Municipal Groundwater Resource Report

Town of North Salem

Westchester County, New York

January 2008

Prepared for:

Town of North Salem
270 Titicus Road
North Salem, NY 10560

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EXECUTIVE SUMMARY

The Town Board of the Town of North Salem retained The Chazen Companies (TCC) to review groundwater relationships in the Town and provide water resource planning recommendations.

Aquifer Summary

Bedrock aquifers underlie all parts of North Salem and provide the sole source of potable water for residents and businesses. Limited sediment deposits in lower valley areas offer some potential for sand and gravel wells. Aquifers in North Salem are recharged by precipitation that enters the subsurface at rates influenced by the infiltration capacity of the Town's many soil types. Once in the aquifer, groundwater drains slowly toward low areas, discharging over many months to streams, riparian wetlands or reservoirs. This groundwater is also withdrawn by wells for domestic and higher-yield water supplies.

Plate 1 shows aquifer boundaries, watershed boundaries, estimated watertable contours, and general directions of groundwater flow in North Salem. Figure 5 suggests rates of aquifer recharge entering aquifers through the Town's soils.

A water balance analysis indicates that, in general, substantial reserve groundwater capacity remains available in North Salem to support present and future water requirements. Less than three percent of total groundwater recharge is estimated to currently be removed from aquifers by wells. By this measure, substantial reserve aquifer capacity remains in the Town. However, groundwater resources can nevertheless be overtapped locally if concentrated pumping exceeds rates of local groundwater recharge.

The varied topography in North Salem separates the bedrock aquifer into separate watershed areas, including areas south of the Titicus Reservoir that drain southward to the adjacent Town of Lewisboro, areas in eastern North Salem which drain to the Titicus River, areas generally south of Hardscrabble Road which drain to the Titicus Reservoir, areas in southeastern North Salem near Hawley Road flowing into the Crook Brook, western areas of the Town which drain to the Muscoot (Croton) Reservoir, and small areas which drain into Peach Lake. Although the bedrock aquifer extending across these watershed basins is generally a continuous groundwater resource, water in these different areas does not mix and cannot be readily moved from one watershed to another or assumed to compensate for overuse in any particular area.

Aquifers in North Salem also receive septic system wastewater. Since septic systems do not treat wastewater to a potable standard, reserve groundwater is needed to dilute septic system wastes. Figures 6 and 7 estimate where the dilution capacity of some aquifer areas may be locally impaired because of the concentration of septic systems. In some areas, public water systems have been installed in such clustered areas so residents will benefit from use of a distant source of potable water supply.

Water Resource Concepts and Planning Recommendations

Hydrogeologic factors governing groundwater availability in North Salem and select groundwater resource planning recommendations are summarized here. Aquifers offer the only ready source of water to residents and businesses and so warrant protection and/or planning management.

- Expanded future water demand can be readily accommodated in North Salem, but wells may need to be spread over wide areas to ensure that sufficient aquifer recharge is available to support each new well. Site specific well testing is warranted for higher water use wells.

- Existing Health Department pumping test procedures for proposed Community Water System wells (e.g. water districts using central wells) are generally quite rigorous. The Town therefore may need to use SEQRA authority primarily to review potential off-site drawdown impacts. However, aquifer testing required for new individual wells, for subdivisions using domestic wells or for commercial settings, is not as thorough. For such projects, North Salem may wish in some cases to use its SEQRA authority to require flow tests longer than 8 hours and to consider impacts from combined discharges from multiple individual wells.

- Groundwater quality degradation from septic systems is a form of groundwater over-use when waste constituent concentrations rise to levels which impair the potable condition of groundwater. Septic systems represent a wide-spread and potentially-significant source of non-point aquifer contamination. Contaminants from septic systems include not only compounds with existing regulatory standards such as for nitrate or *e*-coli, but also more recently-recognized constituents such as caffeine, pharmaceutical residues, and hormone residues, for which no standards yet exist. The reliance on aquifers to provide both potable water to wells, and to receive and dilute septic system wastes, requires active management strategies. This report recommends minimum average parcel sizes for sites with individual wells and septic systems ranging from approximately 2 acres to over 3 acres, depending on soil types. The reliance on aquifers to provide dilution for septic system discharges is a quality-driven form of water consumption, using a far larger fraction of the Town's current groundwater balance than the 3 percent actually physically consumed by removal.

- Small sewage treatment districts have become increasingly cost effective to develop and manage. New technologies include small diameter piping systems, opportunities for solids retention on individual parcels, and package scale treatment plants for districts with limited users and even for individual septic systems. The town may wish to encourage use of such systems to reduce the impacts of subsurface wastewater discharges on groundwater quality. New York State is currently considering legal revisions to allow use of more types of non-traditional decentralized wastewater treatment systems.

- Road salt and water softener salts are non-point contaminant sources affecting groundwater and stream quality. Road salt application rates and snow/salt accumulation areas should be actively managed. In areas with wells near roads, snow aprons, curbing, or even restricted salt application areas may be needed at ends of cul-de-sacs or bottoms of hills where salty snow piles or salty runoff accumulate after snowfalls.

- In most cases, installation of central sewerage rather than central water is a preferred remedy for areas where septic systems have impacted groundwater quality. Providing wastewater treatment will improve groundwater quality both for wells and adjacent surfacewater bodies. Provision of central water without provision of wastewater treatment will allow continued flows of impacted groundwater to surfacewater bodies.

- Various surfacewater management programs also benefit groundwater conservation and management strategies. North Salem should encourage the use of disconnected impervious surfaces, stormwater detention and infiltration techniques, and protection of natural vegetation around water bodies to offset development impacts which can both reduce groundwater recharge and increase stormwater runoff impacts. Such approaches can include infiltration and other Best Management Practices within the stormwater program. A town planning policy should be considered, stating that site development should seek to maintain pre-development runoff characteristics to both ensure adequate aquifer recharge and minimize stormwater flooding and surface water quality impacts.

- The report provides a model aquifer protection ordinance which North Salem may wish to consider for local implementation. A moderate level of protection is recommended for the whole Town. A stricter level of protection is recommended for recharge areas supplying specific high-capacity wells and recharge areas near existing areas with high concentrations of domestic wells. This tiered protective approach is consistent with groundwater management strategies adopted in many communities. Federal and State environmental regulations passed since the 1970s, as well as growing availability of improved remediation techniques, have significantly reduced groundwater contamination threats from point sources (such as gas stations, dry cleaners, and heavy industry activities); therefore, although the enforcement of groundwater protection regulations is a continuing concern, the prohibition of such land uses increasingly appears warranted only in highest-risk aquifer areas.

1.0 INTRODUCTION

The Town Board of the Town of North Salem retained The Chazen Companies to prepare a municipal aquifer report. This report includes an aquifer map, evaluations of groundwater recharge and groundwater flow relationships, a discussion of well yields and yield capacities, and water resource planning recommendations.

To prepare this report, The Chazen Companies has relied on prior aquifer studies completed by others and by our office. One foundational report used for this study is our 2003 Northern Westchester County Groundwater Conditions Summary, prepared for the Westchester County Department of Planning (Chazen 2003b). The water resource planning recommendations developed here specifically for North Salem are generally consistent with recommendations found in that report. The Chazen Companies also visited various areas in North Salem to field check geologic formations and watershed areas described in professional literature. This report includes photographs of the various terrains in North Salem to better provide readers a visual record of the landscape hydrogeology.

Sections 2.0 through 4.0 of this report review geographic characteristics influencing groundwater relationships and our groundwater resource planning recommendations. Various figures, tables, and one plate accompany this report.

Appendix A contains a copy of a model aquifer protection ordinance developed first by The Chazen Companies for the Towns of Dover, Amenia, Pawling and North East in Dutchess County. The ordinance was recently refined for specific use in the Town of Amenia and is currently being adopted as a model ordinance from the Town of Philipstown in Putnam County. If desired, this model could also be adapted for use in North Salem, providing a modest level of protection for aquifers throughout the Town and providing aggressive protection for clusters of domestic wells or for present or future public water system wellfields.

2.0 NORTH SALEM HYDRO-GEOGRAPHY

Many geographic factors influence groundwater resources in North Salem. The following sections summarize some of these influences.

2.1 Setting and Population, Water and Sewer Service

The Town of North Salem lies in northern Westchester County, bounded to the east by Ridgefield, Connecticut, to the west by the Croton River and to the south by the town of Lewisboro. North Salem has an area of approximately 23 square miles of which approximately 1.5 square miles are covered by the surface water bodies of the Titicus Reservoir and Peach Lake. The 2000 census reports a North Salem population of approximately 5,173.

Areas of highest residential and commercial density are found near Croton Falls, the hamlets of North Salem, Salem Center and Purdys, and in primarily residential areas around Peach Lake, near DeLancey Road, in the eastern Hilltop Road area, and along many side roads near and off NYS Route 22 between Sunset Drive and Valeria Circle (Figures 1 and 6). The residential population of North Salem is otherwise broadly distributed. Much of the currently undeveloped land in the Town is rugged and heavily wooded. The Mountain Lakes Camp recreational area in southeast North Salem is unlikely to be the subject of future development.

Currently, all residents of North Salem rely on groundwater as their sole supply of potable water. Most of this water is withdrawn from individual domestic wells on individual residential parcels. Some subdivisions have centralized community water supply wells (Figure 6) and nearly all properties reportedly use individual septic systems or community septic systems for wastewater disposal.

2.2 Topography

The topography of North Salem lies primarily between the elevations of 200 to 500 feet above mean sea level with a few ridge elevations that rise to over 1,000 feet above mean sea level (asl). Large portions of the Town drain to the Titicus Reservoir, which overflows to the Muscoot (Croton) Reservoir.

A graphic sense of the Town's topography is evident on a black-to-white hillshade map (Figure 1). The distribution of valleys and ridges create a series of isolated sub-basins, with receiving streams flowing to the Titicus Reservoir, the Titicus River, the Muscoot (Croton) Reservoir or southward into the Town of Lewisboro (Plate 1). Streams flowing northward from the vicinity of Hardscrabble Road and Peach Lake flow eventually past Croton Falls and into the Muscoot (Croton)

Reservoir. There is no natural opportunity for water in these individual headwater basins to interact or mingle until converging in common streams or reservoirs.

Much of the central and southwest portion of the Town consists of rolling hills. Land becomes more fragmented by ravines and ridges in the eastern and northern parts of the Town. These trends are evident on Figure 1 and Plate 1.

2.3 Geology

Geologic formations in North Salem include bedrock formations and overlying sediment formations.

2.3.1 Bedrock Geology

Bedrock formations in North Salem are collectively recognized by geologists as the Manhattan Prong formations, including gneiss and schist and elongate bands of the Inwood Marble (Figure 2). The Manhattan schist and Fordham gneiss are dominant and weathering-resistant rock formations in the Town, exhibiting higher-elevation and rolling topography (Figure 8A/B). The Inwood formation often underlies valleys since it is a softer rock which over time erodes away due to physical and chemical weathering (Figure 9A/B). The Croton Falls Complex is an igneous intrusion found in the northwest corner of North Salem (Figure 10A/B).

The structural geology of Westchester County has been modified by as many as four different mountain building events (Isachsen, et al.1991), resulting in the metamorphic (altered) nature of most of the geologic formations, and many folds, faults, joints and fractures (Prucha, 1968; Brock, 1993). The joints and fractures in the otherwise massive bedrock formations are beneficial and critical features which store and transmit the Town's groundwater supplies (Figure 11).

2.3.1 Surficial Geology

Surficial geology in North Salem consists of a wide range of sediments deposited by glaciers. Glacial sediments include clay-rich glacial till on hillside and upland areas, and either sandy outwash, ice contact deposits or glacial lake deposits in valley areas (Figure 3A/B).

Glacial till is generally clay-rich and contains varieties of angular and variously sized rock fragments and boulders. Glacial till is the most common cover soil on North Salem's hillsides and upland areas. Few wells are installed in till because till deposits are usually thin and have low permeability. Till is often thin on hilltops.

Glacial outwash deposits and ice contact deposits consist of sand and gravel deposited near melting glaciers. These deposits are most often found in stream valleys that allowed southward flow away from the ice during the post-glacial period. Few sand and gravel deposits of any significance appear to have been deposited in North Salem, perhaps because the Town's primary valley (today occupied by the Titicus Reservoir) is aligned east-west rather than toward the south.

Glacial lake deposits are found in valleys which contained temporary lakes during the immediate postglacial period when ice dams prevented free water flow away from melting glaciers. A wide range of sediments flowed into these lakes from adjacent uplands or glacial ice, sometimes including washed sand and gravel sediments, but more often primarily of silt and clay.

Glacial till, outwash and kame ice contact deposits, and glacial lake deposits are shown in Figures 3A and 3B. Figure 3A was created by The Chazen Companies by matching Soil Conservation Service text descriptions of parent soil materials with soil types mapped in North Salem. Figure 3B is a reproduction of the more general New York State surficial geology map. Organic soils horizons now developed in the uppermost horizons of these surficial geology deposits significantly reflect the composition of the parent glacial materials.

2.4 Water Requirements, Consumption and Wastewater Generation

Residents on individual wells use between 80 to 100 gallons per day (gpd). Residents receiving water from central water supplies, who pay for their water, are generally more conservative with water use and use only 60 to 80 gpd. Water uses normally peak in summer due to increased seasonal water uses.

As outlined in our Westchester County study, approximately 5,173 people reside in North Salem. Using the use estimates above, the residential population of North Salem may withdraw a maximum of up to 517,300 gallons per day from aquifers.

Of these extracted gallons, each resident is estimated to generate up to 80 gallons of wastewater and consume by evaporative uses approximately 20 gallons daily. This sums to 103,460 gpd of residential water consumption and 413,840 gpd of residential wastewater discharges. The consumed portion includes water dissipated by perspiration, steam from cooking, evaporation from watering of plants, washing of cars, and during drying actions by dishwashers and clothes driers among other losses.

Wastewater released to septic systems can recharge aquifers or travel laterally along clayey or rock layers directly to nearby water bodies. During summer, 30 to

50 percent of wastewater released to septic leaching fields may be drawn upward by evaporation or root transpiration. Therefore, approximately 300,000 gpd of residential wastewater is returned to groundwater resources via septic systems in North Salem during the growing season while over 400,000 gpd of residential wastewater returns enter aquifers in winter.

Prior investigations have estimated that non-residential uses such as business, commercial, agricultural and commercial irrigation uses of water generally add an additional 50 percent to community water demands and wastewater flows (Goodkind & Odea, 1970). Using this estimating factor, the total combined groundwater use and consumption estimates for North Salem are:

- Total Groundwater withdrawn from aquifers: 750,000 gallons daily
- Wintertime water returned to Groundwater via Septic Systems: 600,000 gallons daily
- Summertime water returned to Groundwater via Septic Systems: 450,000 gallons daily

Using these figures, water losses from aquifers in North Salem from direct uses and evaporative losses over septic systems is approximately 150,000 gallons daily in winter and 300,000 gallons per day in summer.

If one also considers demands placed on aquifers to assimilate and dilute wastewater received from septic systems then a higher currently daily water utilization budget for North Salem emerges. Using an estimate that approximately 80 percent of North Salem residents, or 4,000 residents, use traditional individual or community septic systems, and estimating that household discharges of approximately 200 gallons of wastewater would need to be blended into approximately 1500 gallons of clean groundwater each day to reduce nitrate and other wastewater constituents to below drinking water standards, then up to 6 million gallons of groundwater is theoretically required each day for dilution purposes if septic systems were distributed uniformly across the Town. However, since there are some areas where septic systems are more densely positioned than recommended (Figures 6 and 7) it is likely that some areas are being over-loaded with wastewater discharges and less than 6 million daily gallons of clean recharge is being used to dilute wastewater. Nitrate modeling discussed elsewhere in this report is a typical wastewater constituent which must be addressed by dilution and is the constituent used to provide the dilution water requirement estimates above.

2.5 Land Use

Land uses influence rates of surface water runoff, evaporation or plant transpiration (evapotranspiration) losses, and aquifer recharge. Farmland, forested lands and low-density residential land are dominant land uses in North Salem.

Concentrated residential and commercial use areas, including those in the various hamlet centers, are generally clustered along transportation corridors and near water bodies.

Precipitation data indicate that the mean annual precipitation in North Salem is between approximately 46 and 48 inches per year and that typical evaporation and plant transpiration rates in North Salem are between 21 and 22 inches (Randall, 1996), leaving approximately 25 to 26 inches of precipitation available each year to recharge aquifers or flow as overland runoff to streams. Recharge rates are addressed in following sections.

Soil Conservation Service programs, such as the TR-55 program, can be used to evaluate how land uses influence changes in runoff rates. In general, increased runoff during heavy rains correspondingly decreases groundwater recharge rates. However, analysis completed by Chazen (2006b) in Dutchess County's Wappinger Creek watershed concluded that runoff rates are changed far less by landscape changes during more common modest and small rainfalls. Approximately 80% of annual precipitation is currently delivered by rainfalls of less than 1.5 inches per day (Chazen, 2006b), so land use changes other than extensive paving changes only reduce recharge minimally during the majority of rainfalls. Runoff values only increase markedly during rainfalls of any magnitude where connected impervious surfaces are channeled off a site or exceed approximately 30 percent of land surfaces. Such high impervious surface ratios in North Salem appear to be restricted to limited areas within Croton Falls.

Most current land uses in North Salem do not and have not therefore significantly influenced or changed historic runoff or aquifer recharge rates except during rare rain events exceeding 1.5 inches. The use of discontinuous impervious surfaces (e.g. roof drains flowing onto lawns), rather than continuous impervious surfaces (road gutter or storm sewer systems directed to single surfacewater discharge locations) is encouraged to preserve this relationship.

It is worth noting that although future regional climate patterns are not fully understood, many investigators believe future weather may include more severe storms and longer periods without rain, with overall warmer temperatures. Such projections could increase overall evapotranspiration losses and increase the number of storm events with large runoff fractions occur. These trends could lead to a long-term expectation of reduced groundwater recharge and amplify the value of and need for municipal groundwater resource planning strategies.

Vegetation transpires large quantities of water to the atmosphere due to transpiration processes. Hardwood deciduous riparian forest in temperate climates can have evapotranspiration rates as high as 118 cm (46.5 inches) per year

(Peterjohn and Correll, 1986). Since this occurs entirely during an eight month growing season, we can estimate peak summertime evapotranspiration losses at approximately 0.2 inches per day from riparian vegetation, including vegetation with root systems most likely to be in direct hydraulic contact with the watertable. Such uptake removes groundwater which might otherwise discharge to streams and enhance summer-time stream flow levels. During extended drought periods, these transpiration losses tend to decrease in hillside and upland areas as soil water capacity becomes depleted although transpiration persists in riparian wetland areas where root systems can continue to reach shallow groundwater resources. Most wetlands develop in riparian settings that benefit from groundwater that is discharging in springs and seeps. A few wetlands form in upland enclosed basins or poorly drained areas which also often do allow some nominal groundwater recharge.

3.0 GROUND WATER RESOURCES

Aquifers provide water for all residential and commercial activity in North Salem. Precipitation is the sole source of groundwater recharge to these geologic formations. Recharge enters the subsurface through the soil layer and replenishes all geologic formations in the Town.

Once precipitation reaches the watertable, the renewed groundwater then migrates within the aquifer through pore spaces or fractures toward lower elevation areas, and re-emerges in springs or in streambeds as stream baseflow. Any wells installed along the groundwater flow-path between the point of recharge and discharge can extract water for human uses. Water removed by wells does not reach the stream, unless portions are returned to the landscape via septic systems or wastewater treatment plants.

In general, directions of groundwater flow may be estimated by looking at topographic maps and interpreting flow moving from higher elevation areas to lower areas within subwatershed areas. Plate 1 shows sub-watersheds and estimated directions of groundwater flow in North Salem.

3.1 Bedrock Aquifers

With few areas with accessible sand and gravel deposits, bedrock aquifers provide virtually all water used in North Salem. The bedrock aquifers in North Salem have no inherent porosity. Faults, fractures and other joints therefore provide the only subsurface openings available for groundwater storage and transmission (Figure 11).

Various investigators have evaluated typical short-term aquifer yields from domestic wells installed in the bedrock formations near and under North Salem. Early well logs were gathered by Asselstine and Grossman (1955) and georeferenced by The Chazen Companies. The locations of these wells are shown on Plate 1. Yield statistics are also available from some of the same geologic formations as they extend into Putnam County immediately north of North Salem. These data are consolidated on Table 1. The well data indicate that yields satisfying domestic needs are generally available from all bedrock formations. Insufficient data are available from the Croton Falls Diorite (Ogb) to provide a significant basis for any complex analysis, but yields available from the more regionally dominant Fordham Gneiss (f), Inwood Marble (Oci) and Manhattan (Om) formations are credible both in North Salem and Putnam County.

Comparison of the Putnam County and North Salem data (Table 1) suggests that wells in Putnam County are deeper than those in North Salem; however, when Putnam County well logs are sorted by drilling years, the older Putnam County wells are equally shallow as the older North Salem well log records. There has been an evolution of drilling technology over the past decades leading toward deeper wells. Newer well drilling techniques take 1 to 2 days to drill rather than weeks, but can block flow in the smallest fractures. Therefore, property owners prefer the trade-off of quicker service with the need to drill deeper to encounter more fractures. The trend to deeper wells is not, as might initially suggest, therefore an indication of regionally falling groundwater levels or groundwater depletion.

The well yield estimates summarized in Table 1 are drawn from well driller's estimates. Such estimates are made shortly after well drilling using brief flow tests. As such, they describe short-term rather than long-term yields available from wells. Therefore, these yield estimates should not be over-interpreted to predict well yields which might be sustained during an extended, continuous pumping period. Some fractures encountered in wells are poorly connected to surrounding fractures resulting in their becoming dewatered during extended pumping tests, identifying why long-term yields may differ from short term yields.

The long-term reliability of wells is more directly related to the degree to which local fractures are interconnected and recharged. Optimal places to drill higher-capacity bedrock wells are in areas with extensive interconnected fractures, such as those suggested by Figure 4A and 4B and where reasonably high recharge rates entering local soils occurs (see Section 3.3).

The locations for domestic wells on small parcels are usually sited on the basis of convenience or to meet health department separation distances from septic systems, without consideration of soils or potential linear features, and so often tap only smaller fractures. Such wells are nonetheless usually suitable to meet homeowner yield demands but may not support higher yields. Where higher yield wells are desired, it is common to consider where extensive fractures (e.g. from analysis such as Figure 4A and 4B) and higher recharge rates (e.g. Figure 5) may exist.

3.2 Surficial Aquifers

Surficial aquifers consist of porous sediments such as sand and gravel and are normally found in valleys where pore-spaces can remain saturated with groundwater throughout the year. Where sediments are found above the watertable, sediments are not referred to as aquifers.

No regional sand and gravel deposits are mapped in North Salem. Figure 3A shows that some limited areas may lie along the Titicus River drainage. The state geologic map (Figure 3B) identifies some glacial kame deposition near Croton Falls, which are deposits commonly including sand and gravel, but soils maps interpreted by Chazen (Figure 3A) suggest the extent of any glacial kame deposits in this area is extremely limited.

The Westchester County Planning Department possesses surficial geology maps (208 maps). An area with suspected thick sedimentary deposits is identified near Route 22 just south of Croton Falls. However, water supply exploration documented by LBG for a proposed Marriott Hotel suggests that sediments are not more than approximately 40 feet deep and of varying washed composition rather than being uniformly sand and gravel (LBG, 2007).

3.3 Soils and Aquifer Recharge

In general, between 15 and 50 percent of precipitation on natural surfaces becomes aquifer recharge, depending upon the local conditions (Coppelman et al., 1996). Estimating rates of aquifer recharge is one of the more difficult tasks faced by hydrogeologists because soils vary, seasonal weather changes influence whether precipitation infiltrates or runs off, vegetation needs for water uptake vary throughout the year, and the topography and fracture density of underlying bedrock aquifers vary in ways that influence aquifer recharge rates.

It is generally accepted that high recharge rates occur over permeable sand and gravel deposits and lower recharge rates occur where soils include silt or clay, or where impervious surfaces exist. A Town of Somers report estimates that 50% of rainfall on sand and gravel deposits becomes aquifer recharge, equating to between 18 to 21 inches of aquifer recharge during normal years (LBG, 1988). A USGS modeling study predicts recharge of between 18 and 19 inches in areas with sand and gravel (Wolcott & Snow, 1995).

Recharge rates are lower where soils are thinner or higher in clay content. A USGS study in Connecticut identified average annual aquifer recharge of 7 inches where soils are clay-rich (Cervione, 1972). A USGS study of areas in southern Dutchess County similarly covered by silty glacial till calculated recharge of 8 inches of water per year (Snavely, 1980). Somer's aquifer study also describes recharge of 8 inches of water in areas of silty, till-covered bedrock. Wolcott and Snow (1995) of the USGS used hydrogeologic modeling to develop a recharge estimate of 7.8 inches per year in areas with clay-rich glacial till. A study in North Castle estimates 7 inches of annual rainfall for till-based soils over bedrock (CA Rich, 1994).

In general, TCC accepts annual recharge estimates of 7 to 8 inches where surficial geology consists of clay-rich glacial till, and 18 inches in areas where soils are derived from sand and gravel, during normal years.

The above recharge rate estimates occur during years of average annual precipitation. When annual precipitation varies, recharge rates can increase or decrease. A Town of Somers report indicates that during the 10-year recurrence drought, precipitation falls to approximately 80 percent of average, and that precipitation during the 30-year recurrence drought drops to as low as 67 percent of average (LBG, 1988). During such drought years, recharge is reduced although the reduction is not fully predictable or linear since effective annual recharge during drought years will be influenced by when limited rains come, their intensity, and the soil moisture content prior to each rain event.

Soils substantially influence rates of surface water entry, or recharge, into underlying aquifers. Soil mapping conducted by the Soil Conservation Service has assigned a Hydrologic Soil Group (HSG) rank to every soil. Recent investigations by Brandes et al (2005) suggest that the distributions of Hydrogeologic Soil Groups in watersheds correlate closely with recharge rates into underlying aquifers. The distribution of Hydrologic Soil Groups in North Salem is shown on Figure 5.

Hydrologic Soil Group A and A/D soils allow high infiltration rates and consist chiefly of deep, well- to excessively-drained sand or gravel. Few sand and gravel or HSG A soils are found in North Salem (Figures 3A and 5).

Hydrologic Soil Group B and C soils have more moderate infiltration rates than HSG A soils. These soils generally have moderately-fine to moderately-coarse textures. HSG B soils are often found on lower hillsides in North Salem. Hydrologic Soil Group C and C/D soils have yet lower infiltration rates often because of high silt content in the soil. Some of the higher hillsides and hilltop areas in North Salem are covered with glacial till containing enough silt to fall in HSG C. Over eighty percent of North Salem is covered by Hydrologic Soil Group B, or C and C/D soils.

Hydrologic Soil Group D soils have the lowest infiltration rates of any natural soils, and consist primarily of clay. Except for limited pockets in a few valley settings, there are few HSG D soils in North Salem (Figures 3A, 3B and 5). Most HSG D soils lie in valley settings coincident either with current wetlands or in areas of glacial-era temporary lakes which became filled with glacial-era clay deposits.

A recent study in Dutchess County calibrated estimated aquifer recharge rates using Hydrologic Soil Groups (Chazen, 2006a). Aquifer recharge rates in the Ten Mile watershed area were based on stream flow analysis and rainfall records similar to those typical in North Salem. These were estimated at

- 20.2 inches/year through HSG A and A/D soils,
- 14.7 inches/year through HSG B soils,

- 7.6 inches/year through HSG C and C/D soils, and
- 4.2 inches/year through HSG D soils.

These aquifer recharge rates are posted on Figure 5 for reference purpose when evaluating groundwater supply potential for domestic wells and public water supply wells.

If we use these aquifer recharge values, total estimated aquifer recharge entering aquifers throughout North Salem each day averages 11.25 million gallons, at average daily recharge rates of

- 1,503 gpd per acre through HSG A,
- 1,094 gpd per acre through HSG B soils,
- 565 gpd per acre through HSG C soils, and
- 313 gpd per acre through HSG D.

These are recharge rates recommended for use during site analyses of new water supply projects using groundwater wells. During drought years, average daily rates may decline by as much as 30 percent.

Groundwater flows supporting streams and riparian wetlands come both from the aquifer recharge flows described above, and from more transient groundwater movement, or interflow, which enters the subsurface but follows root channels, clay seams, or buried bedrock surfaces rather than penetrating deeply enough to reach aquifer formations. Interflow contributions to streams generally dwindle within a few weeks after major rains but are estimated to add an additional 35 percent of baseflow to streams in North Salem (Chazen, 2006b).

Such “interflow” represents an important portion of stream flow for a week or two following rainfall events; as this contribution eventually drains completely, baseflow from the underlying surficial and bedrock aquifers is relied upon to maintain continuing stream flow through longer droughts. The close proximity of most HSG A soils to major steams means that although significant quantities of water recharge aquifers and interflow through these soils, this recharge is likely to reach streams soon after precipitation events. Recharge entering aquifer systems furthest from streams is most responsible for persistent stream flow long after precipitation events. The majority of areas most distant from streams are on hillsides or other upland areas covered by HSG B or C soils.

Considering both aquifer recharge and interflow recharge together, approximate total groundwater recharge through soils in North Salem is estimated as follows

- 27.3 inches per year through HSG A and A/D soils,
- 19.8 inches per year through HSG B soils,
- 10.3 inches per year through HSG C and C/D soils, and
- 5.7 inches/year through HSG D soils.

These are recharge rates recommended for use when considering stream flow or riparian reliance on shallow (interflow) and late-season deep aquifer discharge that supports surfacewater environments. These rates are not listed on Figure 5 to avoid confusion since the combined discharge of interflow and aquifer recharge to streams is used only for stream baseflow studies and seldom use in groundwater supply budget estimates.

3.4 Groundwater Flow

Plate 1 shows the estimated elevation of the watertable, or upper groundwater surface, of aquifers throughout North Salem. The estimates are based on evidence from observed perennial streams, ponds, and available well log records. In general, groundwater fills pore spaces and fractures within 20 to 30 feet below ground level in most areas, and nears the ground surface in the vicinity of streams, ponds, and streamside (reparian) wetlands.

Groundwater moves toward lower elevations in the same manner as surfacewater, albeit far more slowly due to the intricacies of the pore and fracture pathways. Thus, groundwater flow moves from points of higher elevation to points of lower elevation, and then it discharges to valley stream systems. Flow arrows shown on Plate 1 show estimated general directions of groundwater flow, which can be used for general flow analysis. This map may be used to estimate recharge areas for particular wells, stream segments, or wetlands by inspecting lands upgradient (up-arrow, or uphill) from areas of interest. The map may also be used to identify areas downgradient (down-arrow) from any land uses of concern.

Plate 1 also shows discrete subwatersheds within North Salem. Groundwater in each watershed area flows by gravity toward the nearest downhill stream without changing watersheds. This local migration of groundwater from higher to lower elevation areas means that although bedrock aquifers are continuous across the Town, groundwater recharged in each subwatershed remains local. This relationship influences evaluations of sustainability of groundwater uses in discrete subwatersheds.

3.5 Groundwater Quality

For the most part, groundwater quality in North Salem meets potable standards defined by the NYS Department of Health.

<u>3.5.1 Natural Groundwater Quality</u>

Natural concentrations of dissolved iron, manganese, elevated radiologicals (e.g. radon) and occasional hardness are common natural water quality defects in North

Salem bedrock aquifers. Iron and manganese are largely aesthetic concerns. Hardness can lead to calcification of water pipes but is not considered a health hazard. Differences in total dissolved solids reflect the various formations hosting groundwater. Groundwater in carbonate formations is, for example, generally higher in dissolved solids than other rocks due to it's chemical vulnerability to acidic waters. Deeper wells tend to have higher degrees of mineralization because of the greater residence time of groundwater cycling through deeper fractures.

Groundwater in carbonate formations such as the Inwood Marble may have higher sulfate, hardness, and total dissolved solids than other formations in North Salem. In some cases, mineral deposition in wells can lead to decreased yields over time which do not signal aquifer depletion, but rather indicate that the well may need to be rehabilitated or redrilled.

3.5.2 Introduced Contaminants

Typical groundwater quality impacts associated with various land uses include the following:

- Residential Development. Where septic systems are situated close to one another, groundwater quality may be over-loaded with discharges of nitrate, personal-use chemical discharges such as caffeine, pharmaceutical or hormone treatment residues, bacteria, and viruses. Wells or surfacewater bodies near such areas may be negatively affected as groundwater flows into these waters unless adequate recharge or open water movement is available to process or dilute these discharges. Groundwater quality in residential areas can also be impacted by homeowner releases of household chemicals and/or over-application of lawn fertilizers or pest control chemicals.

- Commercial and Industrial Uses. Groundwater quality can be affected by releases of petroleum, solvents, pesticides/herbicides, and dissolved metals. Risks of groundwater contamination associated with road deicing chemicals (salt) tend to be higher in commercial centers because de-icing efforts are often more intensive and paved coverage tends to increase.

- Agricultural. Groundwater quality can be impacted by agricultural activities where nutrient or fertilizer/pesticide management programs are not carefully monitored.

- Discrete areas of groundwater contamination (e.g. spill sites) exist in North Salem, but were not the focus of this investigation.

Salt

Virtually all year-round roads in North Salem represent sources of potential salt contamination to groundwater quality. A USGS study completed in Putnam and Westchester Counties documented that chloride concentrations in streams were highest in watersheds with the most roads, closely relating road mileage to salt concentrations in the streams (Heisig, 2000). Chloride concentrations in the streams sampled by USGS ranged from approximately 5 to nearly 200 mg/l (parts per million). These samples were collected in summer when water in the streams normally comes from the local aquifers rather than from overland flow.

Road salt contamination tends to most severely impact aquifers where flat topography, and where inadequate curbing or other road runoff management allows excessive infiltration of salty snowmelt into the ground. Salt contamination of aquifers also can occur at ends of cul-de-sacs where melting and salty snow piles may accumulate, or near any uncovered salt-storage piles.

Homeowner complaints of road salt contamination often peak in winter. Where seasonal variation in salt complaints occur, road salting may be the suspected source of salt since road salting is heaviest during winter and spring months. Rates of road salting have generally increased in all northeastern States over the past three decades as public expectations for winter road drivability have evolved. No regional well sampling program has documented the full extent of road salt impact on groundwater quality.

Water softeners release salt to groundwater when regeneration wastes are discharged to septic systems. Several of the watersheds studied by Heisig (2000) were fully sewered and yet contained salt in their streams. This suggests road salt, rather than water softening salts was the dominant source of sodium chloride in those streams (Heisig, personal communication). Nonetheless, where softeners are extensively used, Heisig indicates that use of up to 700 or even 1,000 pounds of salt per year (equal to as many as 25 forty pound bags per year) is not unusual. Heavy softener use is most likely in areas with hard water coming from carbonate aquifers or areas with elevated iron in bedrock aquifers. Where wells are impacted by use of water softener salts, complaints are usually received from individual sites rather than over broad areas. Sampling guidance developed by the NYS Department of Transportation can be used to help distinguish between road salt and water softener salt contamination. Sodium concentrations in drinking water exceeding 20 mg/l are not recommended for those on severely restricted sodium diets, and water containing over 270 mg/l should not be used by people on moderately restricted sodium diets, according to NYS Department of Health regulations.

Septic Systems – Nutrients

Individual septic systems are used throughout North Salem since few wastewater treatment plants exist in the town. As reviewed previously, wastewater releases primarily to subsurface systems normally peak in winter and fall in summer due to summer-time plant transpiration of wastewater over leachfields. Wastewater constituent concentrations in such summer returns to aquifer are, however, likely to be enriched since approximately the same waste load is discharged during all seasons, resulting in somewhat constant seasonal wastewater constituent loading to aquifers.

Wastewater constituents include nitrogen compounds. These typically convert to nitrate in aquifers. Nitrate does not decay much in aquifers and has a drinking water standard of 10 mg/l. The average person releases approximately 10 pounds of nitrogen waste per year (NJDEP, 2000). Where septic systems are too close together, groundwater quality can be locally degraded. To ensure that groundwater concentrations of nitrate do not routinely exceed 10 mg/l, a planning target of approximately 5 mg/l has been adopted by various communities, ensuring that most water quality, varying around the target of 5 mg/l remain reliably below the drinking water standard of 10 mg/l.

Sanitary wastewater contains phosphate as well as nitrogen wastes. The average person releases approximately 3 pounds of total phosphorous wastes each year (USEPA, 1980). Phosphorous in surfacewater can degrade lake or stream quality due to water over-nutrification. Phosphorous discharged by septic systems bonds to soils, with a saturation front moving outward as soil bonding sites are sequentially exhausted, resulting in an advancing phosphorous plume downgradient from septic systems, eventually reaching aquifer discharge locations in streams, wetlands or lakes. Phosphorous is not regulated as a drinking water contaminant although phosphorous is a significant contaminant in surface water bodies.

A NYCDEP study (NYCDEP, 2000) demonstrated that phosphorous readily travels more than 100 feet from septic systems toward streams or other open waters. Studies elsewhere indicate that phosphorous plumes therefore advance approximately 3 feet per year (Dr. William Harman, University of Binghamton, personal communication). The NYCDEP (2000) study conclusively documents a wide range of capabilities in different soil types to hold phosphorous, explaining why rates of plume migration will vary widely.

Septic Systems – Bacteria and Viruses

Bacteria and viruses are often assumed to die off or be sufficiently filtered within a few hundred feet of a point of release at a septic system. A NYCDEP septic system study, however, documented several cases where coliform migrated at least 100 feet from septic system leaching fields (NYCDEP, 2000). The NYS Department of Health requires stipulated separation distances between wells and septic systems to limit bacterial or viral transmission to wells.

During several summers in early 2000s, a private laboratory and the Dutchess County Department of Health tallied rates of e-coli detection in water samples submitted by individuals requesting coliform analyses. Analysis of data trends showed that percentages of wells containing e-coli reached up to 10% of submitted samples during dry summer periods (Chazen, 2003a). *E*-coli coliform inhabits intestinal tracts, so is a potential indicator of waste transmission between septic systems and wells. The Dutchess County data suggest that wells may be affected by coliform from septic systems during periods with little effective recharge over periods extending beyond 30 to 50 days

Septic Systems – Pharmaceuticals and other Compounds

Recent research indicates that a wide range of lifestyle chemicals are being released to wastewater systems (USGS, 2002) including septic systems. Chemicals include caffeine and medicines such as steroids, nonprescription drugs such as ibuprofen and acetaminophen, detergent byproducts and plasticizer chemicals from many flexible plastic containers. Few of these chemicals decay when released to septic systems; many have been found in watershed streams where septic systems are the only likely source of wastewater release (P. Phillips, USGS, 2003, personal communication). The relationship between septic system discharges and contaminant presence in streams suggests these chemicals migrate through aquifers from the septic systems to the streams and so may also be withdrawn from aquifers by wells.

No local studies confirming the presence of such life-style chemicals in groundwater are known to be occurring in the region. Sewage treatment plants are also not presently required to analyze or treat wastewater for these chemicals so few wastewater treatment data are available although research studies have documented wide ranges of personal care and pharmaceutical chemicals in wastewater plant discharges. No drinking water standards yet exist for most of these chemicals. Presently, dilution in stream flow or aquifers appears to be existing management approach for these chemicals.

3.6 Future Water Supply Areas

All geologic formations in North Salem have a history of providing adequate groundwater supplies to support domestic wells. In general, therefore, the selection of locations for domestic wells can proceed on the basis of convenience and appropriate separation distances betweens wells and other site features.

Most future higher-flow wells installed in North Salem will need to seek major fracture systems in the Town's fractured bedrock. Where larger fractures exist and extend to the land surface, they can often be detected on topographic and other map formats. Linear landscape features which cross-cut otherwise uninterrupted ridges and valleys are often clues to the locations of such fractures. The Chazen Companies and prior investigators have identified various linear features in North Salem (Figures 4A and 4B), some of which may represent fracture traces. Exploration for higher-capacity wells in areas with potential high-yield fractures will include drilling candidate bedrock wells in areas with intersecting suspected fractures and determining available yields using pumping tests.

Evaluations of the long-term reliability of any new higher-capacity wells should include development of a water balance considering volumes of available groundwater recharge, the demand of the new wells, and consideration of any potential drawdown impacts on pre-existing wells and stream flow depletion which might be caused by use of the new well, particularly if wastewater is not returned locally to offset extracted water volumes.

4.0 GROUNDWATER RESOURCE MANAGEMENT

4.1 Groundwater Summary

Aquifers represent the sole source of water for the current population of North Salem. A regionally-continuous fractured bedrock aquifer underlies the entire Town, generally sufficiently fractured to support domestic wells and some higher yields where wells intercept prominent fractures. Groundwater within the town-wide bedrock aquifer moves locally towards local streams, riparian wetlands and open waterbodies. Natural groundwater discharge to these surface water resources supports their flows and viability during dry periods.

Groundwater in the Town is recharged by precipitation infiltrating through overlying soils. Groundwater recharge occurs at annual average rates of approximately 20.2 inches per year through Hydrologic Soil Group A and A/D soils, 14.4 inches per year through HSG B soils and 7.6 inches per year through HSG C and C/D soils, which together cover the vast majority of developable land in the Town. Little construction is normally proposed on Hydrologic Soil Group D soils. During normal years, something over 11.25 million gallons of groundwater is recharged to the Town's aquifers each day on average. This daily average may fall by as much as 30 percent during drought years. Current uses by residents and businesses consumes up to 300,000 gallons per day, or approximately 3 percent of total available groundwater. However, use of the aquifer for the dilution of septic system discharges currently requires the assimilative dilution capacity of up to several million gallons per day.

A characteristic of North Salem's aquifers is the segmenting of groundwater resources into many small watershed areas. Groundwater in each small watershed is isolated from groundwater in adjacent areas although the water is hosted in similar fractured bedrock environments. Local aquifer depletion by excessive pumping, or by quality degradation from wastewater discharges, can occur although the Town-wide groundwater budget retains consider reserve capacity.

4.2 Available Yield

As indicated in the summary above, estimated water consumption currently represents only a fraction of total available groundwater. Accordingly, considerable additional consumption can be contemplated in North Salem before uses might reach a ten percent consumption factor sometimes considered to be a threshold for significant stream and waterbody depletion.

Notwithstanding, new transient/non-transient non-community public water system proposals and new community water system projects should be required to prepare water recharge budgets to estimate whether sites are self-sustaining and to identify the potential for off-site drawdown impacts.

A second demand on North Salem's available groundwater yield is to provide dilution for septic system discharges.

To address this demand, new residential parcels developed with individual wells and septic systems should meet minimum parcel size criteria to support wells and to adequately dilute septic system wastewater discharges. This management approach will ensure that future residential areas will be assured sustainable sources of potable groundwater. This strategy both preserves groundwater quality and ensures that residual groundwater remains in the ground to discharge to aquatic environments which are dependent on groundwater discharge.

Nitrate loading analysis can be used to help identify minimum sustainable parcel sizes where wells and septic systems. Dutchess County recently funded nitrate dilution modeling (Chazen, 2006a) based on New Jersey's extensive septic system minimum density evaluations. The Dutchess County study is a relevant local study suited to North Salem geology because of similar geologic and soil formations and rainfall rates. For reference purposes, the nitrate loading calculation used in Dutchess County is shown below although it will seldom need to be used by Applicants unless standard variables described below warrant modification.

$$A = (4.4186HM / CqR) + Isc$$

Where

A = recommended minimum acres per system, in acres (e.g. parcel size)
H = persons per system
M = pounds of nitrate-nitrogen per person per year
Cq = Nitrate-nitrogen target average groundwater concentration, in mg/L
R = Annual Recharge Rate, in inches
Isc = Impervious surface cover, in acres

This formula can allow flexibility for evaluating unique projects, but may also be used with default values for broad planning purposes. The recommended default values are:

H = 2.6 persons per household, representing regional typical occupancy levels
M = 10 pounds of nitrate-nitrogen.

Cq = 5 mg/l, equal to half the nitrate drinking water standard so that, as results average around this goal, most outcomes will remain below the standard.
Isc = 0.1 acres, to address runoff from driveways, roofs and other impervious surfaces which cannot readily recharge on the site.
R = Use annual average recharge rates assigned to the four Hydrologic Soil Groups.

Based on this formula, minimum average recommended parcel sizes in North Salem for areas using individual wells and traditional septic systems are as follows:

For areas with Hydrologic Soil Group A:	1.2 acres per system
For areas with Hydrologic Soil Group B:	1.6 acres per system
For areas with Hydrologic Soil Group C:	3.0 acres per system
For areas with Hydrologic Soil Group D:	5.4 acres per system

Figure 7 shows areas in North Salem where existing parcels are below the parcel sizes referenced above. Figure 6 identifies the dominant soil type on each such parcel and also shows where public water supplies are believed to be present, thus isolating these residents from the risks associated with potential groundwater quality under their parcels. It is unlikely that well water quality exceeds nitrate standards on individual undersized parcels where adjoining larger parcels may be providing compensatory recharge that preserves local groundwater quality. However, where larger clusters of under-sized parcels exist, some decrease in groundwater quality may be expected and water quality nitrate concentrations may be nearing or even exceeding the drinking water standard for nitrate of 10 mg/l.

The Town may wish either to ensure that all rural district parcel sizes average at least 3 acres to avoid complications associated with sites containing both Hydrologic Soils Group B and C soils, or would adjust allowable density depending on the site soils. There are few buildable areas with either Hydrologic Soil Groups A or D in North Salem.

Additional sources of nitrate in aquifers do exist but are not included in this density model. For example, properly applied lawn fertilizers are fully utilized by site vegetation and will not contribute to elevated regional groundwater nitrate concentrations. Moreover, lawn fertilizer is not used at all homes, and is applied at ground surface rather than being released below ground level as are septic system discharges. Accordingly, nitrate from lawn fertilization can be readily addressed or mitigated by modified practices and community best management practice education and so need not be included in the calculations above.

4.3 Aquifer Protection

Most residents and businesses in North Salem use wells which are individually owned and for which no routine sampling is required. Since all geologic formations in the Town are used for water supply purposes, this study recommends adoption of an aquifer overlay protection ordinance to provide a measure of groundwater quality protection in the community.

A model aquifer ordinance potentially suitable for adoption is included in Appendix A. The ordinance was developed by several Dutchess County towns. It has received legal review to verify municipal authority on addressed topics. The latest version of this model, provided in Appendix A, has been adopted in the Town of Amenia and could be readily adapted for use in North Salem. This model is also being considered for use in the Town of Philipstown in Putnam County.

Briefly, the advantages of our recommended application of this aquifer protection model include:

1. Some measure of aquifer protection is provided for all lands in the Town.
2. A higher level of aquifer protection is recommended for wellhead protection areas near community wells or near clusters of individual wells.
3. The model provides both groundwater quality and groundwater capacity protection. Proposed activities requiring more water than that recharged on the individual site is accorded a higher level of SEQRA review.

An aquifer overlay map for the Town of North Salem would be needed. It would include the entire Town within a district imposing modest restricts that address gaps in existing State and Federal resource protection regulations. Specific recharge areas would then need to be mapped for community water system wells or clusters of domestic wells identified by the Town for such protection. As more public water supplies are developed, more wellhead protection areas can be delineated and added to this map.

If an aquifer protection ordinance is to be adopted, the first portion of Section B1 of the model ordinance in Appendix A text could be revised as follows:

> 1. The Aquifer Overlay (AQO) District encompasses the entire Town of North Salem and includes two types of aquifers: the town wide Regional Aquifer (RA) offers groundwater protection to bedrock or surficial aquifers throughout the Town. Particular Regional Aquifer Wellhead Protection (RAWP) areas warranting enhanced aquifer protection are delineated where community water system well fields are installed within the RA.

4.4 Pumping Test Protocols

Where wells are installed for new community water systems (defined by the Department of Health as systems serving 5 or more year-round residential service connections or 25 year-round residents), testing of wells must conform with protocols required by the NYS Department of Environmental Conservation. Wells intended for such uses are normally required to undergo testing for at least 72 hours at pumping rates equal to twice the average estimated daily demand rate.

The 72-hour test protocol used for most community water systems is appropriately conservative since it is normally conducted at twice the average proposed project daily water demand, and so is likely to successfully identify groundwater shortages in a project area. During project scheduling and SEQRA scoping for such projects, the Town Planning Board should be encouraged only to ensure that the following additional test and review components are met:

1. Off-site monitoring in any adjacent existing wells, streams and/or wetlands.
2. Analysis and comparison of proposed water consumption (extraction less wastewater returns) to best estimates of local drought-flow levels in nearby watershed streams.
3. Flow tests should be a minimum of 72 hours long, and should be extended if necessary until water levels in test wells and monitored on-site and off-site wells stabilize.
4. Aquifer reports including test results should include well drawdown projections showing how low water levels will fall during extended dry periods of up to 180 days.

Present mandatory well testing protocols for non-community water systems (paraphrased approximately here from Department of Health regulations as systems which are not community water systems but which serve an average of at least 25 individuals daily at least 60 days out of the year) are reasonably conservative, but Applicants proposing non-community systems requiring more than 5 gpm of water daily use should be asked as part of SEQRA analysis to provide a water budget comparing onsite recharge to water uses. This will help predict whether off-site drawdown impacts should be anticipated and/or assessed.

Where subdivisions of more than 3 units are proposed using individual wells and septic systems <u>and</u> where average parcel sizes will be smaller than those recommended in Section 4.3, supplemental aquifer analysis may be warranted as part of project SEQRA reviews. The County Department of Health currently requires pre-installation and testing of either one in 5 or one in 10 of total proposed wells on such subdivisions. Applicants usually test these wells sequentially rather than concurrently, and each test usually lasts less than one day. By means of a local ordinance or local guidance administered by the Planning Board under

SEQRA, testing of pre-drilled individual wells could be improved in North Salem by requiring simultaneous testing of the test wells at a combined rate equivalent to the anticipated withdrawal rate of the full subdivision, and requiring that such tests extend at least to 24 hours, and potentially to as long as 72-hours if particularly-sensitive on-site or off-site conditions are identified by the reviewing board.

4.5 Road De-Icing

Salt is a regionally-recognized groundwater contaminant. Chloride contamination in wells has been documented in many some towns. Road salt is a primary source of salt in groundwater. Water softener salt discharges can also contaminate wells.

Subdivisions with individual wells should include impervious snow accumulation areas for ends of roads or other areas likely to accumulate particularly large snow volumes. In addition to cul-de-sacs, snow accumulation and salt runoff accumulations can also occur in wells found at the bottoms of hills or immediately downhill from intensively managed road margins.

Impervious snow accumulation areas connected to runoff-control conveyances may be warranted in areas like those listed above to ensure that undissolved salt does not accumulate in shallow groundwater or soils near domestic wells. Select areas may warrant “no salt” designations. Infiltration practices introducing road runoff directly into aquifers should generally be discouraged.

Protocols developed by the NYS Department of Transportation can be used to help distinguish between road salt and water softener contamination in wells.

4.6 Stormwater Management

Various surfacewater management programs also benefit groundwater conservation and management strategies. North Salem should encourage the use of disconnected impervious surfaces, stormwater detention and infiltration techniques, and protection of natural vegetation around water bodies to offset development impacts which can both reduce groundwater recharge and increase stormwater runoff impacts. Such approaches can include infiltration and other Best Management Practices within the stormwater program. A town planning policy should be considered, stating that site development should seek to maintain pre-development runoff characteristics to both ensure adequate aquifer recharge and minimize stormwater flooding and surface water quality impacts.

4.7 Other Recommendations

In 2003, The Chazen Companies published a review of existing groundwater data available in Towns throughout northern Westchester County (Chazen 2003b). This study also identified data gaps and provided recommendations for follow-up groundwater resource planning and analysis.

This report provides North Salem with some of the missing data identified in that report while leaving some matters unresolved. The 2003 recommendations, and the responsiveness of this study of those recommendations, are summarized below.

OBJECTIVE 1: PROTECT GROUNDWATER QUALITY, SPECIFICALLY IN AREAS USING DOMESTIC WELLS

Problem Statement: In residential areas using individual wells and septic systems in northern Westchester County, between 4 and 7 million gallons of septic system wastewater are discharged daily to aquifers. Road salt and petroleum from buried home heating oil tanks also infiltrates aquifers. These wastewater, salt, and petroleum contaminants threaten domestic well water quality.

Data or Policies Needed to Protect Groundwater Quality:

- REGIONAL GROUNDWATER QUALITY DATA: Groundwater quality trends should be monitored in regions relying on domestic wells. Sampling should focus on
    - nitrate and coliform (total and *e*-coli) levels and trends,
    - minerals such as iron, manganese, and hardness levels. These tend to increase during drought periods when normally isolated and mineral-enriched groundwater is drawn into domestic wells,
    - salt from deicing chemicals and water softeners. Particularly in low or poorly drained areas,
    - newly-recognized contaminants such as caffeine, various pharmaceutical drugs, or endocrine disrupting chemicals (EDCs) including estrogen and birth control residues. These pass through our bodies during use and enter aquifers via septic systems.

  Groundwater quality data should be sampled in a network of monitoring wells installed near and within settled areas, potentially along municipal or county road rights-of-way. Data from the monitoring network will help define existing groundwater quality trends and distributions of detected contaminants. Sampling results will help prioritize watershed protection programs.

- LOT SIZE RECOMMENDATIONS: TCC studies and recent New Jersey DEP policies suggest that where individual wells and septic systems are used, average minimum lots in areas with clay-rich soil should be 3 to 5 acres in size. In areas with sandy soils, higher recharge rates allow smaller sustainable average lot sizes of 1 to 2 acres. Westchester County municipalities should evaluate and consider using the NJDEP sustainable lot size guidance policy. Some municipalities already have 3 to 4 acre zoning in more rural areas, but many municipalities have 1 and 2 acre zoning with no proposals for central water or sewer service. In such cases, the resulting high septic system density may lead to drinking water standard violations in wells.

- ROAD SALT: Highway department Best Management Practices should be developed to protect domestic well quality and stream quality. Recent reports of chloride contamination in wells demonstrate the need for improved road salt management. Regional chloride monitoring, as described above, will further define the prevalence of groundwater contamination by de-icing chemicals.

- PROTECTION GAPS STUDY: NYCDEP, NYSDEC, and USEPA and some municipality regulations already protect groundwater quality through various programs, however, regulatory gaps exist. Examples of gaps known to TCC include: burial of home heating oil tanks underground is allowed in most municipalities, there is an absence of highway salt management regulation, and, local wellhead protection is absent for many larger wells and most areas with many domestic wells. A protection gaps study is needed, leading to development of a model groundwater ordinance available for municipal adoption.

This North Salem Study: This study has recommended minimum average sustainable lot sizes for parcels served by individual wells and septic systems. This study has also provided a model aquifer protection ordinance which, if adapted to Town needs and adopted, will help close federal and state protection gaps. Finally, some guidance for salt use contaminant controls has been offered. No program has been implemented yet to evaluate regional groundwater quality trends. Such programs can be implemented at either Town or County levels and often take the form of required well sampling at times of property transfer.

OBJECTIVE 2: PROVIDE TIMELY WARNINGS TO INDIVIDUAL WELL OWNERS WHEN WATER SCARCITY OR QUALITY DEFECTS OCCUR DURING DROUGHTS

Problem Statement: Municipal administrators often do not know when to recommend or relax water conservation measures as droughts begin or end. Residents are also not warned when drought impacts are affecting water quality.

Data Needed to Provide Timely Warnings:

- GROUNDWATER LEVEL DATA: Regionally-distributed groundwater level monitoring stations are needed to continually monitor groundwater levels. Data from such sites will help identify when low watertable conditions are occurring in aquifers.

- DATA DESCRIBING GROUNDWATER QUALITY DURING DROUGHTS: Domestic well water can contain e-coli contamination or elevated concentrations of dissolved minerals during droughts. Contamination occurs when expanded watertable drawdown occurs during droughts, drawing contaminants from septic systems or remote fractures toward wells. Knowing when such drought-related water quality defects are occurring will help municipalities inform residents of potential problems. Collecting these water quality data should be integrated into the water quality sampling recommended under Objective 1.

This North Salem Study: This study did not include tasks to establish groundwater level or groundwater quality sampling. Such programs might best be implemented regionally. The Chazen Companies have assisted Dutchess County to establish a regional aquifer level and stream monitoring program.

OBJECTIVE 3: IDENTIFY AND PROTECT FUTURE HIGH-YIELD WELL LOCATIONS

Problem Statement: Locations that could serve as future high-capacity groundwater well sites have not been identified.

Data Needed to Identify Valuable Aquifer Areas:

- MAP AND TEST HIGH-YIELD AQUIFERS: Detailed stream gauging data of discrete stream segments will help identify where local, high-yield sections of surficial aquifers routinely discharge large groundwater volumes into streams. GIS-based analysis of soils and geologic formation maps will also help identify prospective well locations. Analysis of well driller well logs, once available in digital format, will allow statistical identification of bedrock aquifers with the highest capacity for supporting high-yield bedrock wells. As candidate production well sites are identified by these approaches, they should be investigated and tested to determine whether suitable groundwater is present to warrant site procurement or protection.

This North Salem Study: Some potential for water supply development in unconsolidated aquifers may exist along the Titicus River or along the east shoreline of the Muscoot reservoir. This study did not include tasks to gauge streams or map such areas or tasks to map individual potential well sites. This report has provided preliminary analysis of bedrock aquifers and shown that the general water-bearing potential for most formations in North Salem have approximately equivalent yield opportunities. To enhance yields from future wells drilled in these bedrock aquifers, this report has provided linear feature data and groundwater recharge rate data that may be used when seeking higher-yield bedrock wells. This study did not include tasks to identify or evaluate specific sites.

OBJECTIVE 4: PRESERVE GROUNDWATER FLOWS REACHING STREAMS AND WETLANDS

Problem Statement: Groundwater consumption reduces groundwater flows to aquatic habitats including riparian wetlands and stream corridors.

Data and Policies Needed to Support Aquatic Resources:

- STREAM FLOW AND DEMOGRAPHIC DATA: Historic dry-season stream flow data, precipitation data, demographic data and wastewater disposition patterns should be studied to assess human water use impacts on streams. Analysis may suggest that groundwater consumption limits are necessary to avoid stream depletion.

- GROUNDWATER CONSERVATION BEST MANAGEMENT PRACTICES: Water conservation programs should be promoted to off-set some, if not all, impacts of future development. Conservation programs should include use of water saving devices in homes, and implementation of development Best Management Practices (BMPs) that enhance compensatory recharge areas on project sites or minimized recharge losses from pervious surfaces. Making such BMPs available to municipalities will help encourage their use.

This North Salem Study: This study did not include tasks to address these issues. However, adoption of minimum average parcel sizes for parcels developed with individual wells and septic systems result in significant groundwater conservation within aquifers, which contributes positively to stream baseflow preservation. The Phase II stormwater program may be an opportune area for biasing development of projects toward BMPs which enhance groundwater recharge.

OBJECTIVE 5: MONITOR RATES AND LOCATIONS OF GROUNDWATER CONSUMPTION

Problem Statement: Planning Boards and other entities do not know how much groundwater is being consumed in their municipalities or know where existing groundwater wells are located. Preliminary groundwater consumption estimates have been developed in this report, but need to be refined. If stream flows are to be preserved or wells are to be protected from contaminant threats, records of existing well locations and estimated rates of groundwater consumption are necessary.

Data Needed to Track Groundwater Uses:

- ACCESSIBLE WELL LOG DATA: Well drilling records are currently stored in paper format in Health Department files. A computerized GIS record of these logs should be created so that planners, groundwater investigators, and others can review the location, depth, geologic formation, and yields of existing wells. Data will need to be manually transferred into a computer database and then georeferenced (located on a digital map) using GIS software. Since drillers use informal terminology when completing their logs, a geologist should add a geologic interpretation to each well log so that the wells can be reviewed or sorted by geologic formation as well as by location.

- REGIONAL GROUNDWATER BUDGETS AND CONSUMPTION ESTIMATES: Planning Boards and other decision makers will be better prepared to evaluate potential groundwater impacts of projects once they understand existing regional groundwater budgets and consumption rates. Regional groundwater budgets should be developed for sub-watersheds in the County, and groundwater consumption rates should be updated into these budgets either by County agencies or municipal staff as new projects add consumptive demand.

This North Salem Study: This study has provided estimates of groundwater consumption in North Salem, both in the form of direct removal and in the form of assigned assimilative capacity to dilute wastewater reserves. This study did not include tasks to collect and manage well log data. Such a program would best be implemented regionally because well logs submitted to the County from all Towns are filed collectively. The Chazen Companies has assisted Putnam County to establish a regional well log database. NYSDEC may soon be releasing updated minimum streamflow standards in New York State. Once available, intermunicipal efforts within shared watersheds may be needed to evaluate groundwater budgets on basin levels and assess sustainable consumption levels which do not unduly reduce stream flows. Consideration of these tasks was not part of the current work contract.

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Tables

Table 1 - Well Yield Data

Municipal Groundwater Resource Report
Town of North Salem

North Salem

Bedrock Formation Statistics			Yield (gpm)			Depth (feet)		
	Number	Percent	Average	Median	Mode	Average	Median	Mode
Fordham Gniess (f)	13	26.53	21.75	16	10	166.46	150	NA
Gabbro/Norite/Diorite (Ogb)	4	8.16	7.25	8.5	9	106	66.5	NA
Inwood Marble (Oci)	10	20.40	19.55	9.5	NA	131.4	126	NA
Manhattan Formation (Om)	22	44.90	14.33	10	10	152.5	107.5	100

Putnam County

Bedrock Formation Statistics			Yield (gpm)			Depth (feet)		
	Number	Percent	Average	Median	Mode	Average	Median	Mode
Gabbro/Norite/Diorite (Ogb)	8	0.14	19.38	8.5	5	310.63	270	500
Inwood Marble (Oci)	24	0.43	8.29	9	10	299.64	300	300
Manhattan Formation (Om)	292	5.23	21.42	12	10	327.36	297.5	285

Figures

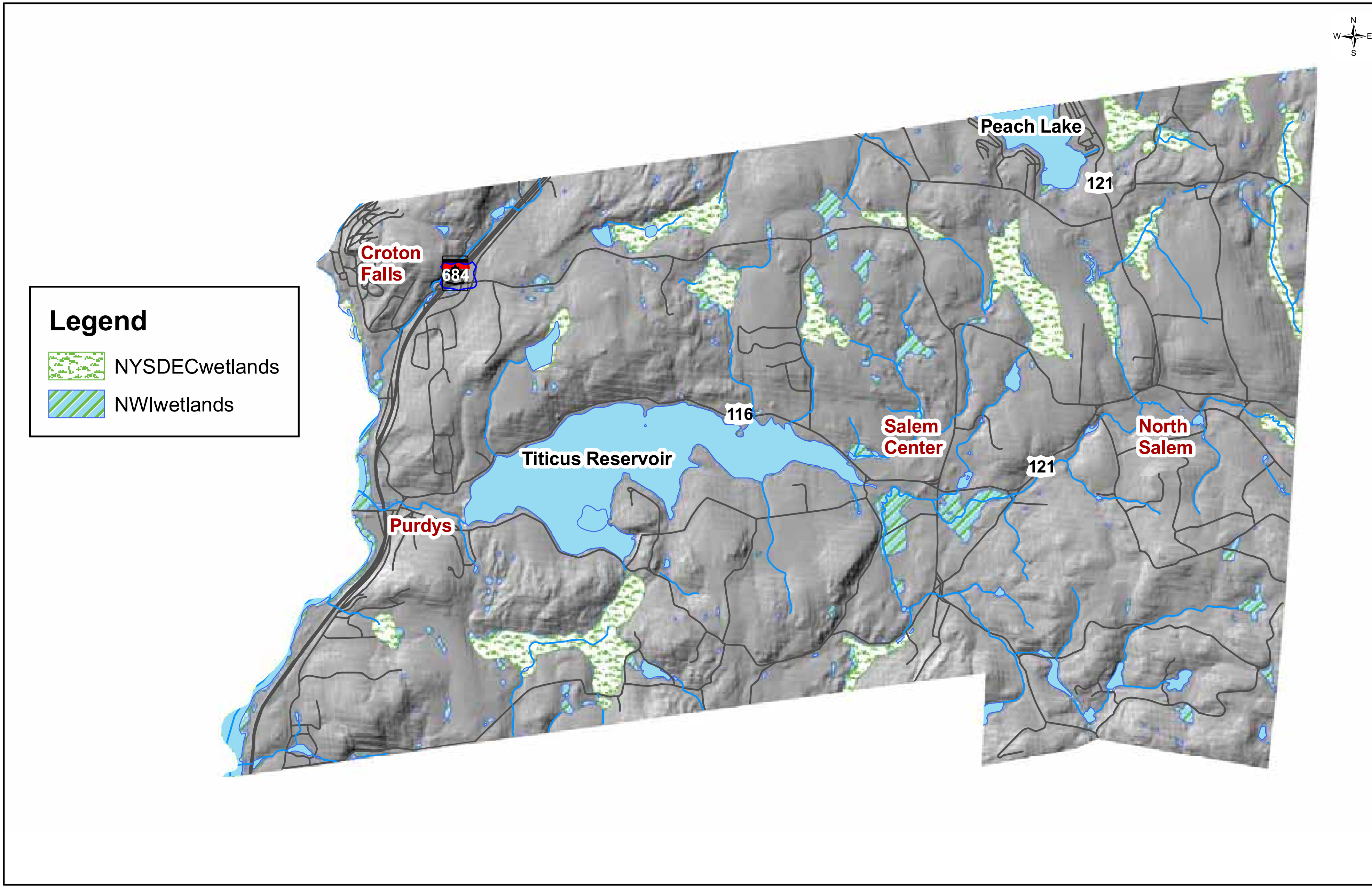

FIGURE 1 - OVERVIEW MAP

North Salem Aquifer Report

Town of North Salem, Westchester County, New York

Source: TCC GIS database for Westchester County

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Figure:	1

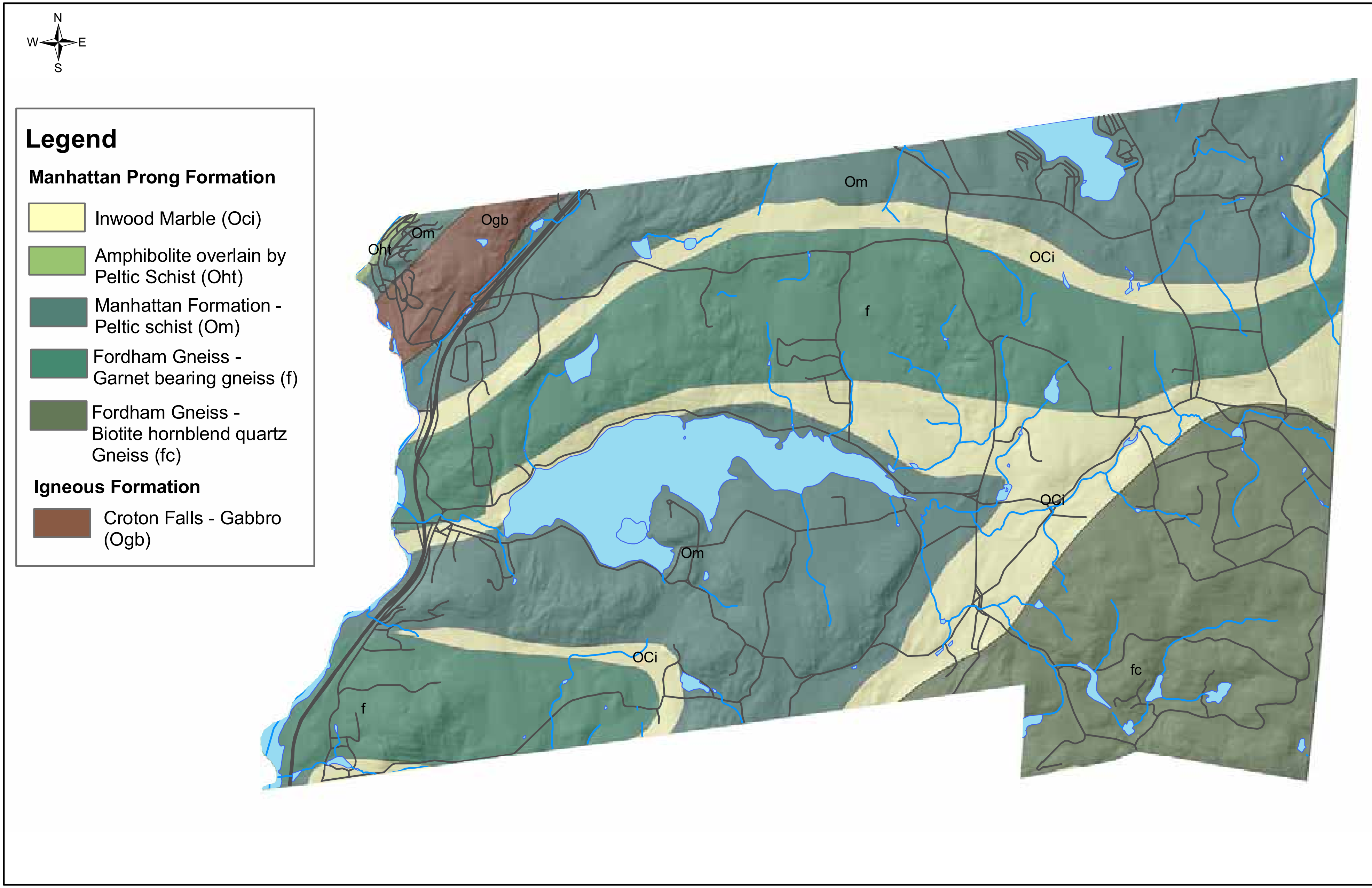

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FIGURE 2 - BEDROCK GEOLOGY MAP

North Salem Aquifer Study

Town of North Salem, Westchester County, New York

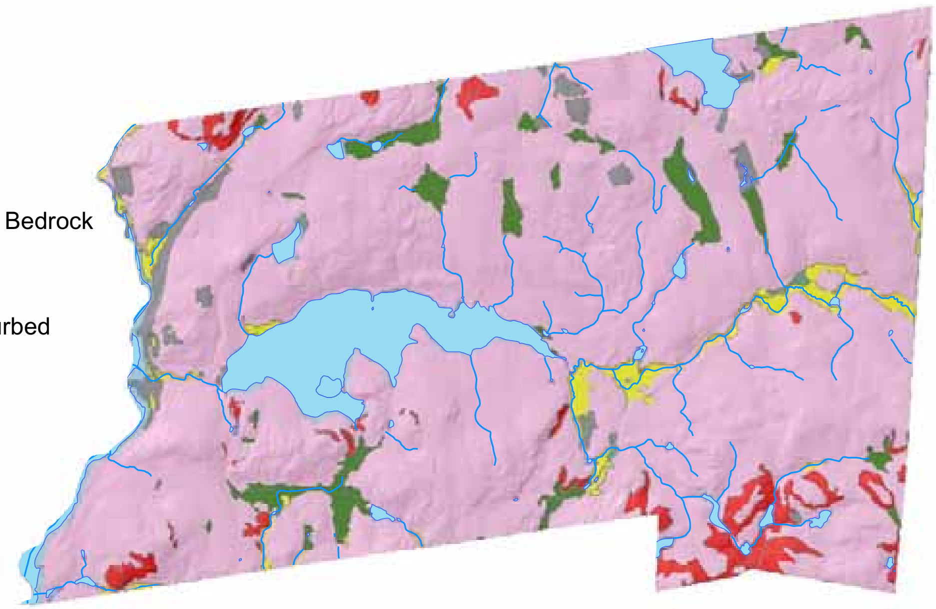
Source: Bedrock Geology from NYSGS Bedrock Geology Map, Lower Hudson Sheet, Dated 1970.

Drawn:	CMW
Date:	December, 2007
Scale:	1 in equals 4,500 ft
Project:	40701.00
Figure:	2

FIGURE 3 A- Interpreted from Soil Survey

Legend

- Outwash Gravels
- Swamp Materials
- Near or Exposed Bedrock
- Till
- Undefined / Disturbed
- Water



1 in equals 5,000 ft

FIGURE 3 B- State Surficial Geology Map

Legend

- Kame
- Outwash Gravels
- Swamp Materials
- Near or exposed bedrock
- Till
- Water

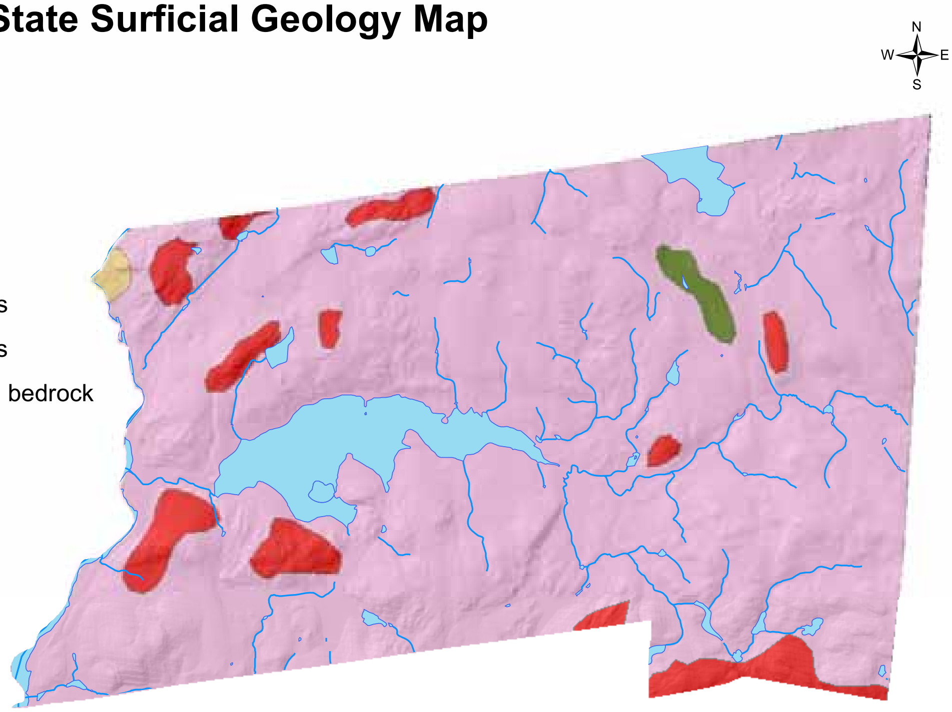


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FIGURE 3 A, B - SURFICIAL GEOLOGY MAPS

North Salem Aquifer Study

Town of North Salem, Weschester County, New York

Sources: Figure 3A derived by TCC from USDS Soil Survey of Westchester County. Figure 3B from Surficial Geology Map, Lower Hudson Sheet, 1989.

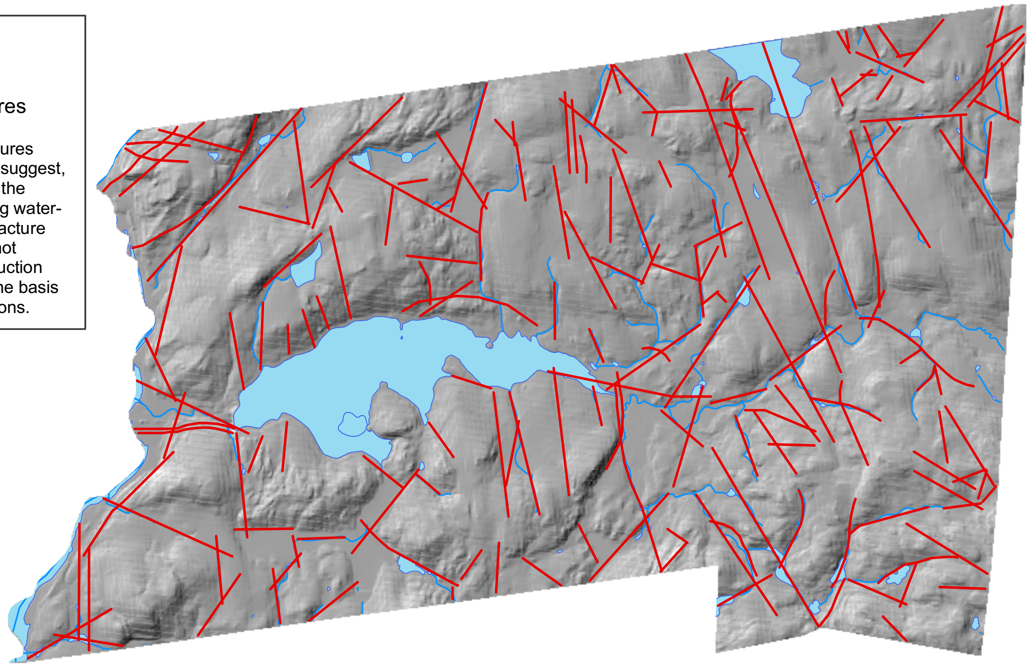
Drawn:	CMW
Date:	December, 2007
Scale:	As shown
Project:	40701.00
Figure:	3

Figure 4 A - Bedrock Linear Features & Hillshade

Legend

—— Linear Features

NOTE: The linear features identified on this map suggest, but do not guarentee, the existance of underlying water-bearing fractures or fracture systems. TCC does not guarentee water production from wells drilled on the basis of these feature locations.



Interpreted from 208 Maps, (1977) Areawide Waste Management Plan. Westchester County offices, with some linear feature traces provided by TCC.

1 in equals 4,500 ft

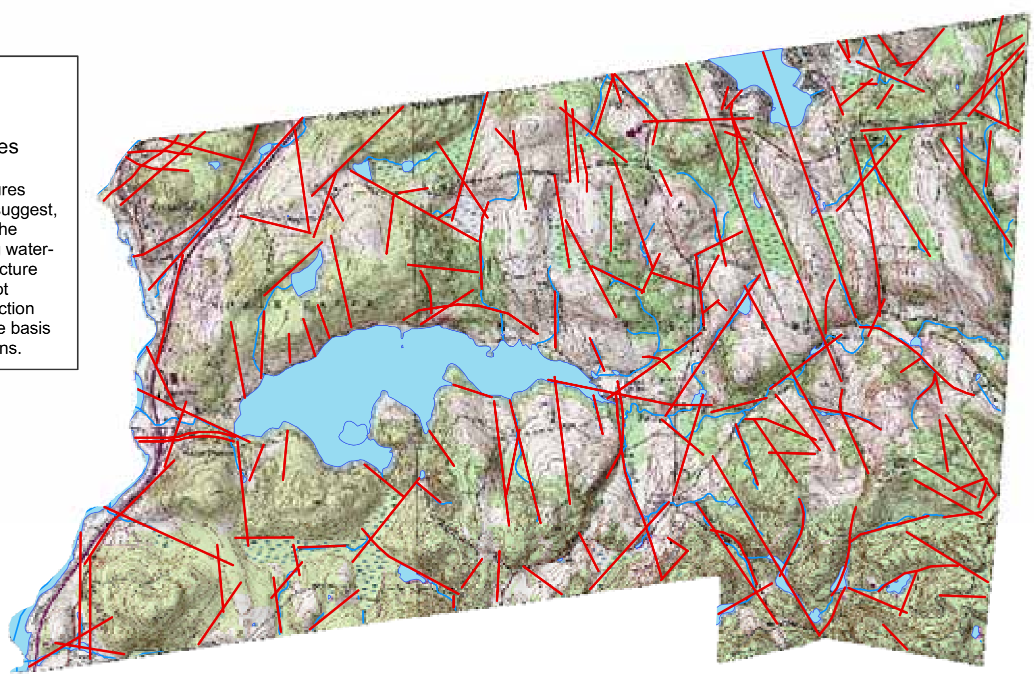
Figure 4 B - Bedrock Linear Features & Topography

N
W E
S

Legend

—— Linear Features

NOTE: The linear features identified on this map suggest, but do not guarentee, the existance of underlying water-bearing fractures or fracture systems. TCC does not guarentee water production from wells drilled on the basis of these feature locations.



Interpreted from 208 Maps, (1977) Areawide Waste Management Plan. Westchester County offices, with some linear feature traces provided by TCC.

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FIGURE 4 A, B - LINEAR FEATURES MAP

North Salem Aquifer Report

Town of North Salem, Westchester County, New York

Source: 208 Maps. 1977. Areawide Waste Management Plan. Westchester County offices. USGS Topographic Map of the Peach Lake, NY-CT Quadrangle, 7.5 Minute Series. Dated 1998.

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Figure:	4

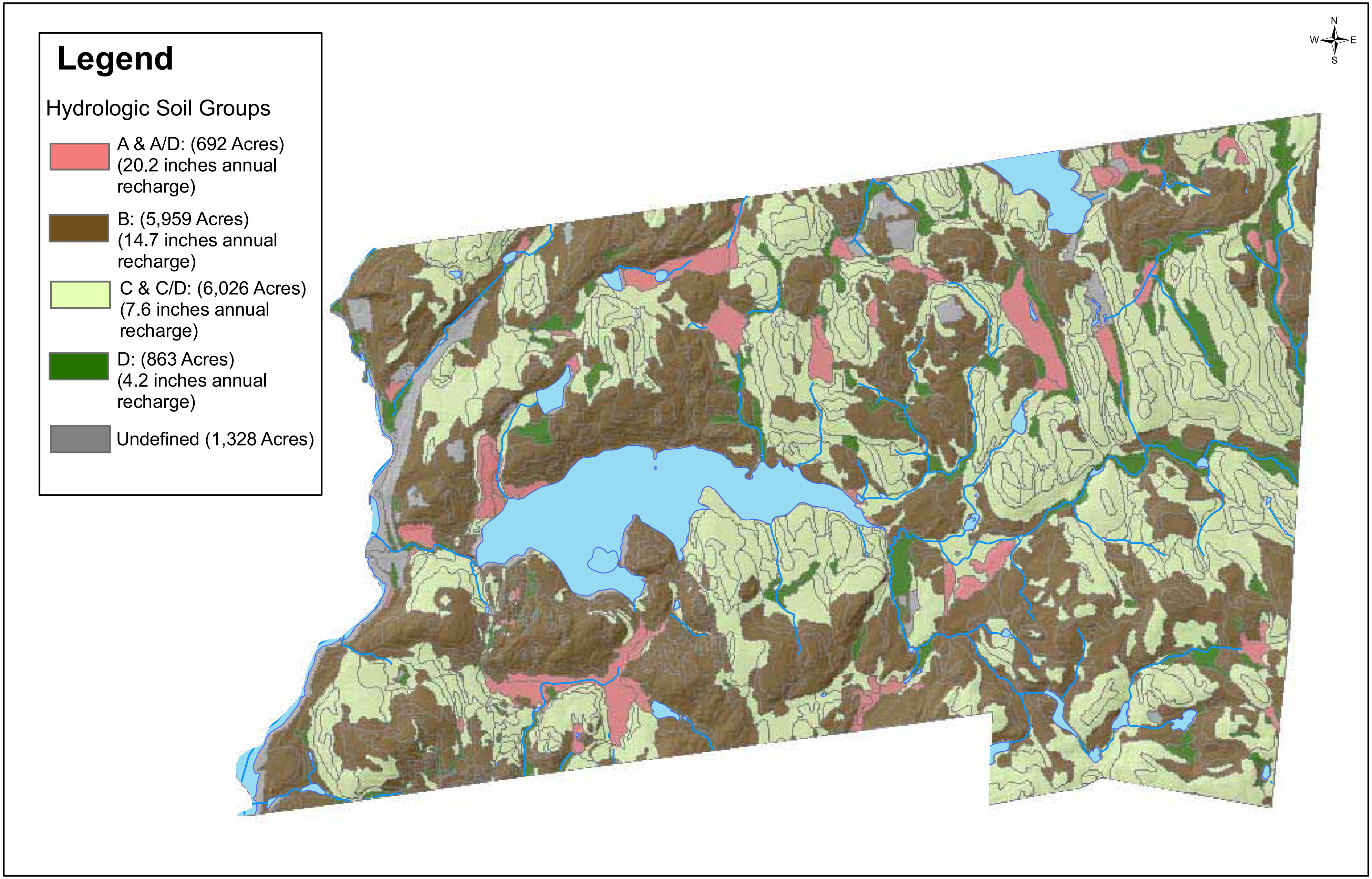

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FIGURE 5 - HYDROLOGIC SOIL GROUPS

North Salem Aquifer Report

Town of North Salem, Westchester County, NY

Source: Hydrologic Soil Groups from USDA Soil Survey of Putnam and Westchester Counties, 1994.

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Figure:	5

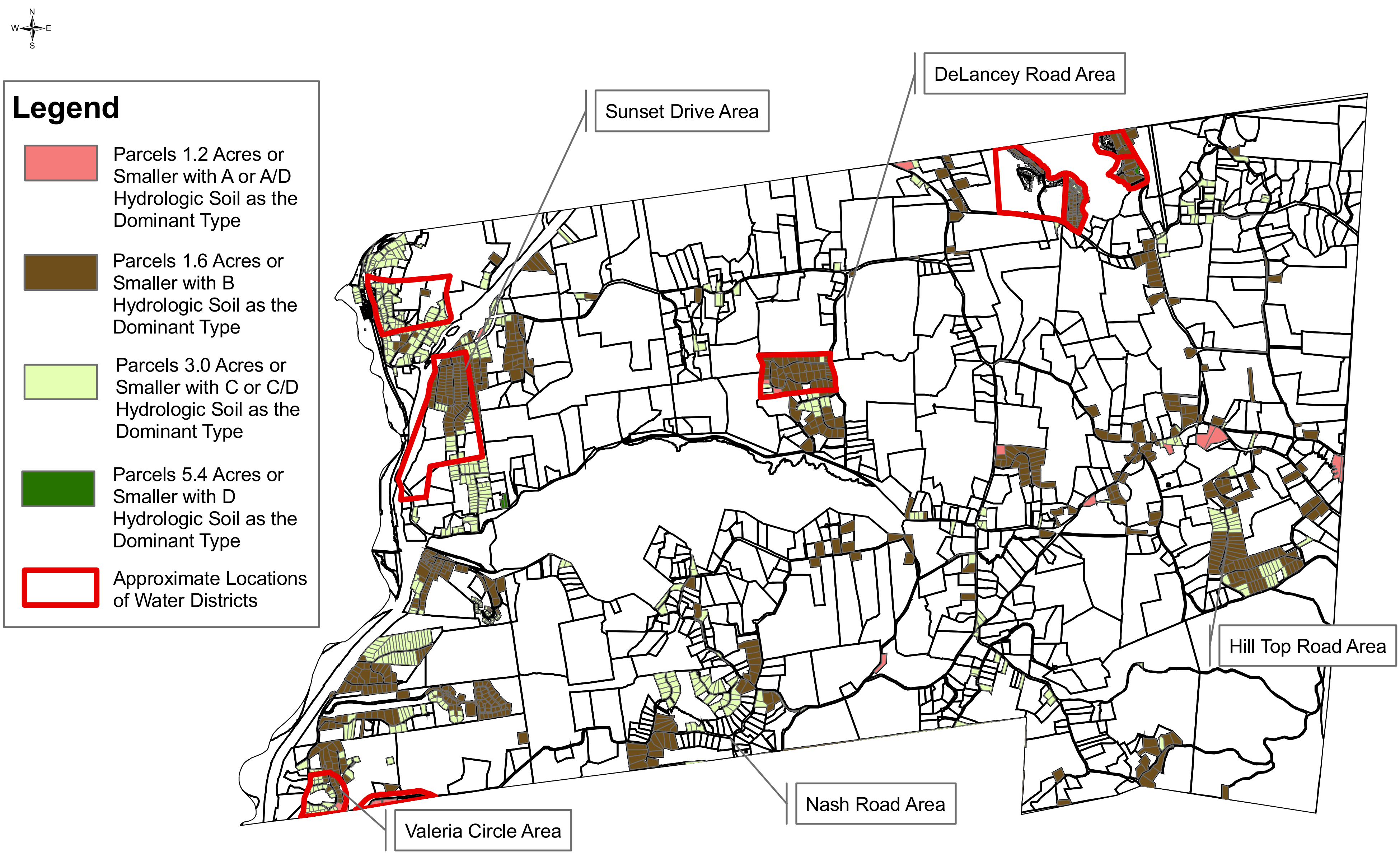

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FIGURE 6 - EXISTING PARCELS LESS THAN THE RECOMMENDED SUSTAINABLE FOR WELL AND SEPTIC SYSTEM USE, BY SOIL TYPE

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Town of North Salem, Westchester County, New York

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Project:	40701.00
Figure:	6

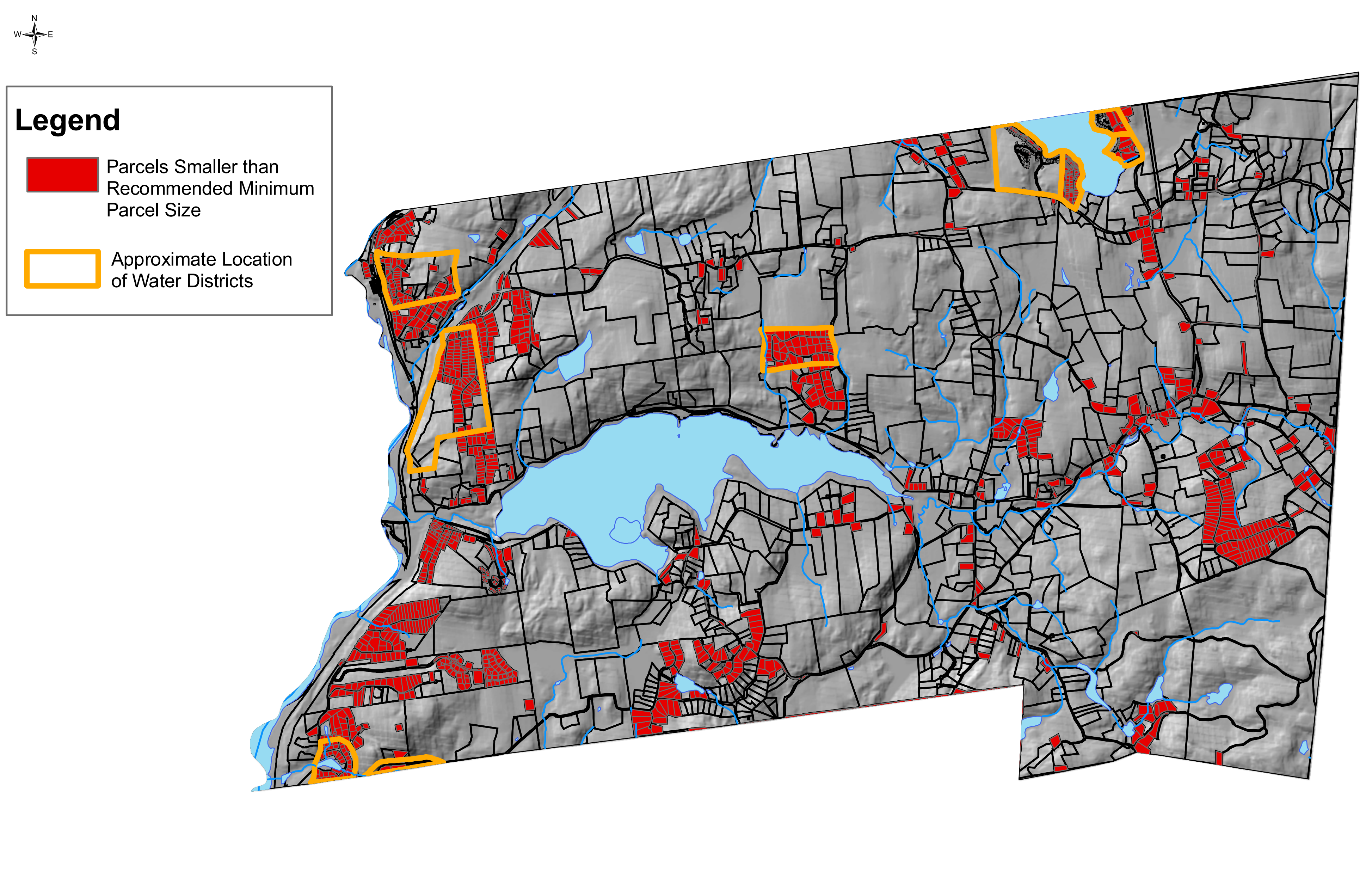

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FIGURE 7 - EXISTING PARCELS LESS THAN THE RECOMMENDED SUSTAINABLE FOR WELL AND SEPTIC SYSTEM USE

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Town of North Salem, Westchester County, New York

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Date:	December, 2007
Scale:	1 in equals 4,500 ft
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Figure:	7