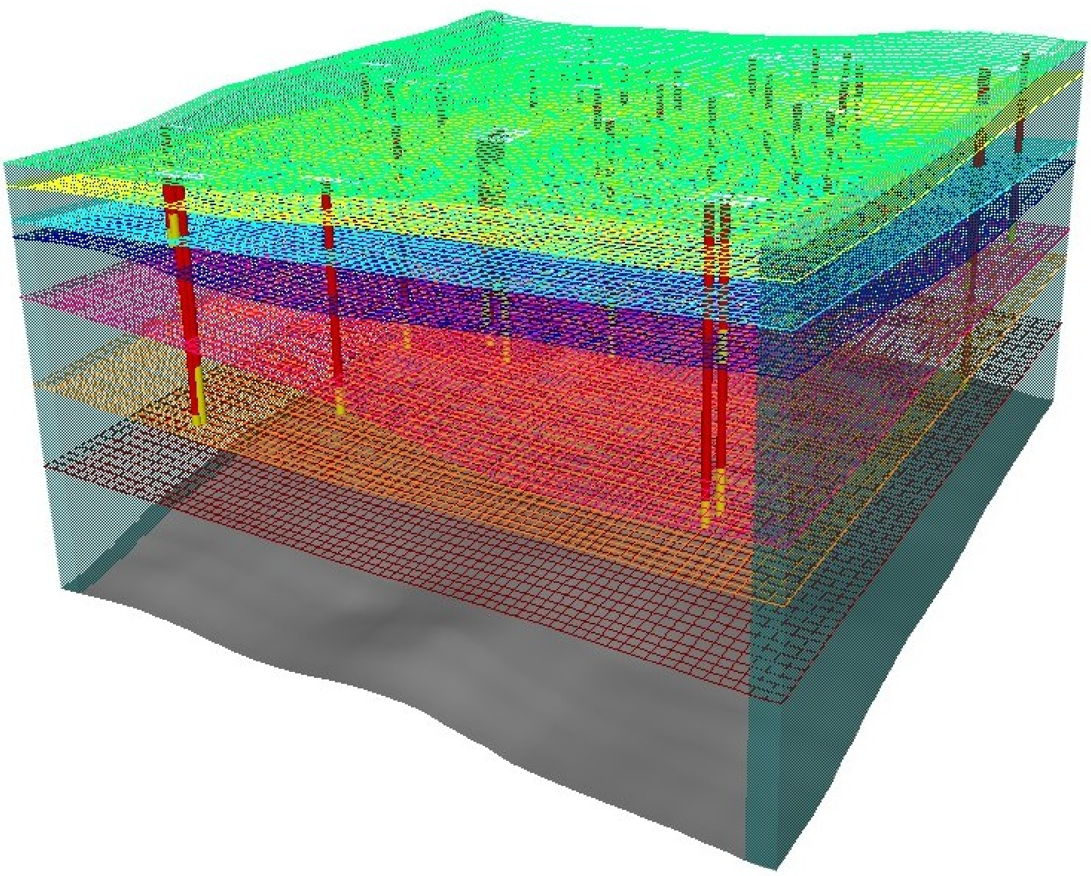
FIGURE 3-1

ISOMETRIC VIEW OF MODEL GRID



- Color shadings differentiate hydrogeologic formations.
- The top layer represents ground surface and the bottom layer represents bedrock.
- Public supply wells and monitoring wells are represented as vertical red cylinders, with screen intake sections shown in yellow.

FIGURE 3-2

HYDRAULIC CONDUCTIVITY LAYERS

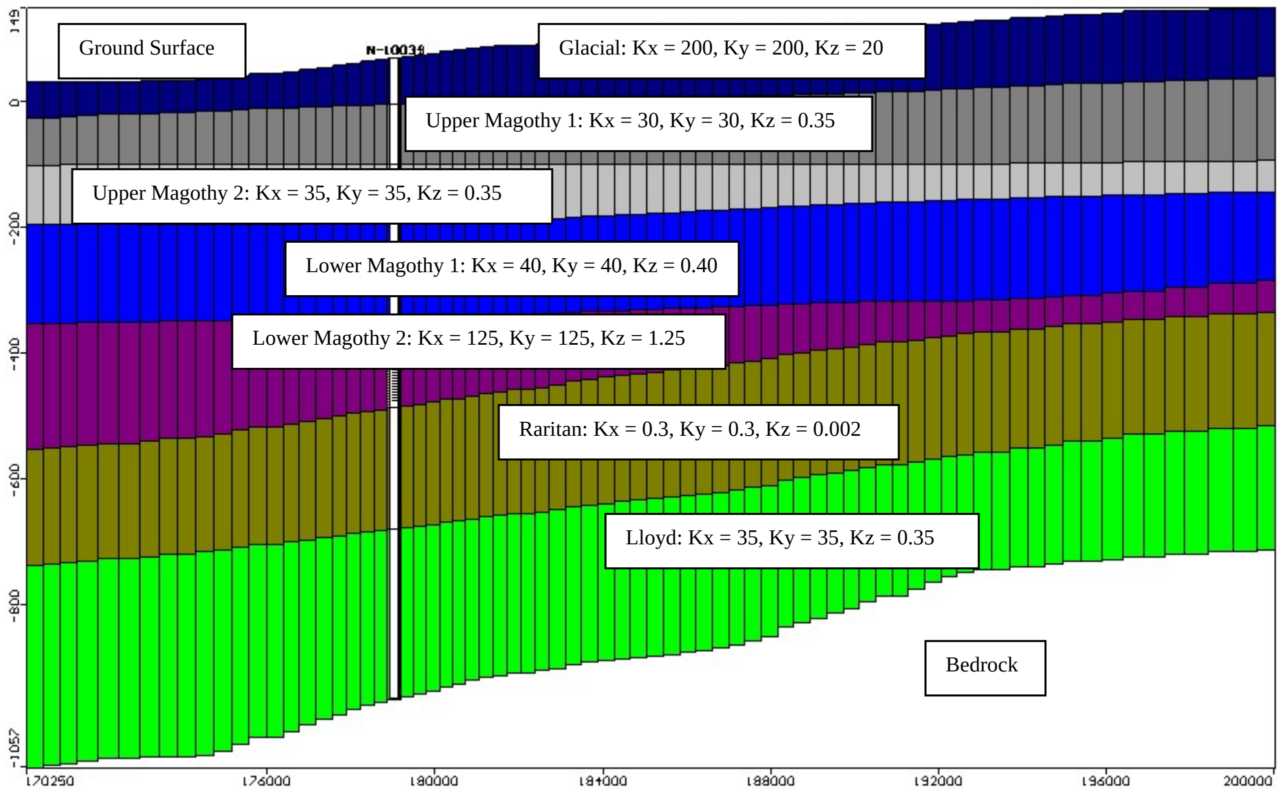
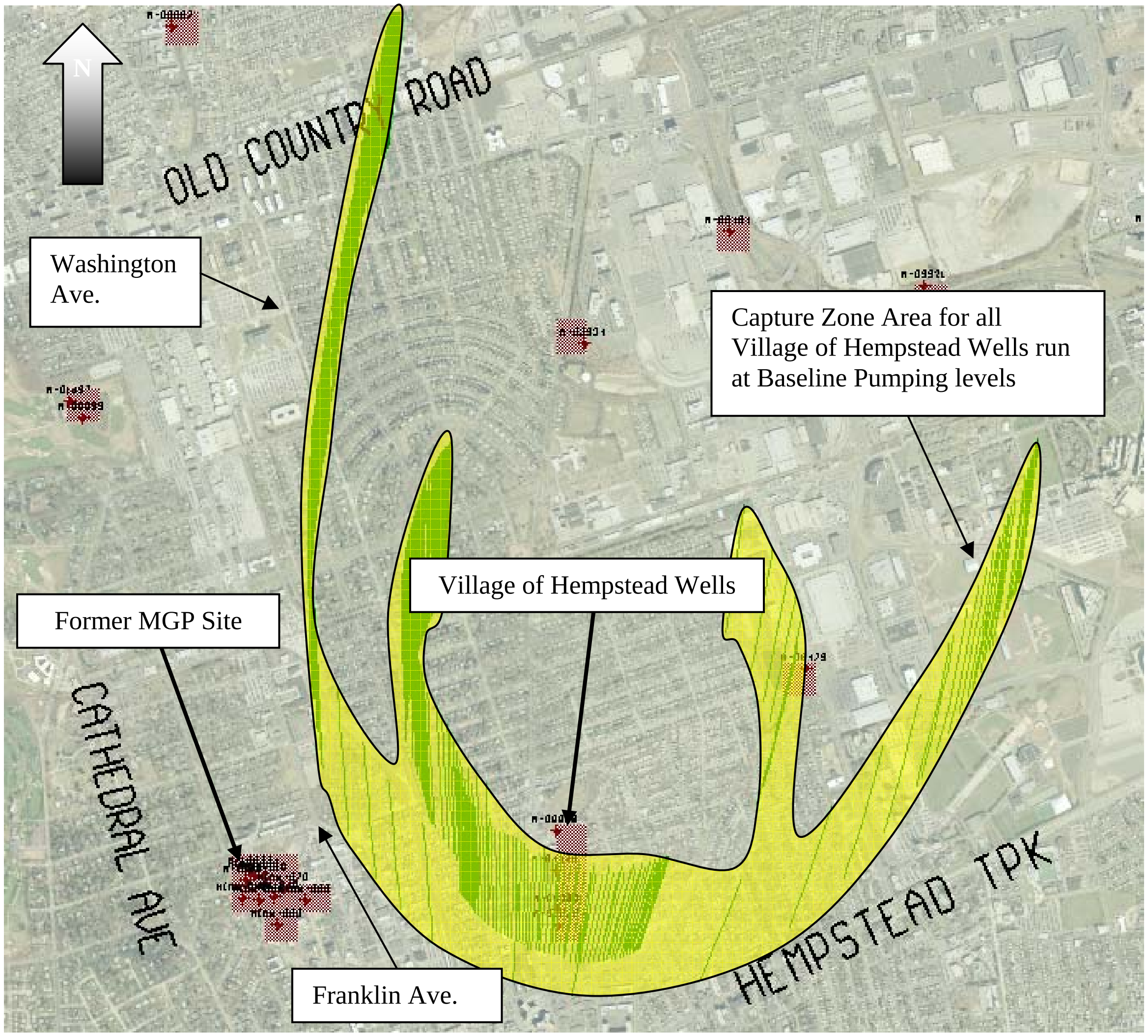
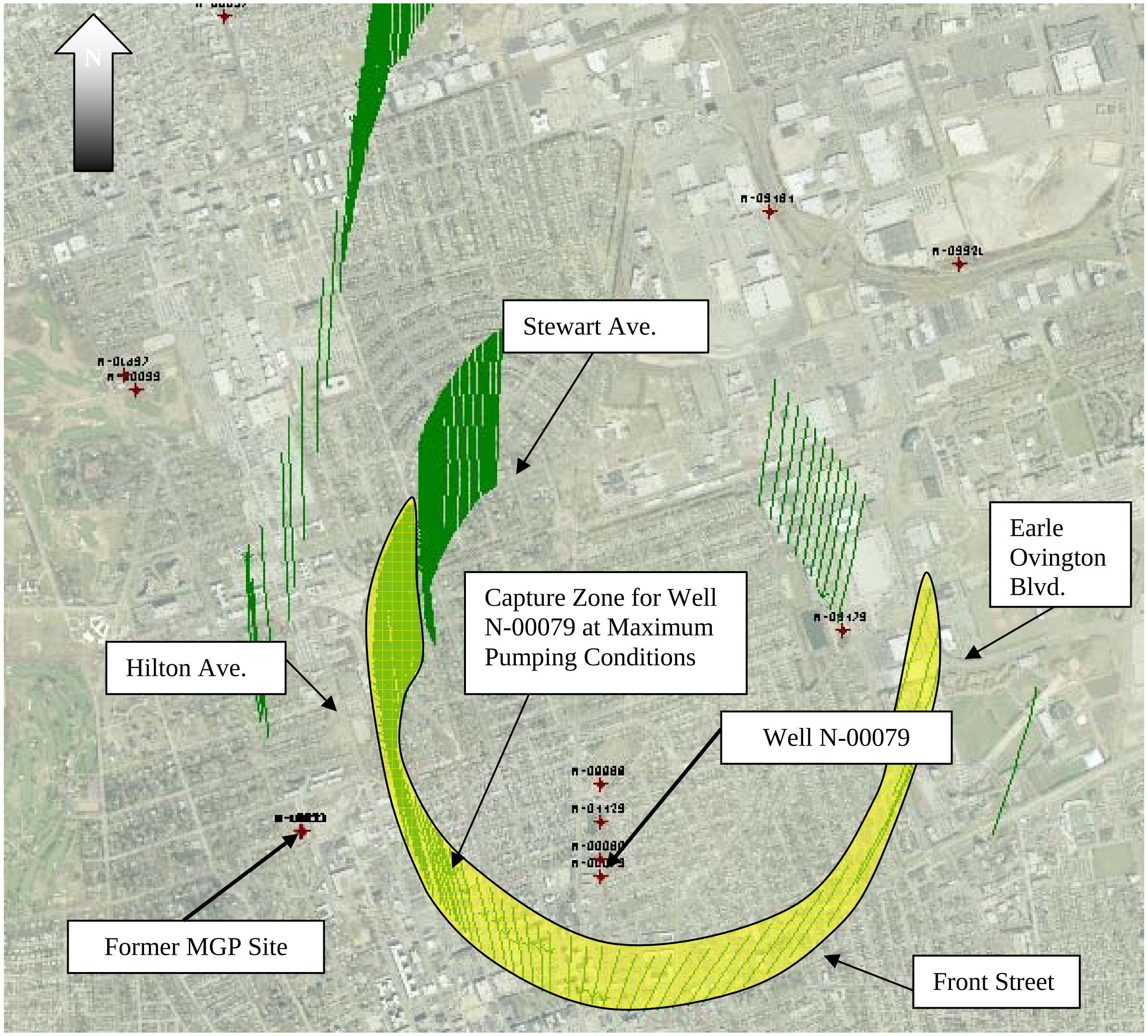


FIGURE 5-1
CAPTURE ZONE FOR BASELINE PUMPAGE SCENARIO



Note: The shape and configuration of the capture zone is influenced by several factors, including the subject well and other pumping wells in the region.

FIGURE 5-2
CAPTURE ZONE FOR WELL N-00079 MAXIMUM PUMPAGE SCENARIO



Note: The shape and configuration of the capture zone is influenced by several factors, including the subject well and other pumping wells in the region.

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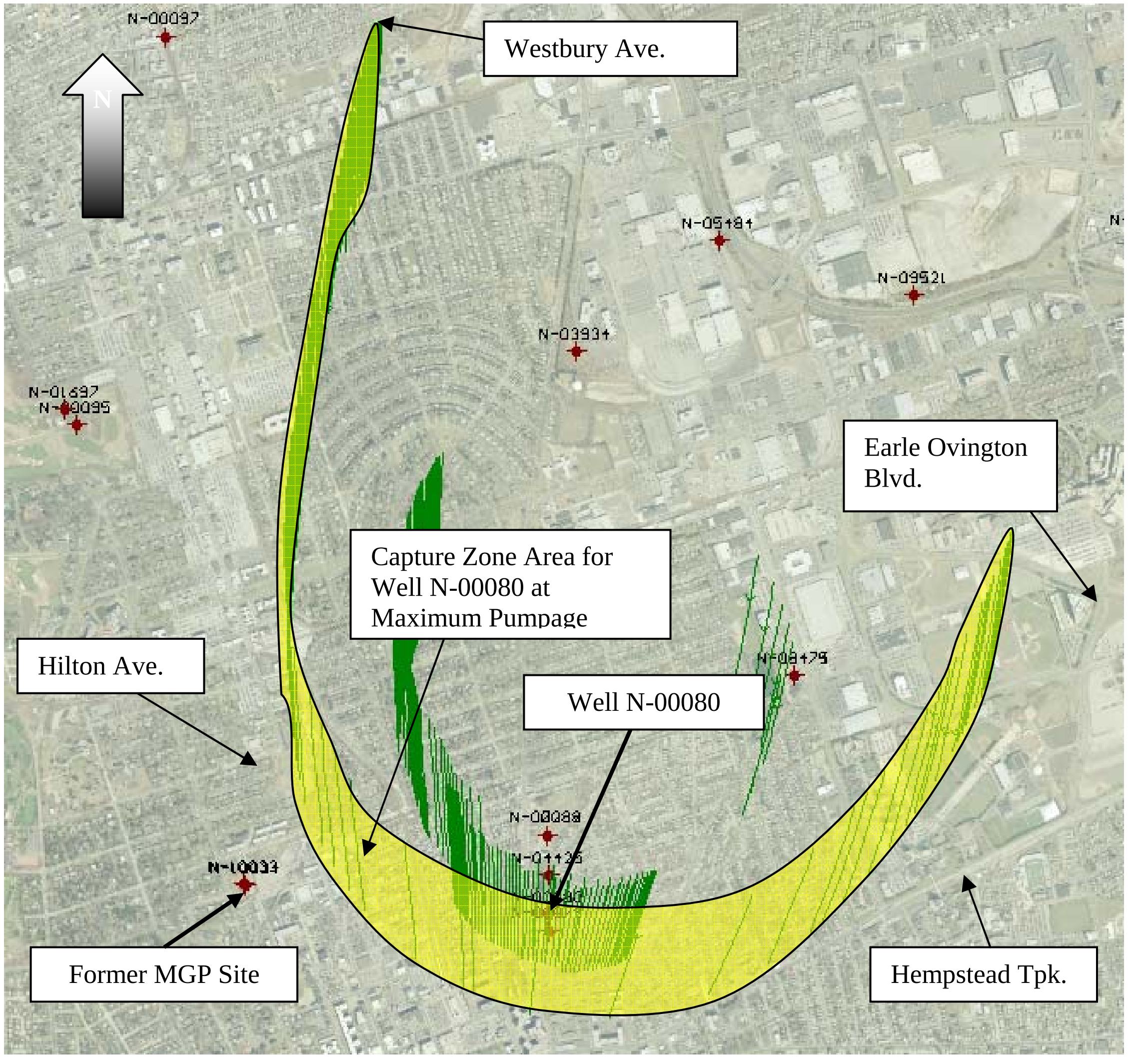
FIGURE 5-3
CAPTURE ZONE FOR WELL N-00080 MAXIMUM PUMPAGE SCENARIO



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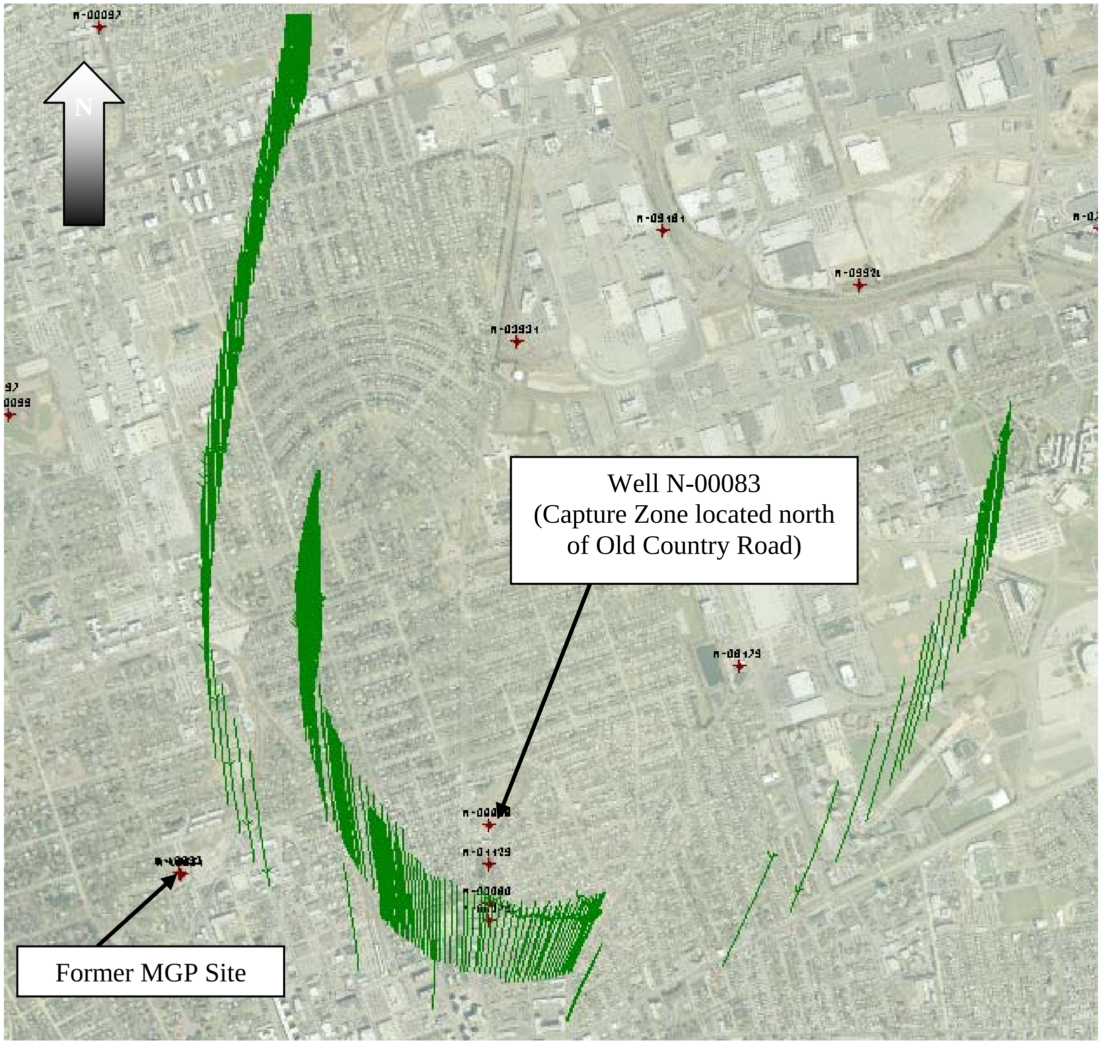
Note: The shape and configuration of the capture zone is influenced by several factors, including the subject well and other pumping wells in the region.

FIGURE 5-4
CAPTURE ZONE FOR WELL N-00082 MAXIMUM PUMPAGE SCENARIO

Note: The shape and configuration of the capture zone is influenced by several factors, including the subject well and other pumping wells in the region.

FIGURE 5-5
CAPTURE ZONE FOR WELL N-00083 MAXIMUM PUMPAGE SCENARIO



Note: The shape and configuration of the capture zone is influenced by several factors, including the subject well and other pumping wells in the region.

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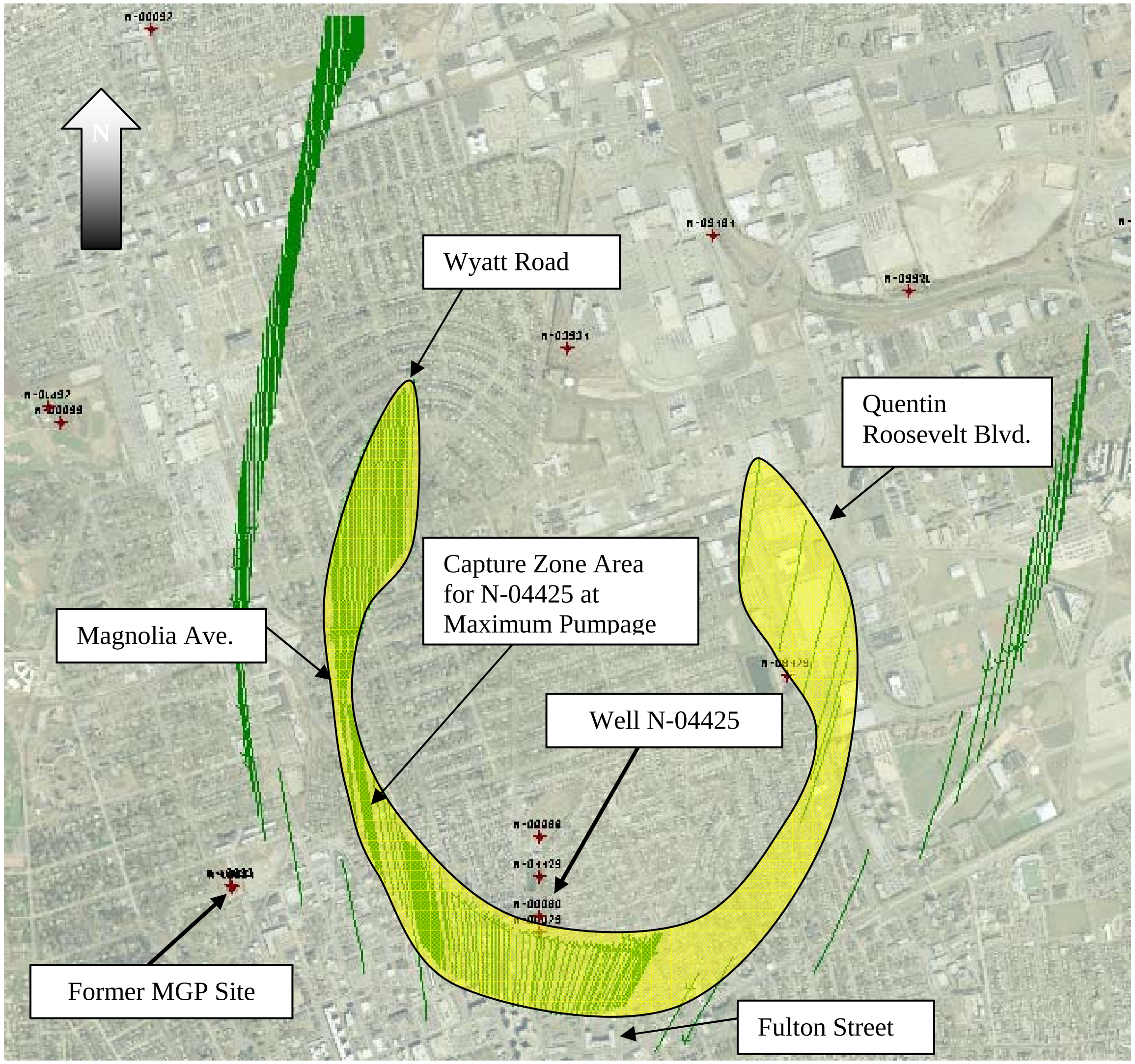
FIGURE 5-6
CAPTURE ZONE FOR WELL N-04425 MAXIMUM PUMPAGE SCENARIO



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Note: The shape and configuration of the capture zone is influenced by several factors, including the subject well and other pumping wells in the region.

FIGURE 5-7
CAPTURE ZONE FOR WELL N-07298 MAXIMUM PUMPAGE SCENARIO

Note: The shape and configuration of the capture zone is influenced by several factors, including the subject well and other pumping wells in the region.