CHAZEN ENVIRONMENTAL SERVICES, INC.

Capital District Office
Phone: (518) 273-0055

Orange County Office
Phone: (845) 567-1133

21 Fox Street, Poughkeepsie, New York 12601
Phone: (845) 454-3980 Fax: (845) 454-4026
Web: www.chazencompanies.com

North Country Office
Phone: (518) 812-0513

January 4, 2007

Supervisor Marirose Bump and Town Board Members
Red Hook Town Hall
7340 South Broadway
Red Hook, NY 12571

Re: Red Hook Central Aquifer Area - Water Resource Assessment
TCC Job No. 40627.00

Dear Supervisor Bump:

The Chazen Companies (TCC) were retained to conduct a groundwater resource assessment for a central part of the Town of Red Hook and the Village of Red Hook, in Dutchess County, New York State (Figure 1). This report evaluates overall available aquifer recharge capacity which the Village and Town could draw upon, and the present reserve capacity of the existing Town and Village wellfields. This report also evaluates the Town and Village's existing wellhead protection zones and recommends levels of groundwater protection appropriate to ensure sustained potable water quality from these or any future wellfields.

Findings of this evaluation are summarized as follows:

1. **Demand**: The Town and Village water supplies currently meet an approximate, combined average daily demand averaging 256 gpm. With the addition of water demand from Red Hook Commons, Knollwood Commons, and Anderson Commons currently under various stages of SEQRA review, and demand from the future proposed North Village and South Broadwater Project Areas, increased typical daily water demand could rise to a daily average of 466 gpm, with peak demand periods requiring wellfield daily yields averaging 640 gpm.

2. **Aquifer Capacity Relative to Demand**: The central area around the Village and central Town of Red Hook lies within a local watershed bounded by low hills to the east and west, by a groundwater divide near the intersection of Rokeby Road and NYS Route 9 to the south,

and by the Sawkill Creek to the north. Our hydrogeologic review indicates that aquifer recharge refreshing aquifers in this area provides a sustainable annualized groundwater supply likely to average under future build-out conditions approximately 2,345 gpm during normal years and approximately 1,641 gpm during drought years.

The self-replenishing rate at which aquifer recharge occurs under the Village and Town central area exceeds the proposed average Village/Town water demand rate of 466 gpm rate by approximately 5 times during normal years and by approximately 3.5 times during drought years. To the degree that wells are, or can be, optimally positioned to capture this groundwater, it appears that there is therefore sufficient renewable groundwater moving under Red Hook's central area to meet the community's present and proposed water demands.

3. Current Well & Distribution Capacity: Hydrogeologic data made available to TCC and conversations with individuals familiar with the Town and Village wellfields suggest that the current arrangement of wells in the Town and Village wellfields cannot supply the future proposed demand. Interconnecting water mains, a lift pump to deliver Town water to the elevation of the Village water tank, and one or more new wells may be needed to best manage future proposed water demand.

4. Water Consumption: At least 70% of water used in households and businesses normally becomes treated wastewater returned to watersheds via septic systems or sewage treatment plants. When considering the average daily 256 gpm currently pumped by the Red Hook Village and Town wellfields, this means approximately 77 gpm are currently lost by such uses as plant watering, cooking, perspiration, laundry drying, and other evaporative processes. If proposed future water demand in the central areas rises to 466 gpm, consumptive losses will rise by approximately 63 gpm to 144 gpm. The loss of water from watersheds slows the flow of groundwater supporting local streams. The loss of 63 gpm new gallons in the Village and Town central area would represent an approximately 6 percent reduction in flow during extreme droughts (10 year statistical flows) but only a small fraction of normal flows, normally ranging between 2,200 and 13,000 gpm (the 10% to 90% normal flow percentiles).

5. **Wellhead Protection Zones:** Wellhead protection areas previously mapped for the Town and Village wellfields appear adequate to describe the highest-risk recharge areas near the Village and Town wellfields.

6. **Aquifer Protection**: A model aquifer protection overlay regulation is available from the Dutchess County Water & Wastewater Authority (DCWWA). It recommends providing moderate levels of aquifer protection for all areas in the Town and Villages, with a higher level of protection in particularly valuable aquifer areas and community water system wellfield wellhead protection areas. Within wellhead recharge areas, higher-risk land uses should be managed or prohibited. Examples of higher-risk land uses include such uses as underground storage tanks for any soluble or semi-soluble chemicals, unmanaged above-ground storage of soluble chemicals, and subsurface disposal of wastewater. In addition, wherever domestic wells and septic systems are in use, parcel sizes should at a minimum meet average sizes recommended by DCWWA's 2006 septic density study (Chazen, April 2006) are recommended.

Fuller discussion of each of the above summary topics is explored below.

Red Hook Geology and Hydrogeology

TCC reviewed existing readily-available data describing the geologic characteristics of Red Hook's central area. For purposes of this study, the central area was defined by the local watershed boundaries surrounding the Village/Town central area, roughly defined as extending northward from Rockeby Road to the Sawkill Creek, and between rocky hills east and west of the central areas (Figure 1).

Within this central area, predominant bedrock units exhibit variations of shale and sandstone sedimentary rocks. The most common bedrock unit found in Red Hook is the Austin Glen formation consisting of shale and impure sandstone (greywacke). A north-south gorge in the buried bedrock (Figure 1) passes under the central area of Red Hook; it is up to 150 feet deep but is not visible today because it is filled with sediments deposited during the most recent glacial period (Urban-Mead, 1991).

Soil formations in Red Hook were deposited approximately 14,000 years ago. Prior soils were largely scoured away during the glacial period. Throughout Red Hook, new deposits of compressed clay and rock debris ("glacial till") were deposited under the glacial ice in hillside areas and under some low-lying areas. Then, as

glacial ice eventually began to melt away, a temporary lake occupied central Red Hook until east-to-west flow of the Saw Kill to the Hudson River could be re-established. During this lake period, a wide range of water-washed sediments were deposited throughout the Town center areas. Coarse sediments ("kame" glacier deposits) were deposited under and north of the Village center where the Sawkill flowed into the temporary lake; the very coarsest sediments were dropped between the current Town wellfield and Rockerfeller Lane and also immediately east of the Village wellfield where gravel mining has occurred in the past. Silt and clay deposits accumulated further out in the temporary glacial lake, south of Rokeby Road and north of Rockerfeller Lane (glacial "lacustrine" deposits).

Figures 2 and 3 show the surficial geology and origins of soil types in the central Red Hook area. New York State Surficial Geology mapping (Figure 2) uses glacial geology terminology referenced in the prior paragraph. Figure 3 provides more detailed mapping derived from Dutchess County's soil survey; the soil survey does not distinguish between glacial outwash and glacial kame deposits within Red Hook, but does closely identify where the coarser sand/gravel sediments may be found.

The Village and Town of Red Hook wellfields each lie within some of the coarsest, glacial kame and outwash formations.

Figure 4 identifies the general direction of groundwater flow moving through overburden and bedrock aquifers in Red Hook's central area. Groundwater contours were interpreted from site hydrogeologic features and prior studies (Urban-Mead, 1991). In the valley center, groundwater generally migrates toward the Sawkill Creek, its tributaries and it adjacent wetlands. Groundwater flow under adjacent upland bedrock areas is also toward the central valley area and thence to the Sawkill Creek. East of Linden Avenue, substantial groundwater has been documented by stream gauging to directly supplement Sawkill Creek flows through the gravelly bottom sediments (Urban-Mead, 1991). West of Linden Avenue, the bed of the Sawkill Creek is more clayey, forcing shallow groundwater to reach the Sawkill via springs and small overland streams south of the main creek (Urban-Mead, 1991).

Red Hook's Central Area Aquifer - Recharge Analysis

Average annual rainfall over the period between 1951 and 1980 in the Town of Red Hook was approximately 38 inches (Randall, 1996). A portion of this successfully recharges underlying aquifers.

A recently-published study by The Chazen Companies (April 2006) was used to identify aquifer recharge rates in Red Hook based on infiltration capacities grouped

into Hydrologic Soil Groups by the Natural Resources Conservation Service (NRCS). The distribution of Hydrologic Soil Groups (HSG) in Red Hook's central area is shown on Figure 5.

- 17.3 annual inches of recharge enters aquifers through Hydrologic Soil Group (HSG) A and A/D soils,
- 12.6 inches per year recharge aquifers through HSG group B soils,
- 6.5 inches per year recharge aquifers through HSG group C and C/D soils,
- 3.6 inches per year recharge aquifers through HSG group D soils.

Using these recharge rates and the acreages of soils in each Hydrologic Soil Group within Red Hook's central local watershed area, a raw estimate of annual aquifer recharge was calculated to be approximately 1.35 billion gallons, equivalent to an average flow of 2,574 gpm (Table 1).

Impervious surfaces can limit or prevent recharge to underlying aquifers if water cannot recharge through adjacent areas. The TR-55 runoff analysis method developed by the Soil Conservation Service does not identify significant runoff increases during rainfalls of modest duration (e.g. less than approximately 1 inch per day) for any land uses except dense residential and commercial uses. This is because moderate rainfall events, comprising a majority of all rainfall events, result in water flows traveling only short distances before reaching vegetated margins where recharge can still occur (e.g. along driveways, along sidewalks, around roof drip-lines). Therefore, only in areas with extensive and connected impervious surfaces and/or intentionally collected runoff is aquifer recharge substantially reduced during most typical, moderate rainfall events.

Substantial interconnected present and future impervious surface may lie in and around the current Red Hook Village municipal boundaries. Inspection of Figure 5 shows that the most densely settled areas in and near the Village of Red Hook overlie Hydrologic Soil Group B soils. TCC conservatively therefore estimates that approximately 50% of HSG B soils may therefore have sufficiently interconnected impervious surfaces or managed stormwater drainage systems now or in the future to reduce recharge by up to 25% of natural recharge potential, equivalent to a 12% reduction to overall recharge entering HSB B soils in the study area. With this modification to the Table 1 raw data, the total annual recharge estimate during normal years is modified to average approximately 2,345 gpm over a year. Finally, during a drought year, the normal recharge rate might be reduced by 30%, resulting in an average recharge rate over a year of 1,641 gpm.

Based on these recharge predictions, average aquifer recharge in Red Hook's central area is estimated to vary around 2,345 gpm during normal years and may fall to approximately 1,641 gpm during drought years. Rates of aquifer recharge

could be improved over those predicted here if stormwater management practices encouraging recharge are included in Red Hook's central area planning processes.

The recharge rate estimates described above appear consistent with available stream gauging data provided by Urban-Mead (1991), documenting a gain in Sawkill Creek flow of approximately 2,500 gpm between Route 9 and the west valley wall during May of 1991 and a smaller dry-season gain of 940 gpm over the same stream reach during July of 1991. Such rates of groundwater entry into the Sawkill are reasonable given seasonal cycles, and appear consistent with rates which might be expected over a 12 month interval fluctuating around the average predicted rate of gain of approximately 2,300 gpm from the watershed area south of the Sawkill near the central Town/Village area.

These rates of groundwater replenishment and potential availability exceed rates of current and potential future demand outlined in the following section by substantial margins, suggesting that the proposed water uses can be supported provided that sufficient well capacity is available.

Estimates of Current and Future Water Demand

Documents and/or conversation with Village and Town water district personnel indicate that the two wellfields currently meet average daily demands of their respective water districts using their current wellfields. The Town's recent average and peak water delivery values are approximately 70,000 gpd and 90,720 gpd, respectively. The peak flow is approximately 30% over average daily demand. A Village engineering report indicates that the Village's peak 2005 water delivery rate was 386,000 gpd. From this peak value, TCC estimated an average Village water demand using the approximately 30% ratio of Average to Peak delivery experienced by the Town water district. From Table 2, the two systems can together be shown to deliver 256 gpm during average demand days and as much as 331 gpm during coincident peak demand days.

The Village engineer report indicates that three projects currently under review will require approximately 48,000 gpd, or 33 gpm. Estimating that this represented average daily demand, TCC increased this value by 30% to 62,000 gpd, to represent estimated peak demand days at an average of 43 gpm during peak demand days.

Generalized project details were provided via the Town to TCC describing the conceptual North Village and South Broadway project areas. Using standard design criteria, future average and peak water demand values were estimated for these areas (Table 3). The North Village project area was predicted to require 68 gpm and 102 gpm during average and peak daily demand periods, respectively, and

the South Broadway project area was predicted to require 109 gpm and 163 gpm during average and peak daily demand periods, respectively. Peak demand was calculated using a more conservative multiplier of 150%.

Combined total future water supply demand is estimated to average 466 gpm and peak at approximately 640 gpm between the Village and Town water districts assuming no other use demands or service district areas will occur.

Town and Village Water Demand and Well-field Capacities

TCC contacted Mr. Hank Van Parys from the Town of Red Hook and Morris Associates to acquire production and well yield information from the Town and Village of Red Hook wellfields, respectively. Estimates of yield capacity for each well were provided to TCC and summarized on Table 4. No new analysis or engineering review work were provided to test or analyze the validity of the supplied data. We also met with Mr. Van Parys on November 14, 2006 to visit both wellfields as well as the Village of Tivoli wellfield.

The Town of Red Hook wellfield contains two 60 foot deep gravel wells capable of producing individual flows of approximately 225 gpm. If pumped simultaneously, they are reportedly able to produce approximately 420 gpm. The wells are currently configured to satisfy a NYSDOH redundancy requirement, assigning PW-2 to remain available only as a mechanical back-up well for PW-1. Thus, as currently configured, the wellfield produces 225 gpm. Excess storage capacity reportedly exists in the Town's water tank system.

The Village of Red Hook wellfield consists of six production wells. Wells 1, 3, 4, and 9 penetrate to bedrock fractures, while wells 12 and 13 are installed in the overlying sediment formation. Morris indicates wells 12 and 13 were originally designed to each produce flows greater than 150 gpm but are currently yielding between 78 and 84 gpm. The four Village bedrock wells reportedly provide yields of between 46 and 80 gpm although it is not known if these rates have been verified since additional groundwater began being withdrawn from the overlying sediment aquifer in wells 12 and 13. The wellfield's current highest-yielding well is PW-13. Thus, as currently configured, this wellfield can reportedly produce 329 gpm with well PW-13 serving as a mechanical back-up well.

The Town and Village wellfields can separately provide 554 gpm, each with their best well out of service. This total exceeds the future estimated average daily demand needed by the proposed Red Hook center concept plan, but does not meet the estimated future peak demand (Table 2).

We suspect the Village wellfield has little remaining reserve capacity due to its small property holding and existing wells arrangements, while the Town wellfield is likely to have more reserve capacity on the basis of reported test results and untapped land areas on the existing parcel. The Town wellfield is reportedly capable of supporting 420 gpm when wells 1 and 2 are pumped simultaneously. If this is verified and the water district's operating permit is changed, such available capacity could increase the combined wellfield yield available to support the projected peak demand for the Village/Town center expansion project.

To realize this capacity, the following would be needed among other potential improvements:

- Steps should be explored to increase permitted yield. This could occur at the Town wellfield by evaluating the reputed available capacity of 420 gpm from combined pumping of Wells 1 and 2, or by exploring other sites. Either action would likely lead to required installation of one more well, either for a third well at the Town wellfield or for a new well at another location. Locations for new wells could include the existing Town wellfield, portions of the Town recreation park across the creek from the Town wellfield, or a new location. Well locations outside of the developed Village/Town central area are preferred on the basis of ease of quality protection.
- A properly sized connection pipe between the Town and Village water systems and pump facilities to compensate for different storage tank elevations would be needed. Interconnected water storage, treatment, and pump controls may also be required.
- Organizational, operational, and legal adjustments may be required to allow efficient inter-operational adjustments between the two present water systems.

If the two wellfields are more formally operated as a unified system, the Village of Red Hook wellfield may be able to use all its wells and credit the Town's reserve well as its redundant well, increasing the capacity of the Village system to 413 gpm. Then, by adding a new backup well at or near the Town wellfield site, the Town capacity may also increase by up to 420 gpm as a result of combined use of existing Town wells 1 and 2. Jointly, these changes would appear sufficient to allow the two existing wellfields to meet the future proposed average and peak daily water demands.

An engineering evaluation of operational improvements (e.g. lines, lift pumps, and operational interconnections) and the installation and testing of existing and new Town wells will be needed if the municipalities wish to more closely dimension and allocate future project costs.

The water source capacity of the Village of Tivoli water district has not been a primary focus of this investigation, but based on reported data, it appears the district may be capable for producing up to 113 gpm with either one of its two 40 gpm wells reserved as a redundant well.

Production Well Locations

On November 14, 2006, TCC and Mr. Hank Van Parys from the Town of Red Hook visited the Town and Village of Red Hook wellfields and the Village of Tivoli wellfields to identify the locations of all actively-used production wells using a handheld global positioning system (gps) unit. In advance of this meeting, TCC reviewed readily-available reports and map resources to discuss well yields and geologic formations when applicable.

The approximate location of each wellfield is shown on Figure 6 and a list of all production wells is found on Table 4. The Town of Red Hook wellfield contains two production wells located north of the Village center (Figure 7). The Village of Red Hook wellfield is located south of the Village center and contains eight production wells (Figure 8). The Village of Tivoli wellfield is spread out over five separate parcels and contains a total of ten productions wells (Figure 9).

Electronic versions of the mapping produced as part of this study is available to the Town in several formats and may be used by the Town in the future if it wishes to update municipal water resource or groundwater ordinance maps.

Aquifer Protection

The County has developed an aquifer protection model available to Towns at no charge. The Town of Amenia is currently considering this model for adoption and has offered minor but helpful grammatical and content improvements. The approach provides a rigorous level of aquifer protection for most vulnerable aquifer areas, including wellhead protection areas, and recommends more modest but carefully targeted comprehensive aquifer protection for all other areas in a Town where populations rely on groundwater at a quality suitable for human consumption.

TCC worked on the development of the County aquifer protection model and recommends it for consideration in the Town of Red Hook and within both Villages, as applicable. The text for this model is available from the Dutchess County Water & Wastewater Authority. An aquifer overlay map would be needed for the Town and Villages. As a starting point, TCC would recommend applying the model's highest level of aquifer protection to the Town and Village wellhead protection

areas. The model's broader protection levels should then be applied throughout the balance of the municipalities.

An aquifer protection model has already been under consideration in the Town of Red Hook. It is far less comprehensive than the County model and does not address many land uses commonly recognized to pose potential threats to aquifer quality. Notwithstanding, since any aquifer protection is better than no protection, efforts to adopt the draft Red Hook ordinance should not be abandoned unless the more comprehensive Dutchess County model is to be considered.

Wellhead Protection Areas

TCC has briefly reviewed the existing wellhead protection delineations available for the Town and Village of Red Hook water supply wells. It is our belief that neither requires revision at this time.

The Village delineation was prepared by Horsely Witten and Hegemann in 1992 based on a Village wellfield operational pumping rate of 330 gpm. This rate coincidentally effectively matches the Village's current effective capacity of 329 gpm with a best well out of service although the wells in use today include two sand and gravel wells installed near the bedrock wells. The delineation method used in 1992 assumed that the sand and gravel aquifer and underlying bedrock aquifer are interconnected and access effectively the same water; accordingly, although the Village now has sand and gravel as well as bedrock wells, the similar net yield and interconnected aquifer condition suggests the wellhead protection delineation is adequate until yields increase.

The Town delineation was prepared by Urban-Mead (1991) based on an operational pumping rate of 225 gpm. Until the pumping rate from this source area is increased over 225 gpm, the prior delineation remains adequate.

No known wellhead protection delineations are known to exist for the Village of Tivoli wellfields, so TCC did not review delineations for these wells.

Other Considerations

At least 70% of water used in households and businesses normally ends up as treated wastewater returned to watersheds via septic systems or sewage treatment plants. Wastewater returned to septic systems is not as thoroughly treated as water treated by sewage plants but benefits from dilution in the receiving underlying aquifer. Only where wells and septic systems are located too close to one another may operational difficulties be anticipated. DCWWA has published in 2006 recommendations for overall residential well and septic density guidance to

complement firm separation distances currently recommended by the NYS and County Departments of Health. Where septic systems are situated close to wells, measures including provision of central sewerage or wastewater pretreatment to existing septic systems may be necessary. Where septic systems are close together but no wells are jeopardized, groundwater carrying heavy wastewater loads will flow eventually to aquifer discharge areas, including riparian (streamside), ponds or receiving streams. Biological activity and the presence of abundant oxygen in open water bodies significantly reduces many biological wastewater constituents entering streams although excessive doses can result in eutrophic pond and stream conditions and other surfacewater degradation.

When considering the 256 gpm currently pumped by the Red Hook Village and Town wellfields, approximately 77 gpm are currently lost by such uses as plant watering, cooking, perspiration, laundry drying, and other evaporative processes, while some 179 gpm are currently being released to aquifers from a widely distributed network of septic systems. These returns contribute to and preserve flow in the Sawkill Creek so that the current stream flow reduction is 77 gpm rather than 256 gpm. TCC is not aware whether septic system returns have been shown to reduce water quality of the Sawkill or any of its tributaries or riparian ecological areas but suspects not since the release of 179 gpm into normally far higher stream flows provides ample dilution and natural treatment opportunity.

If future water demand in the Town and Village center rises to 466 gpm, consumptive losses will rise by approximately 63 gpm to 140 gpm, and wastewater discharges will increase either to septic systems or a sewage treatment plant by approximately 147 gpm. The impact of such additional wastewater discharges to septic systems or to sewage treatment plants may require analysis if new subsurface disposal areas lie close to domestic or community wells.

The evaporative loss of water from a watershed reduces flows of groundwater able to support local streams. The loss of 63 new gallons per minute in the Village and Town central area would represent an approximately 6 percent flow reduction in the Sawkill Creek during lowest flows (10 year statistical flows) recorded for this creek in Red Hook (Ayer & Pauszek, 1968). Under more typical weather conditions, defined here as the 10% to 90% common flow levels of this creek, between 2,200 and 13,000 gpm respectively, the future consumption of 63 gpm represents a small fraction.

Closing

TCC appreciates the opportunity to serve you on this project. Should you have any questions or comments, please do not hesitate to contact Russell Urban-Mead or me at 845-454-3980 to discuss these findings. TCC would be pleased to present

these findings at a public meeting and is prepared, if requested, to provide a follow-up proposal to dimension the engineering costs for a joint Town/Village water district with one or more new wells, or to assist with development of an aquifer protection ordinance and aquifer overlay map.

Sincerely,

Daniel P. Michaud
Project Hydrogeologist

Russell Urban-Mead
Senior Hydrogeologist

Figure 1 to 9, Tables 1 to 4

cc: D. McClure, PE, TCC

References:

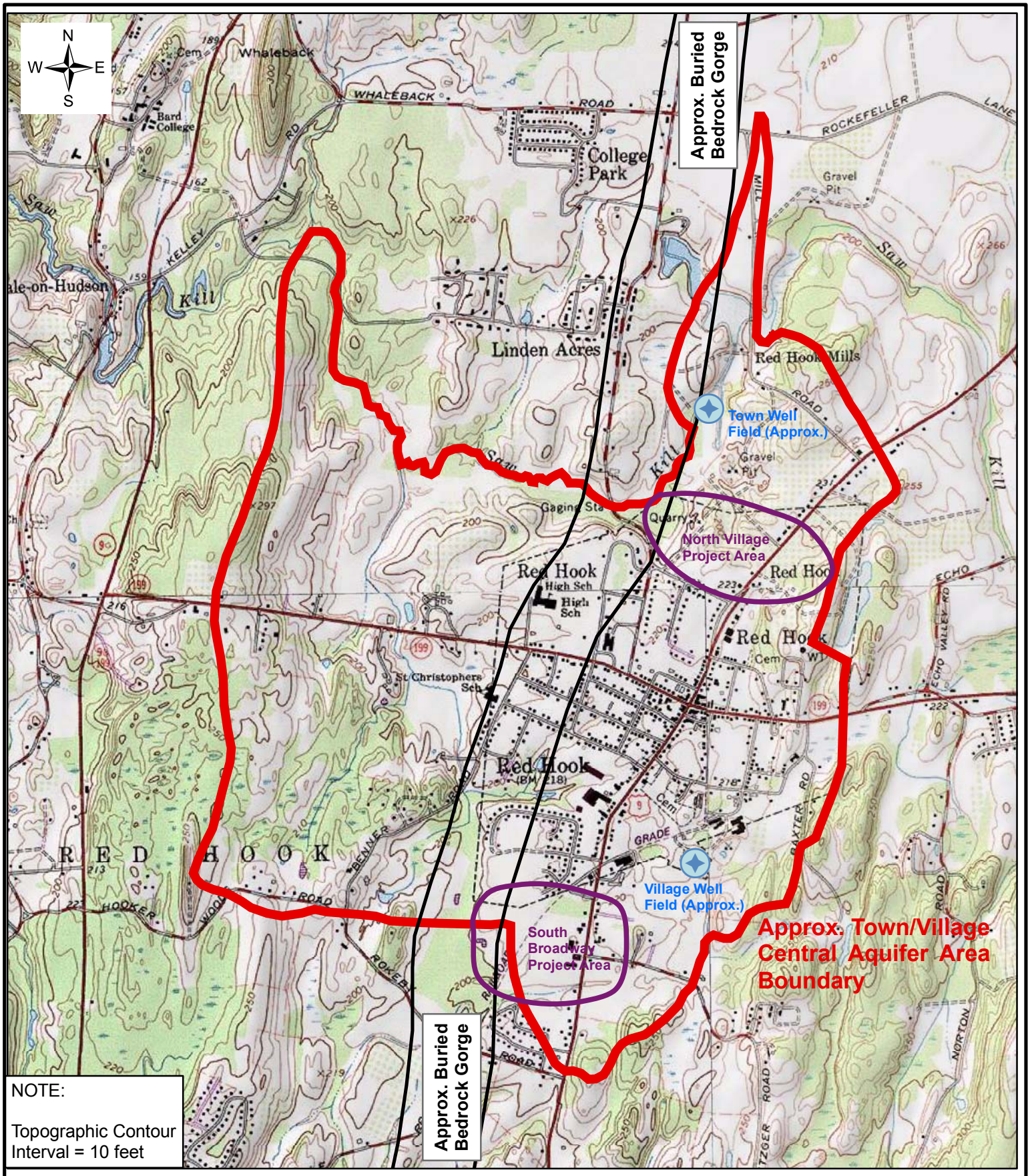
Ayer, G.R., Pauszek, F.H., 1968, Streams in Dutchess County, NY. State of NY Conservation Department, Water Resources Commission Bulletin 63.

Chazen Companies, April 2006, Dutchess County Aquifer Recharge Rates & Sustainable Septic System Density Recommendations. For Dutchess County Water & Wastewater Authority.

Horsley Witten Hegemann, Inc., 1992, Water Supply Protection Program for Dutchess County, NY, for the Dutchess County Water & Wastewater Authority.

Morris Associates, 2006 draft, Red Hook [Village] Water Supply Feasibility Study, for the Village of Red Hook.

Urban-Mead, R. 1991, Wellhead Recharge for the Town of Red Hook District 1 Wellfield. Master's Thesis.



THE Chazen COMPANIES
ENGINEERS/SURVEYORS
PLANNERS
ENVIRONMENTAL SCIENTISTS

Dutchess County Office:
21 Fox St. Poughkeepsie, NY 12601
Phone: (845) 454-3980

Orange County Office:
356 Meadow Ave. Newburgh, NY 12550

Capital District Office:
547 River Street Troy, NY 12180

Glens Falls Office:
110 Glen Street Glens Falls, NY 12801

FIGURE 1 - LOCATION MAP

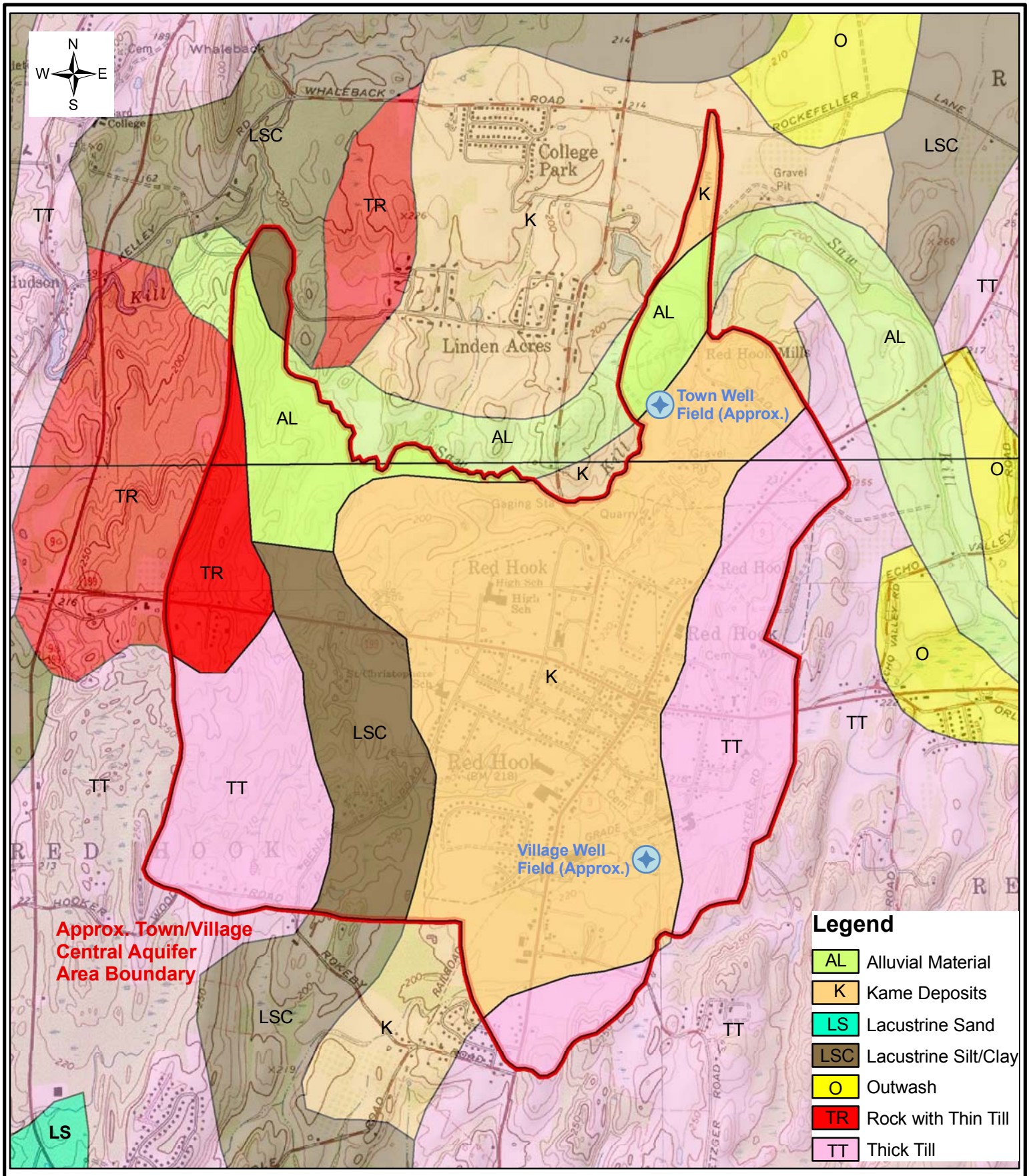
Town and Village of Red Hook, New York

U.S.G.S. Topographic Map of the Kingston East Quadrangle, dated 1980, 7.5-minute series.

Date: December 2006

Scale: 1 in equals 2,000 ft

Project #: 40627.00



THE Chazen COMPANIES
ENGINEERS/SURVEYORS
PLANNERS
ENVIRONMENTAL SCIENTISTS

Dutchess County Office:
21 Fox St. Poughkeepsie, NY 12601
Phone: (845) 454-3980

Orange County Office:
356 Meadow Ave. Newburgh, NY 12550

Capital District Office:
547 River Street Troy, NY 12180

Glens Falls Office:
110 Glen Street Glens Falls, NY 12801

FIGURE 2 - SURFICIAL GEOLOGY

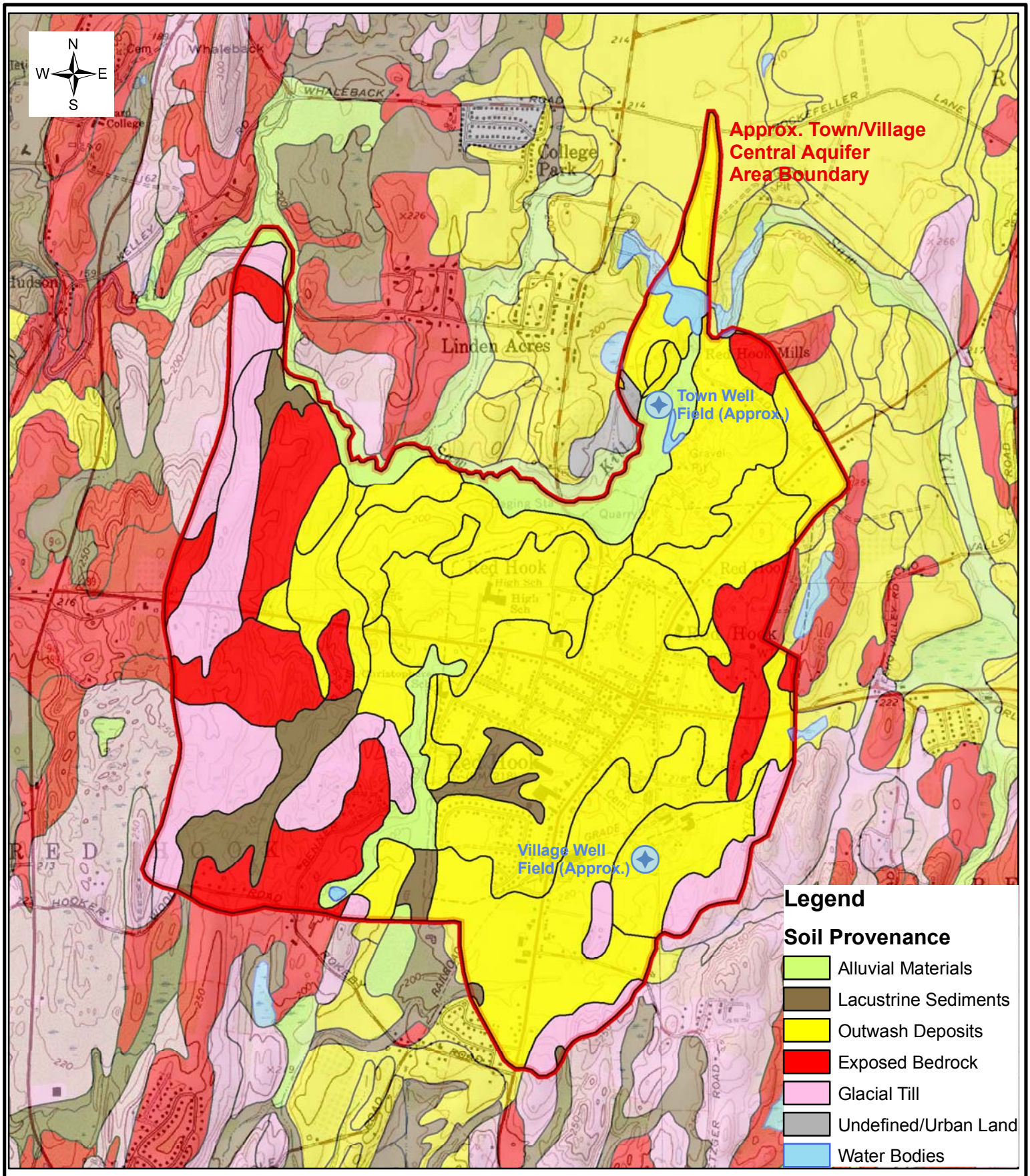
Town and Village of Red Hook, New York

NYS Geological Survey Surficial Geology Map of New York, Lower Hudson Sheet (1989) and Hudson-Mohawk Sheet (1987).

Date: December 2006

Scale: 1 in equals 2,000 ft

Project #: 40627.00



THE Chazen COMPANIES
ENGINEERS/SURVEYORS
PLANNERS
ENVIRONMENTAL SCIENTISTS

Dutchess County Office:
21 Fox St. Poughkeepsie, NY 12601
Phone: (845) 454-3980

Orange County Office:
356 Meadow Ave. Newburgh, NY 12550

Capital District Office:
547 River Street Troy, NY 12180

Glens Falls Office:
110 Glen Street Glens Falls, NY 12801

FIGURE 3 - ORIGIN OF SOILS

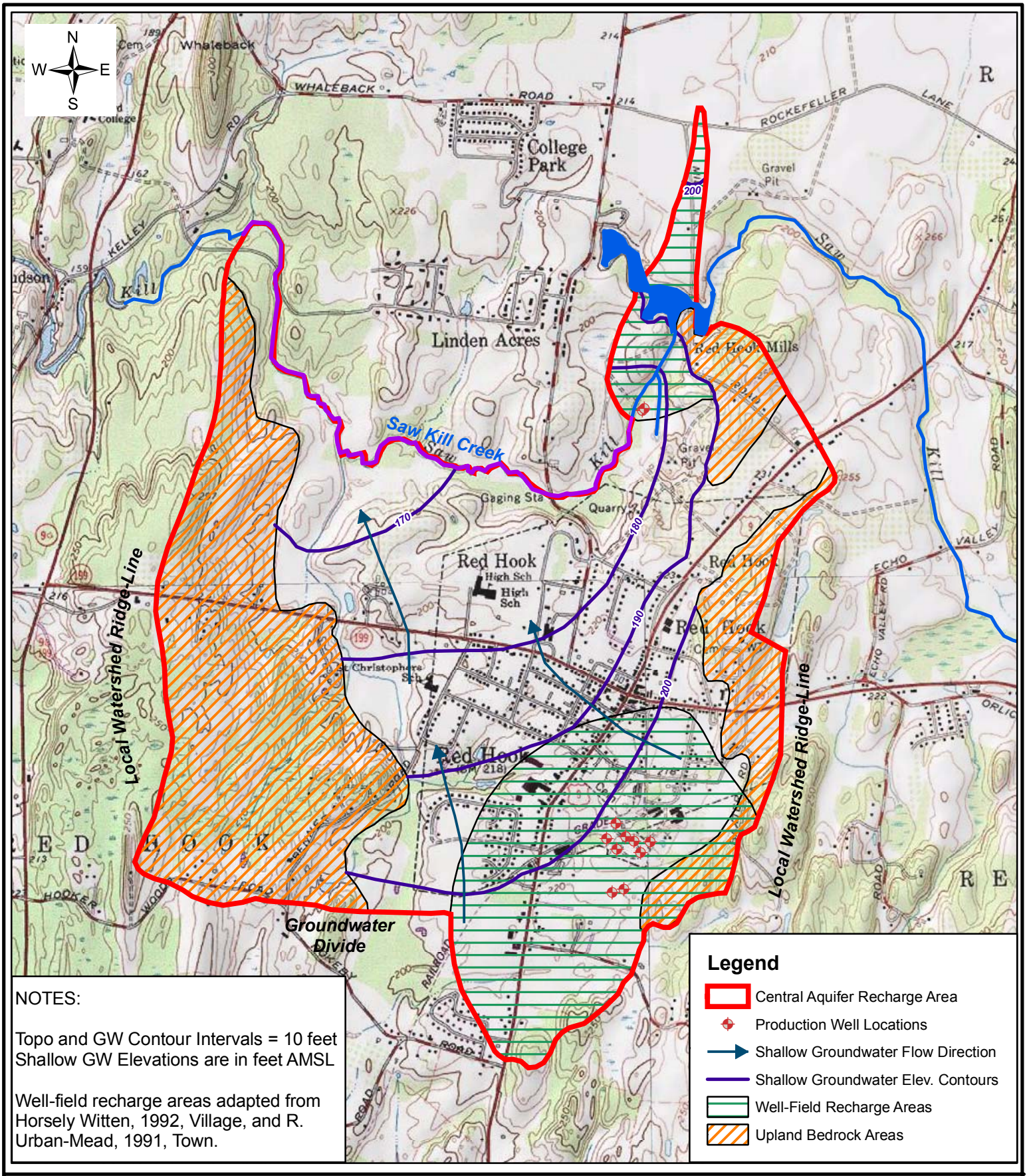
Town and Village of Red Hook, New York

Derived from Soil Survey of Dutchess County, 2002.

Date:
December 2006

Scale:
1 in equals 2,000 ft

Project #:
40627.00



NOTES:

Topo and GW Contour Intervals = 10 feet
Shallow GW Elevations are in feet AMSL

Well-field recharge areas adapted from Horsely Witten, 1992, Village, and R. Urban-Mead, 1991, Town.

THE Chazen COMPANIES
ENGINEERS/SURVEYORS
PLANNERS
ENVIRONMENTAL SCIENTISTS

Dutchess County Office:
21 Fox St. Poughkeepsie, NY 12601
Phone: (845) 454-3980

Orange County Office:
356 Meadow Ave. Newburgh, NY 12550

Capital District Office:
547 River Street Troy, NY 12180

Glens Falls Office:
110 Glen Street Glens Falls, NY 12801

FIGURE 4 - SITE HYDROGEOLOGY MAP

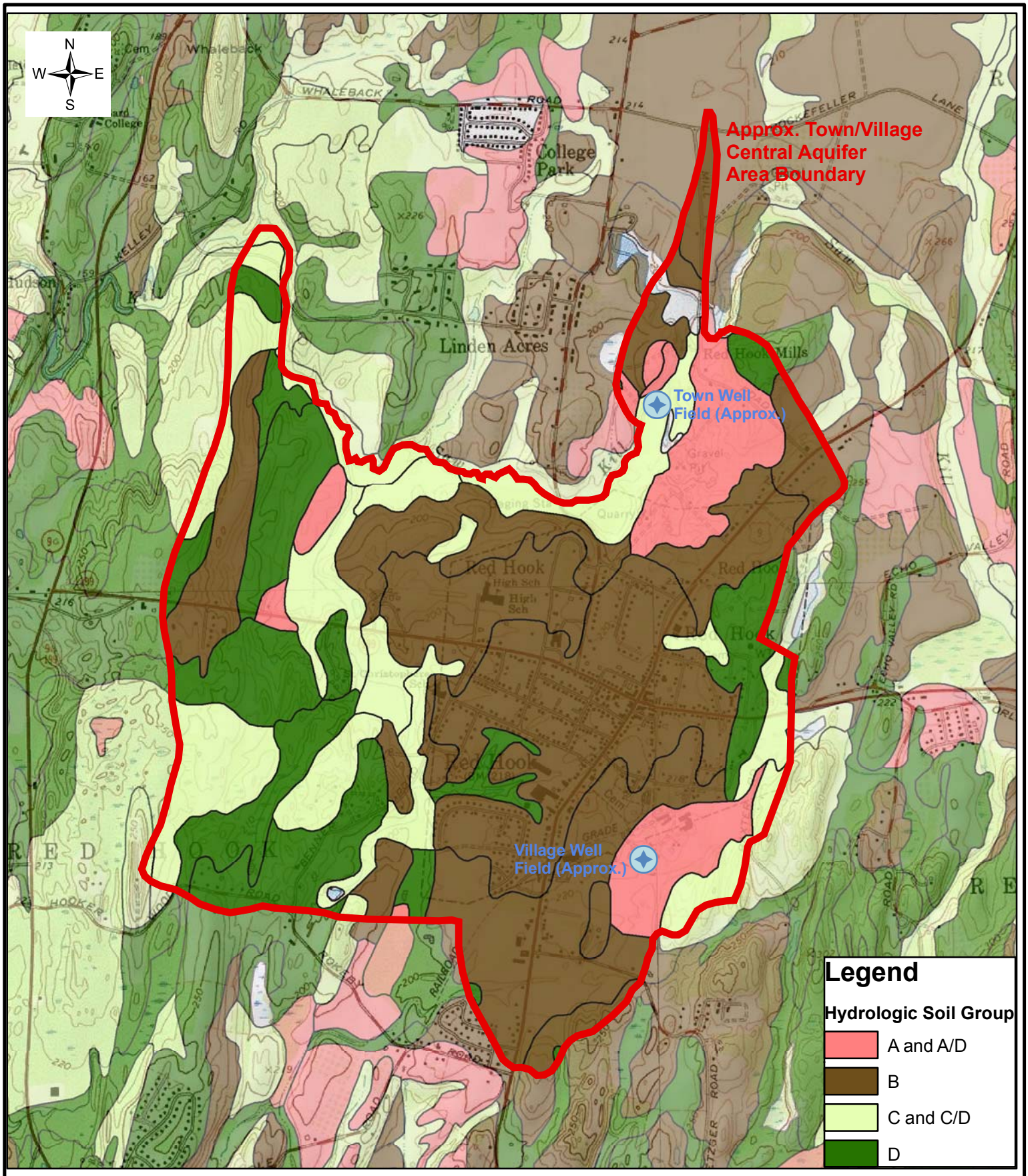
Village and Town of Red Hook Well-Fields
Town of Red Hook, Dutchess County, New York

U.S.G.S. Topographic Maps of the Saugerties, Kingston East, Rock City and Clermont Quadrangles, Dated 1967, 1963, 1963 and 1963 respectively, 7.5-Minute Series.

Date: December 2006

Scale: 1 in equals 2,000 ft

Project #: 40627.00



THE Chazen COMPANIES
ENGINEERS/SURVEYORS
PLANNERS
ENVIRONMENTAL SCIENTISTS

Dutchess County Office:
21 Fox St. Poughkeepsie, NY 12601
Phone: (845) 454-3980

Orange County Office:
356 Meadow Ave. Newburgh, NY 12550

Capital District Office:
547 River Street Troy, NY 12180

Glens Falls Office:
110 Glen Street Glens Falls, NY 12801

FIGURE 5 - HYDROLOGIC SOIL GROUPS

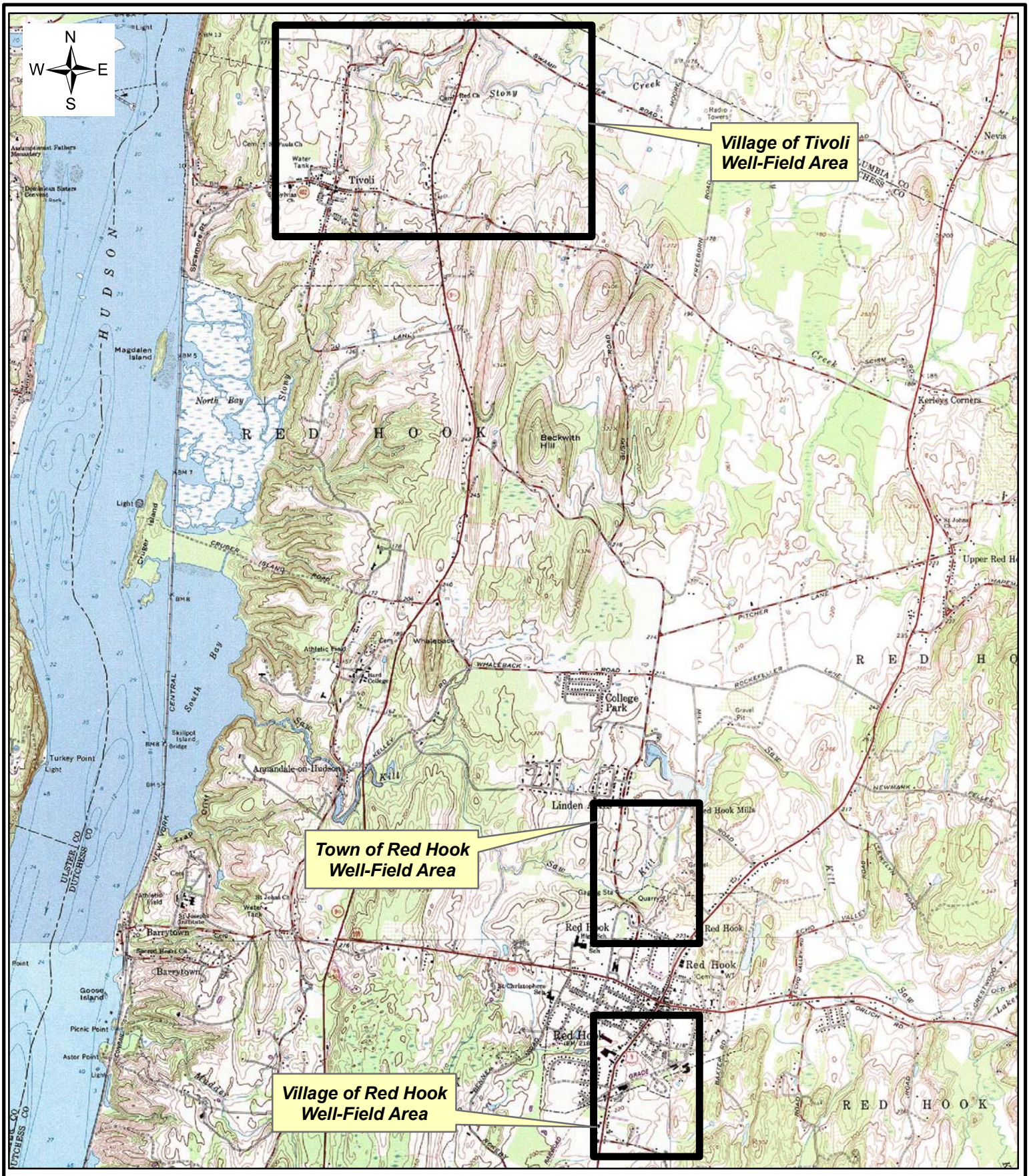
Town and Village of Red Hook, New York

USDA NRCS Soil Survey of Dutchess County, 2002.

Date:
December 2006

Scale:
1 in equals 2,000 ft

Project #:
40627.00



THE Chazen COMPANIES
ENGINEERS/SURVEYORS
PLANNERS
ENVIRONMENTAL SCIENTISTS

Dutchess County Office:
21 Fox St. Poughkeepsie, NY 12601
Phone: (845) 454-3980

Orange County Office:
356 Meadow Ave. Newburgh, NY 12550

Capital District Office:
547 River Street Troy, NY 12180

Glens Falls Office:
110 Glen Street Glens Falls, NY 12801

FIGURE 6 - TOPOGRAPHIC MAP

Villages of Tivoli and Red Hook Well-Fields and Town of Red Hook Well-Field

Town of Red Hook, Dutchess County, New York

U.S.G.S. Topographic Maps of the Saugerties, Kingston East, Rock City and Clermont Quadrangles, Dated 1997, 1963, 1963 and 1963 respectively, 7.5-Minute Series.

Date:
December 2006

Scale:
1 in equals 3,625 ft

Project #:
40627.00

THE Chazen COMPANIES
ENGINEERS/SURVEYORS
PLANNERS
ENVIRONMENTAL SCIENTISTS

Dutchess County Office:
21 Fox St. Poughkeepsie, NY 12601
Phone: (845) 454-3980

Orange County Office:
356 Meadow Ave. Newburgh, NY 12550

Capital District Office:
547 River Street Troy, NY 12180

Glens Falls Office:
110 Glen Street Glens Falls, NY 12801

FIGURE 7 - PRODUCTION WELL LOCATIONS

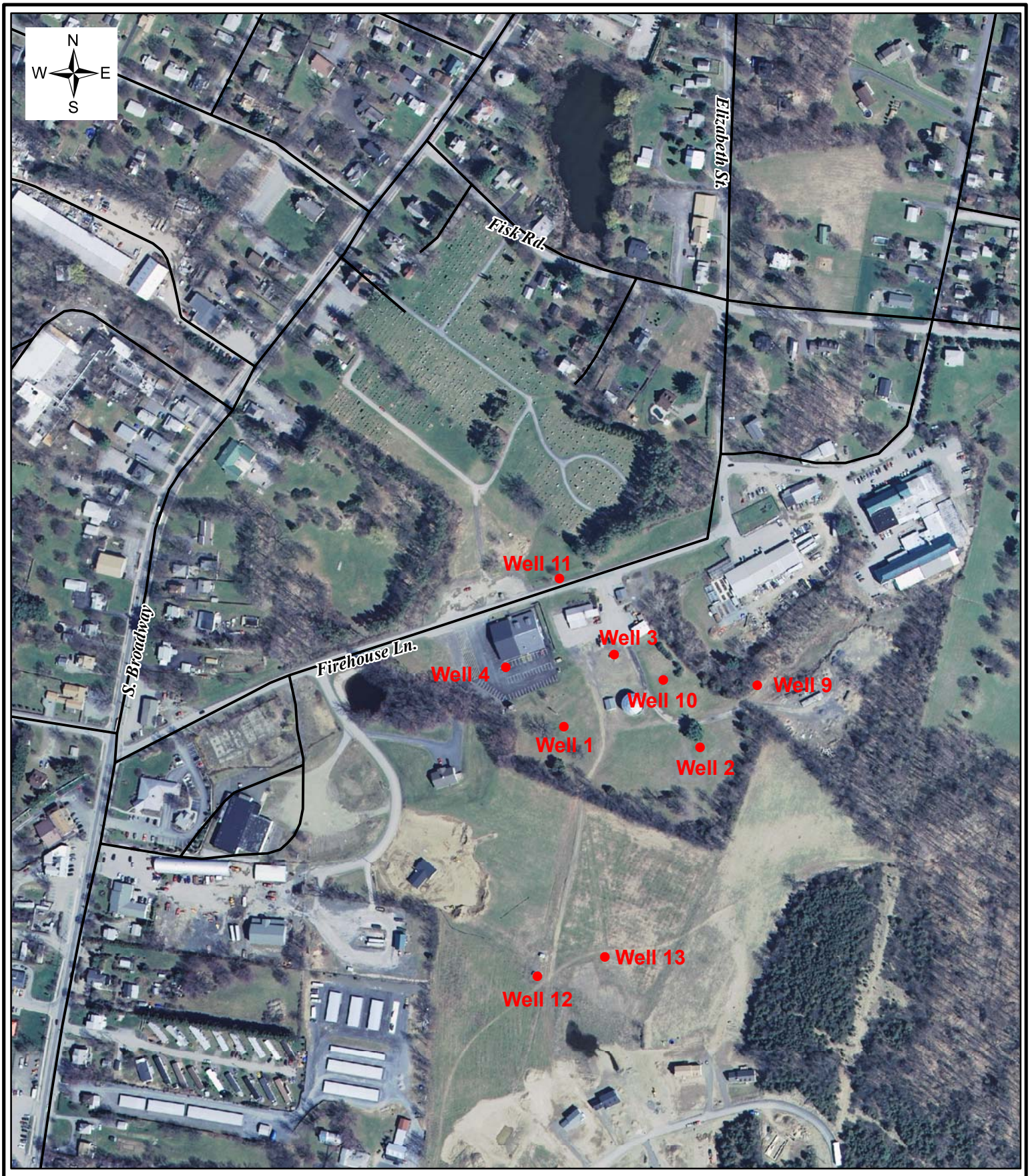
Town of Red Hook Well-Field
Town of Red Hook, Dutchess County, New York

Orthoimagery Source: NYS Office of Technology 2004 Orthophoto

Date:
December 2006

Scale:
1 in equals 350 ft

Project #:
40627.00



THE Chazen COMPANIES
ENGINEERS/SURVEYORS
PLANNERS
ENVIRONMENTAL SCIENTISTS

Dutchess County Office:
21 Fox St. Poughkeepsie, NY 12601
Phone: (845) 454-3980

Orange County Office:
356 Meadow Ave. Newburgh, NY 12550

Capital District Office:
547 River Street Troy, NY 12180

Glens Falls Office:
110 Glen Street Glens Falls, NY 12801

FIGURE 8 - PRODUCTION WELL LOCATIONS

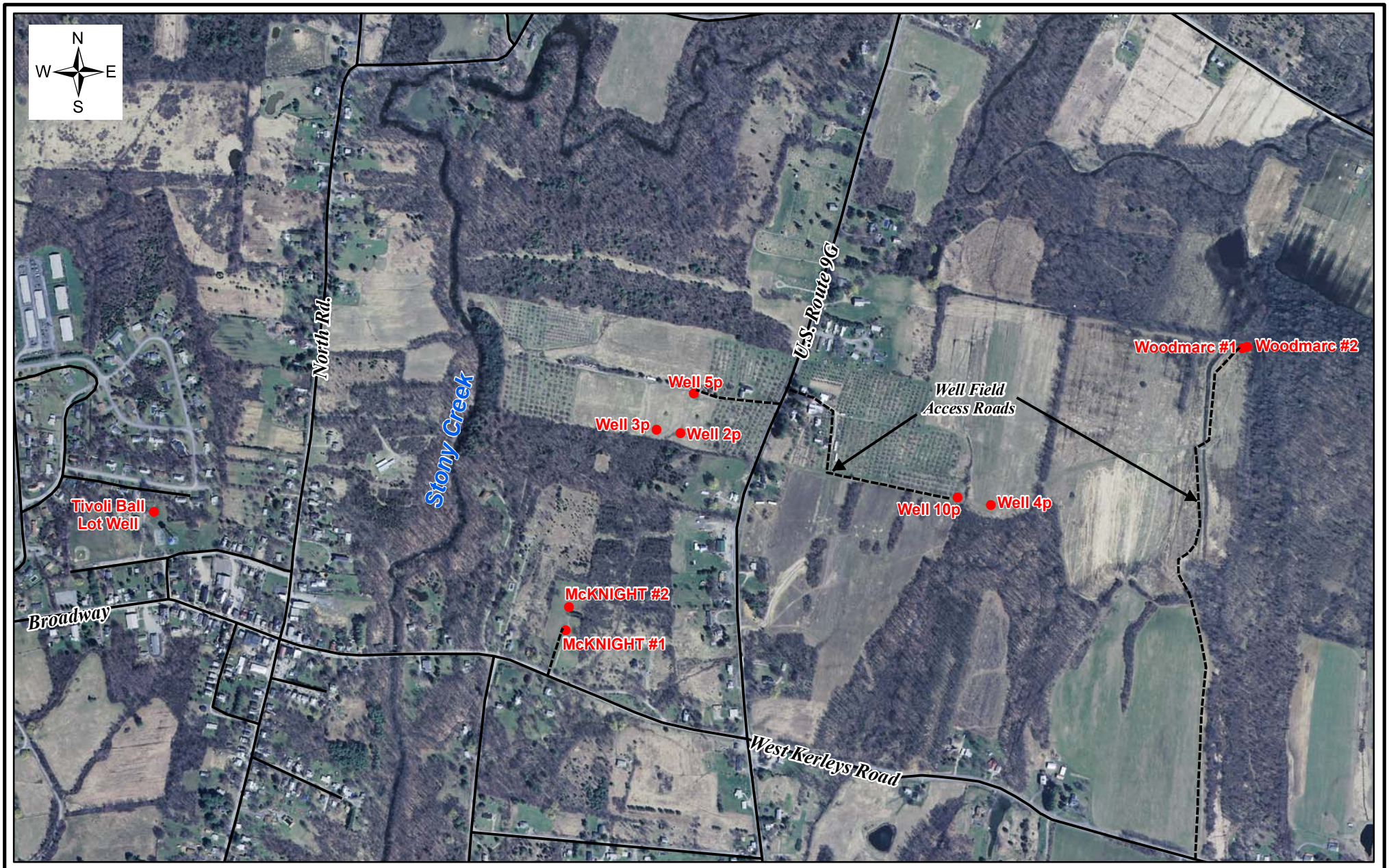
Village of Red Hook Well-Field
Town of Red Hook, Dutchess County, New York

Orthoimagery Source: NYS Office of Technology 2004 Orthophoto

Date:
December 2006

Scale:
1 in equals 350 ft

Project #:
40627.00



THE Chazen COMPANIES
ENGINEERS/SURVEYORS
PLANNERS
ENVIRONMENTAL SCIENTISTS

Dutchess County Office:
21 Fox St. Poughkeepsie, NY 12601
Phone: (845) 454-3980

Orange County Office:
356 Meadow Ave. Newburgh, NY 12550

Capital District Office:
547 River Street Troy, NY 12180

Glens Falls Office:
110 Glen Street Glens Falls, NY 12801

FIGURE 9 - PRODUCTION WELL LOCATIONS

Village of Tivoli Well-Field
Town of Red Hook, Dutchess County, New York

Orthoimagery Source: NYS Office of Technology 2004 Orthophoto

Date:
December 2006

Scale:
1 in equals 800 ft

Project #:
40627.00

Table 1: Water Budget for Red Hook Central Area Using NRCS Hydrologic Soil Groups and DCWWA Recharge Rates
Red Hook, Dutchess County, New York

			Average Year Estimate	
Annual Recharge (inches)	**Acres**	**Hydrologic Soil Group**	**Raw Recharge - GPD**	**Raw Recharge - GPM**
17.3	218	**A**	280,555	195
12.6	2,927	**B**	2,743,523	1,905
6.5	1,306	**C**	631,498	439
3.6	188	**D**	50,347	35
	4,639	****	***3,705,923***	***2,574***

	Impervious Surface- 12% Reduction in HSG B Soils from Development	
	Normal Recharge - GPD	**Normal Recharge - GPM**
A	280,555	195
B less 12%	2,414,300	1,677
C	631,498	439
D	50,347	35
	3,376,700	***2,345***

	Drought Correction- 30% Reduction	
	Dry Year Recharge - GPD	**Dry Year Recharge - GPM**
A less 30%	196,388	136
(B less 12%) less 30%	1,690,010	1,174
C less 30%	442,049	307
D less 30%	35,243	24
	2,363,690	***1,641***

The Chazen Companies
December 2006

Table 2: Water Demand Summary
Red Hook, Dutchess County, New York

	Water Supply Demand	GPD-Average Day	GPM-Average Day	GPD-Peak Day	GPM-Peak Day
Existing	**Current Town of Red Hook Demand***	70,000	49	90,720	63
Existing	**Current Village of Red Hook Demand****	297,840	207	386,000	268
New Uses	**Pending New Demand (Red Hook Commons, Anderson Commons, Knollwood Commons)^**	48,000	33	62,208	43
New Uses	**Projected North Village Project Area*****	98,310	68	147,465	102
New Uses	**Projected South Broadway Project Area*****	156,870	109	235,305	163
	Total Current and Projected Demand:	***671,020***	***466***	***921,698***	***640***

Notes:

* Estimates of daily well demand provided by Town of Red Hook Water Board.

** Estimated peak daily water demand provided by Village Engineer. Other values calculated proportional to Town's Average/Peak ratios.

^ Estimated demand provided by Village Engineer (48,000 gpd), conservatively assumed by TCC to be average daily demand. Peak values calculated proportional to Town's Average/Peak ratios.

*** Estimated by TCC based on available project data and using DCHD guidance and Ten States Standards (see Table 3).

NOTE: Relationships between Average and Peak days for first three rows are based on actual data from Town water system. Peak Day factor for projected North Village and South Broadway project areas are calculated using standard 1.5 peaking factor.

Table 3: Estimated Water Demand for Expansion Areas
Red Hook, Dutchess County, New York

	North Village Project Area Demand Estimates			
	No. Units	**BR/Unit**	**GPD/BR**	**GPD Total**
Single Family	152	3.5	130	69,160
Townhouses	32	2.5	130	10,400
Apartments	54	2.5	130	17,550
Commercial Space	12,000	1.0	0.1	1,200
				98,310

	North Broadway Project Area Demand Estimates			
	No. Units	**BR/Unit**	**GPD/BR**	**GPD Total**
Single Family	189	3.5	130	85,995
Townhouses	70	2.5	130	22,750
Apartments	105	2.5	130	34,125
Commercial Space	140,000	1.0	0.1	14,000
				156,870

Estimates based on project descriptions provided by client and average daily water requirements per DC Health Department guidance and Ten States Standards.

Table 4: Well yields for Water Districts: Town of Red Hook, Village of Red Hook, Village of Tivoli.
Dutchess County, New York

Water District	*Well Name*	*Reported Yield (gpm)*		*Well Depth (feet)*	*Aquifer Formation*
Village of Tivoli	Tivoli Ball Lot	9		183	*Bedrock*
	McKnight #1	10		N/A	*Bedrock*
	McKnight #2	10		N/A	*Bedrock*
	5p	10		50	*Bedrock*
	3p	5		30	*Bedrock*
	2p	9		30	*Bedrock*
	10p	10		50	*Bedrock*
	4p	10		60	*Bedrock*
	Woodmarc #1	40		90	*N/A*
	Woodmarc #2	40*		90	*N/A*
Town of Red Hook	1	225		60	*Gravel*
	2	225*		60	*Gravel*
Village of Red Hook	1	80		N/A	*Bedrock*
	3	70		N/A	*Bedrock*
	4	55		N/A	*Bedrock*
	9	46		N/A	*Bedrock*
	12	78		N/A	*Gravel*
	13	84*		N/A	*Gravel*

Notes:
Town of Red Hook Wells can reportedly be pumped jointly to produce 420 gpm.
but with best well out of service, yield is 225 gpm.
Village of Red Hook Wells can reportedly be pumped jointly to produce 413 gpm.
but with best well out of service, yield is 329 gpm.

* Likely or identified best well, used as reserve well by water district and therefore removed from available yield total.