GROUNDWATER RESOURCES STUDY
AND
PROTECTION PLAN

for the

TOWN OF COPAKE
COLUMBIA COUNTY, NEW YORK

January 2009

Prepared by:

Steven Winkley
New York Rural Water Association

Prepared for:

Town of Copake Environmental Committee

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EXECUTIVE SUMMARY

New York Rural Water Association (NYRWA) has prepared this Groundwater Resources Study and Protection Plan in cooperation with the Town of Copake Environmental Committee. This study and plan inventories and maps the groundwater resources and aquifers of Copake, identifies potential sources of contamination and the vulnerability of groundwater to pollutants, discusses sources of drinking water, evaluates the susceptibility of groundwater resources to growth and development, and outlines potential protection planning strategies.

The vast majority of residences and businesses in Copake utilize bedrock wells. Overall, these wells have a median yield of 8 gallons per minute (gpm), a median depth of 285 feet, and a median depth of casing of 30 feet. Twenty-eight percent of Copake bedrock wells yield less than 5 gallons per minute - the minimum well yield necessary for Federal Housing Administration (FHA) insured loans for new construction. Most of the variation in bedrock well yields across Copake is due to the type of bedrock. Carbonate rocks across the central portion of Town have significantly higher than in the Walloomsac Formation (see Executive Figure 1). The median yield in the carbonates is 10 gallons per minute. The median yield in the Walloomac is 6 gpm. Over one-third (36 percent) of all wells drilled in the Walloomsac Formation yield less than 5 gallons per minute.

NYRWA has mapped several unconsolidated (sand and gravel) aquifers in Copake (see Executive Figure 2). Although these aquifers are not being widely utilized for households, the Taconic Shores Homeowners Association and the Taconics Hills Central School District are both dependent upon such aquifers. The median yield of screened wells completed in unconsolidated aquifers in Copake is 76 gpm. The distribution of water-bearing unconsolidated deposits is generally limited to areas along or near the valleys in Copake, particularly the Roeliff Jansen Kill Valley where glacial meltwater drainage was once concentrated. Areas with potential for high-yield well development have been indicated in some valleys. These areas have deeper sand and gravel deposits located a sufficient distance from both surface water and potential sources of contamination.

In addition to Taconic Shores and Taconic Hills Central School District, there are at least 20 other public water systems in Copake. These are privately owned community water systems that serve apartments and a mobile home park, as well as non-community systems that serve establishments such as restaurants, camps, etc.

Groundwater resources are susceptible to contamination from a variety of manmade sources that can be associated with present or future land uses. An inventory of regulated facilities and land uses revealed some areas that pose a higher risk of contamination to well supplies. The potential for contamination is also controlled by the *hydrogeologic sensitivity* of a location. This is the relative measure of the ease and speed with which a contaminant could migrate into and within the upper-most water-bearing unit. Hydrogeologic sensitivity was mapped for Copake. It was found that areas with coarse-grained soils and underlying unconsolidated or limestone/dolostone aquifers have the highest hydrogeologic sensitivity. Upland areas with clay-rich bedrock, till soils, and steeper slopes have the lowest sensitivity.

Development involves a number of potential groundwater resource issues such as water supply, wastewater disposal, impervious surfaces and storm water systems, and improper waste disposal and spills. For much of the Town, it appears that the density of residential development has not exceeded recommended levels to prevent excess nitrate loading and depletion of streamflow. However, development surrounding Copake Lake and Robinson Pond has exceeded recommended levels, as has the density of development in portions of the hamlets of Copake and Copake Falls. (Executive Figure 3). There are also relatively undeveloped areas where the density permitted by zoning would exceed recommended densities, such as north of Copake Lake, between Copake hamlet and Robinson Pond, and south and west of Copake Falls.

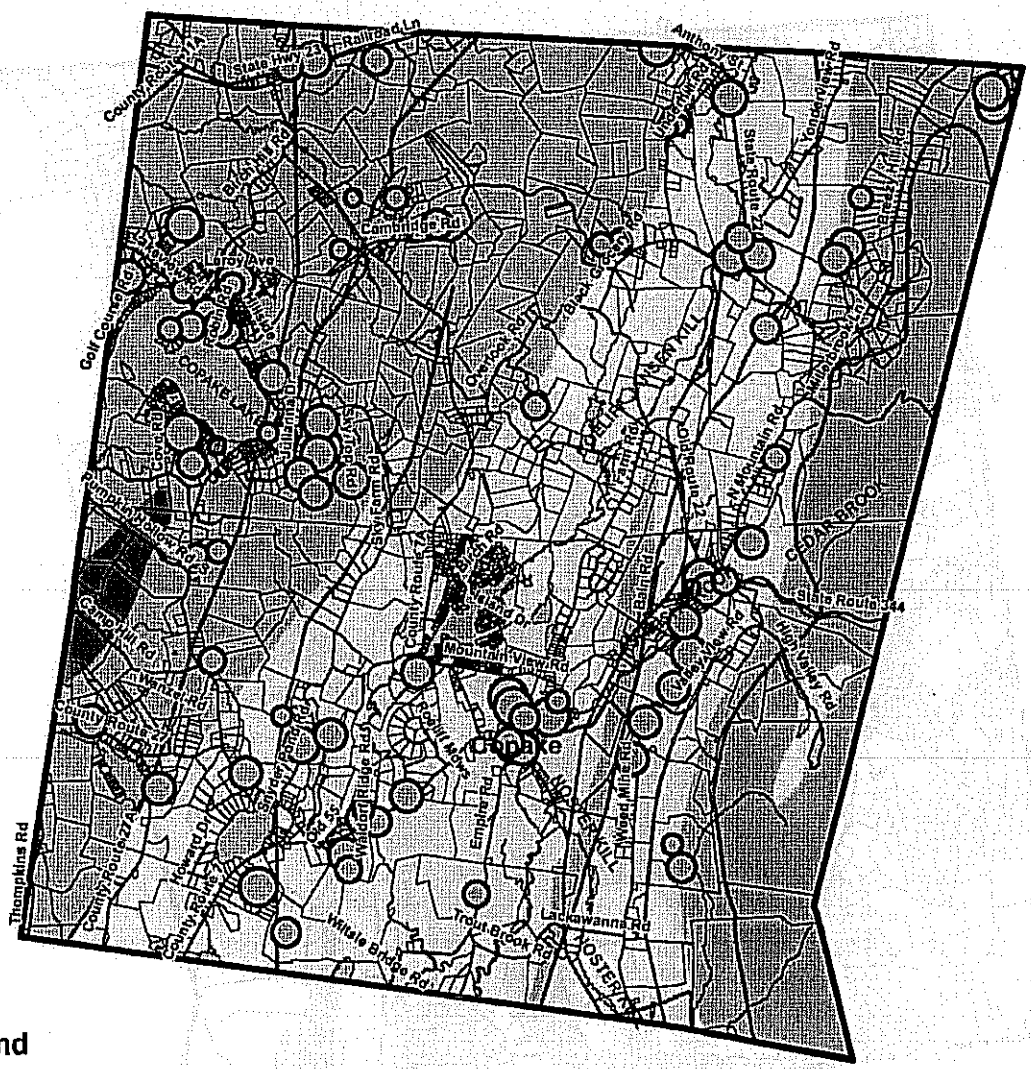
The issue of groundwater supply availability and impact should be addressed early in the land development process. NYRWA recommends that the location, yield, and quality of wells should be considered prior to approval of a new subdivision. Relatively large subdivisions could have a hydrogeological report completed prior to approval. Another possible approach is to use site plan review regulations to require a hydrogeological study and minimum standards for some forms of development. For example, any development that uses at least 1,000 gallons per day of water could trigger more hydrogeological study. Calculated recommended housing densities should be considered when amending zoning. In the future, Copake may also wish to enact overlay districts to protect public water supplies and sensitive hydrogeologic areas.

Finally, several areas in Copake may merit further study due to potential water quality/quantity concerns.

New York Rural Water Association
Address: P.O. Box 487, Cleverack, NY 12513
Phone: 518-828-3155
Web Site: http://www.nyruralwater.org

Bedrock Hydrogeology
Town of Copake, New York

Steven Winkley
2008



Legend

Bedrock Well Data

Yield

- No Data
- 0.1 - 1
- 1.5 - 2.5
- 3 - 5
- 6 - 9
- 10 - 15
- 20 - 30
- 50 - 100

Bedrock Hydrostratigraphic Unit

- Austin Glen
- Everett
- Stockbridge-Wappinger Carbonates
- Walloomsac
- Fault

Scale

0 0.375 0.75 1.5 2.25 3 Miles

N

Executive Figure 1

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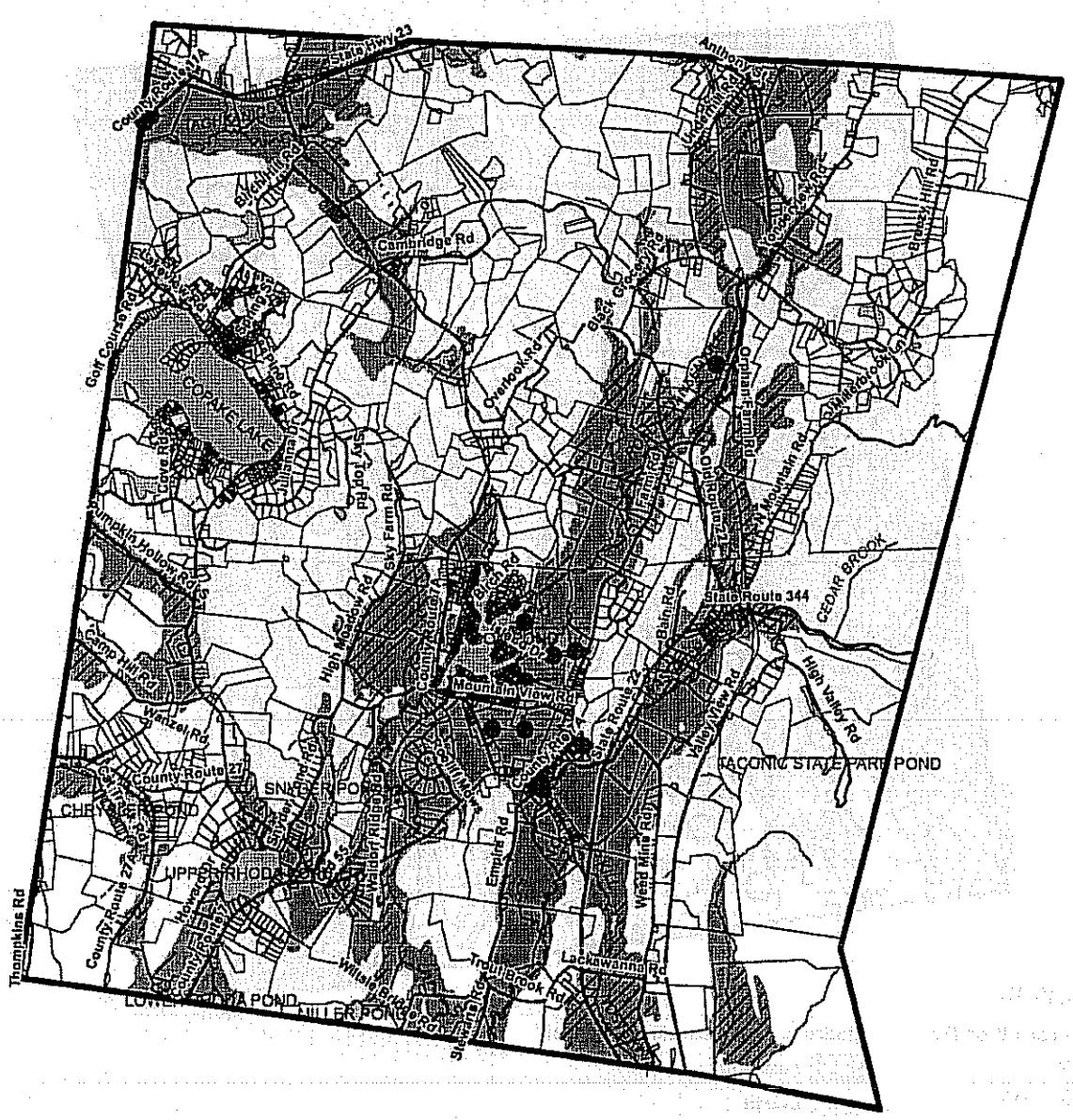
Unconsolidated Aquifers
Town of Copake, New York

Steven Winkley
2008



Legend

- Well In Unconsolidated Aquifer
- Unconsolidated Aquifer Area
- Area With Enhanced Potential for High-Yield Supply Well(s)
- Thin sand & gravel (< 20 ft.)

Scale

0 0.375 0.75 1.5 2.25 3 Miles

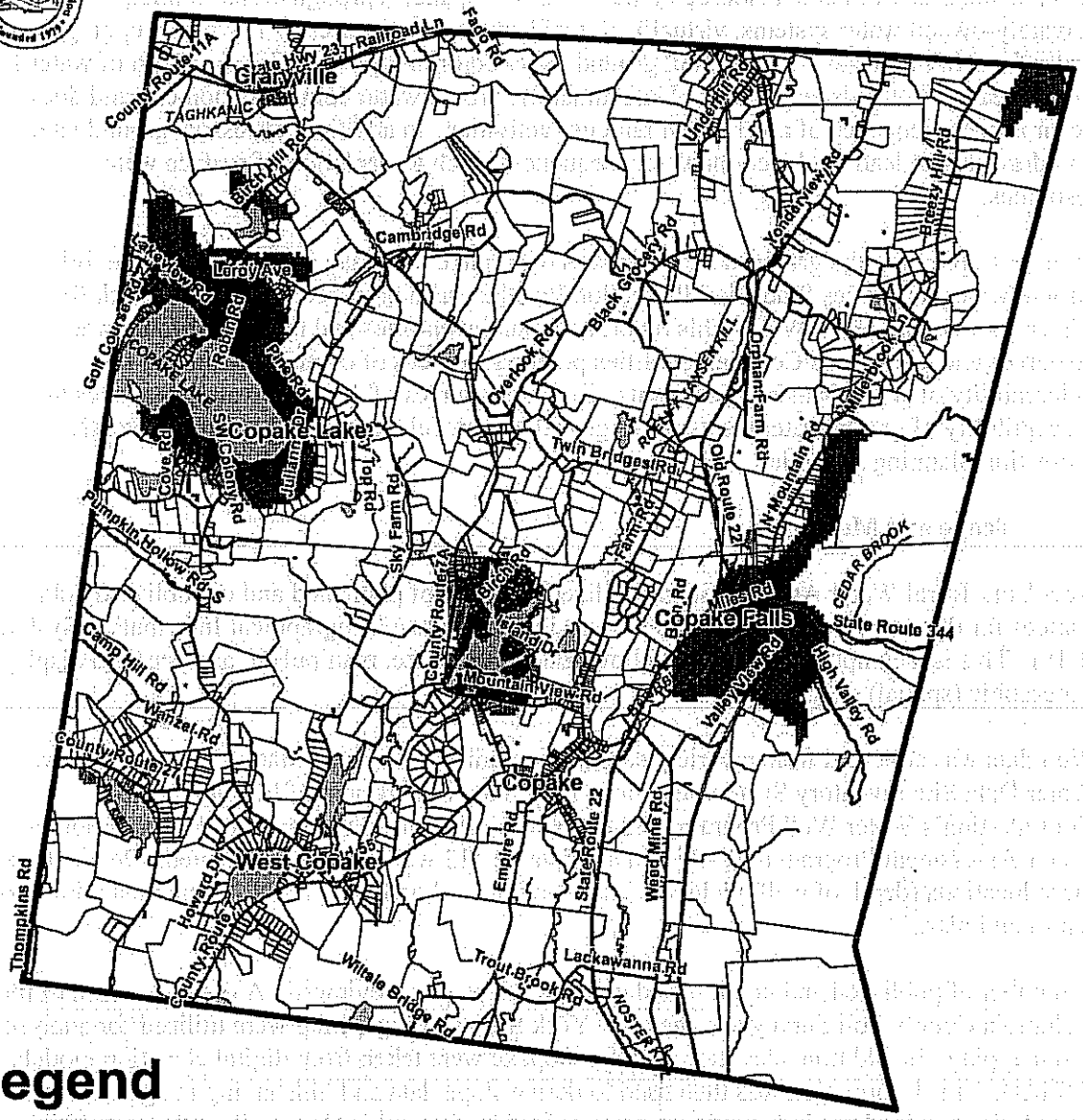
N

Executive Figure 2

Actual Housing Density vs. Recommended Densities

Town of Copake, New York

Steven Winkley, New York Rural Water Association



Legend

Actual Density > Density to Minimize Nitrate Loading

Actual Density > Density to Conserve Drought Baseflow

N

Scale

0 0.75 1.5 2.25 3 Miles

Executive Figure 3

1.0 INTRODUCTION

1.1 Goals and Objectives

Ground water is a valuable resource in the Town of Copake. Through either municipal or privately-owned water systems, virtually all residents and businesses in Town rely upon ground water for drinking water. In addition, ground water contributes a significant portion of water to local streams, wetlands, and ponds. Unfortunately, groundwater contamination can and does occur as a consequence of a variety of land use activities. In addition, excessive groundwater withdrawals can lead to objectionable consequences, such as depletion of surface water resources.

In order to preserve the groundwater resources of Copake for today and the future, the following Groundwater Resources Study and Protection Plan has been prepared by the New York Rural Water Association (NYRWA). This report and plan inventories and maps the groundwater resources and aquifers of Copake, identifies potential sources of contamination and the vulnerability of groundwater to pollutants, discusses sources of drinking water, evaluates the susceptibility of groundwater resources to growth and development, and outlines potential protection planning strategies.

1.2 Scope and Methods

New York Rural Water Association has utilized a variety of published and unpublished data sources for this report and plan. All data were inputted into a Geographical Information System (GIS). This is a computer system that allows one to visualize, manipulate, analyze, and display geographic (spatial) data.

Well data was collected from a variety sources, including the United States Geological Survey's Water Data Site Inventory System, the New York State Department of Environmental Conservation's Water Well Program, and the New York State Department of Health's Source Water Assessment Program (SWAP). In all, data on 112 wells were documented. Details from these locations (depth of well, yield, etc.) are summarized on Plates 1 and 3 contained within this report and plan.

A number of published and unpublished geologic maps were reviewed. A digital version of the Columbia County Soil Survey and the New York State Geologic Map were utilized for analyses and mapping. In addition, elevation data for Copake were taken from digital elevation models (DEMs). This information was then used to derive slope data and hillshading images. Parcel boundaries and land use information were provided by Columbia County Real Property Tax Service and the New York State Office of Real Property Services respectively. Other digital data on wetlands, floodplains, surface waters, roads, regulated facilities, aerial photography, etc. were downloaded from the New York State GIS Clearinghouse and the Cornell University Geospatial Information Repository.

Finally, New York Rural Water Association conducted on-site activities in Copake to map surficial geology and unconsolidated aquifers, and to also document the location of public water supply wells, potential contaminant sources, etc. A global positioning system (GPS) device was used to capture the geospatial coordinates of such features.

2.0 SETTING

2.1 Physiography and Bedrock Geology

As illustrated on Figure 1, Copake spans three different physiographic regions. Each of these physiographic regions has distinctive topographic relief, landforms, and geology.

The Southern Taconic Mountains occupy the eastern portion of the Town of Copake. Here, elevations rise dramatically eastward from 900 feet above sea-level to heights of 2,100 feet above sea-level along the New York/Massachusetts border. Slopes in the Southern Taconics typically range from 20 to 45 percent. The Southern Taconic Mountains are the result of a collision of crustal plates that began to occur some 450 million years ago. As the two plates collided, the Southern Taconic Mountains were thrust upwards and older rocks were pushed large distances westward over the younger Walloomsac Formation and the Wappinger-Stockbridge carbonates. The rocks that were pushed up and thrusted include the Everest Schist (see Figure 2 and Plate 2) that today underlies most of the Southern Taconic Mountains. It is a highly metamorphosed rock that is greenish in color due to the distinctive minerals in it. Bedrock is at or near the surface across the Southern Taconics.

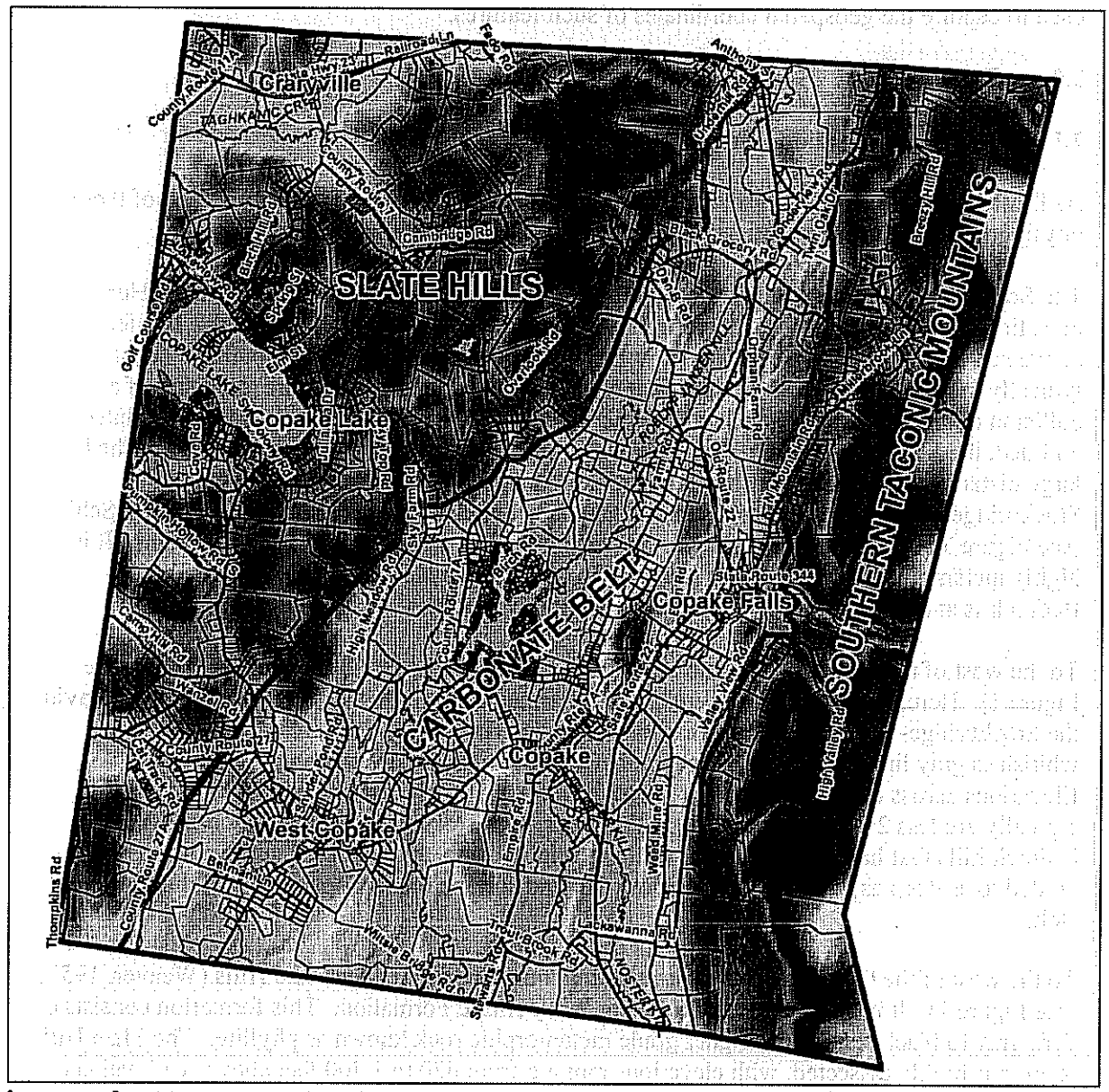
To the west of the Southern Taconic Mountains lies the Carbonate Belt (Weaver, 1957) (see Figure 1). Here, the rocks of the Walloomsac Formation have largely been eroded away, leaving the Stockbridge-Wappinger Group carbonates underlying most of the area. These rocks are whitish to gray limestone and dolostone, that often weathering to an orange-gray color. Elevations across the Carbonate Belt range from 500 to 900 feet above sea-level. Slopes typically are less 2 percent across the valley floor, with steeper slopes present on elongated bedrock hills that have been streamlined by glacial erosion. The bedrock surface has been eroded to as deep as 150 to 200 feet below the land surface in the Copake area of the Carbonate Belt.

To the west of the Carbonate Belt is an area that has been termed the Slate Hills (Weaver, 1957) (see Figure 1). It is an area underlain by the Walloomsac Formation. This formation consists of dark gray to black slate and a higher grade metamorphic rock known as phyllite. The Slate Hills Region is highly dissected, with elevations ranging from 620 to 1,400 feet above sea-level and variable slopes from less than 1 percent along the Taghkanic Creek valley to 20 to 45 percent along hill slopes. Bedrock is fairly shallow in the Slate Hills, with numerous exposures present.

Topography and Physiography

Town of Copake, New York

Steven Winkley, New York Rural Water Association



Legend

Physiographic Region Boundary

Elevation

Feet

High : 2607.6

Low : 459.856

Scale

0 0.375 0.75 1.5 2.25 3 Miles

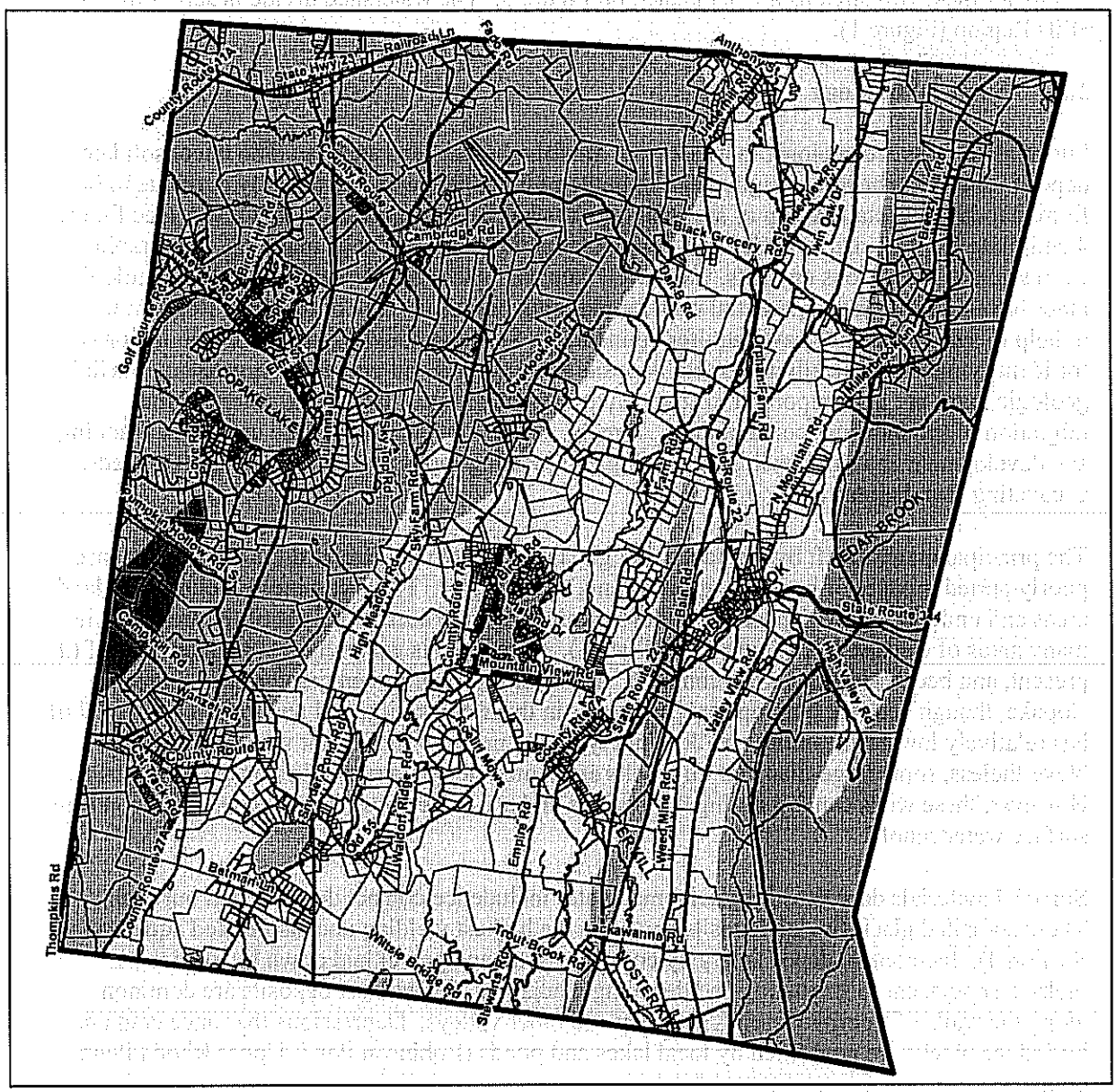
N

Figure 1

New York Rural Water Association
Address: P.O. Box 487, Clarmack, NY 12513
Phone: 518-828-3155
Web Site: http://www.nyruralwater.org

Bedrock Hydrogeology
Town of Copake, New York

Steven Winkley
2008



Legend

Bedrock Hydrostratigraphic Unit

- Austin Glen
- Everett
- Stockbridge-Wappinger Carbonates
- Walloomsac
- Fault

Scale

0 0.3 0.6 1.2 1.8 2.4 Miles

N

Note: Bedrock contacts and faults are from the New York State Geological Survey.

Figure 2

2.2 Drainage

The Town of Copake resides within the Hudson River Basin. In Copake, the major tributaries of the Hudson River are Taghkanic Creek and the Roeliff Jansen Kill (Figure 3). The drainage basins for these two streams are delineated on Figure 3. The watershed divide is across the Slate Hills Region (Figure 1).

2.3 Surficial Geology

Surficial deposits are geologic materials that are found at the land surface. The unconsolidated deposits above the bedrock originated within the past 15,000 years and actually continue to be formed today. A detailed map of surficial deposits has been completed by NYRWA (see Figure 4 and Plate 1). This map was derived from examination of digital soils mapping, topographic expression of the various deposits, water well data, and site reconnaissance. Surficial geologic maps have many different potential uses for planning purposes. One of the most frequent uses is to help identify sand and gravel aquifer boundaries. Surficial geologic maps are also important for identifying economically important deposits such as sand and gravel for aggregate. Surficial geologic maps are also important to study environmental issues such as the potential for migration of groundwater contaminants. Finally, surficial geology maps are useful for planning site development activities such as designing and locating septic systems, building new roads, excavating foundations, etc.

The principal material left by the advancing glacial ice sheet was glacial till, a relatively dense poorly-sorted mixture of boulders, gravel, sand, silt and clay. Till is commonly found in upland areas and underlies other deposits in valleys. Relatively thin accumulations of till are found in many areas of Copake (see Figure 4 and Plate 1). Here there is generally less than ten feet of till present, and bedrock outcrops are common. Till thicknesses are often greater than ten feet in Copake, though bedrock outcrops can still occur in these areas (Figure 4 and Plate 1). Glacial till has relatively low permeability and does not typically produce significant water well yields. Nevertheless, some large-diameter dug wells are sometimes constructed in thicker till deposits. However, these wells can fail during dry periods and are sometimes prone to contamination from surface water runoff.

Surficial materials deposited by glacial meltwater include ice-contact deposits and outwash. These so-called glaciofluvial deposits comprise the highest yielding unconsolidated aquifers (see Section 4). Ice-contact deposits largely consist of sand and gravel laid down by glacial meltwater adjacent to stagnating and decaying glacial ice. Ice-contact deposits are common along the walls of Roeliff Jansen Kill valley and other valleys. Depressions that once contained buried ice blocks are now filled by local lakes and ponds (Robinson Pond, Upper Rhoda Pond, etc.).

Outwash is generally well-sorted sand and gravel deposited on flat plains or deltas by glacial meltwater beyond the ice margin. The largest accumulation of outwash is found in the valley of the Roeliff Jansen Kill and Taghkanic Creek (see Figure 4 and Plate 1). A particularly large outwash delta exists to the south of Robinson Pond. This flat-topped feature appears to have been fed by meltwater originating to the north in the area of ice-contact deposits.

Drainage Basins

Town of Copake, New York

Steven Winkley, New York Rural Water Association

Legend

Drainage Basin

NAME

- Taghkanic Creek
- Roeliff Jansen Kill

Scale

0 0.375 0.75 1.5 2.25 3 Miles

N

Figure 3

New York Rural Water Association
Address: P.O. Box 487, Claverack, NY 12513
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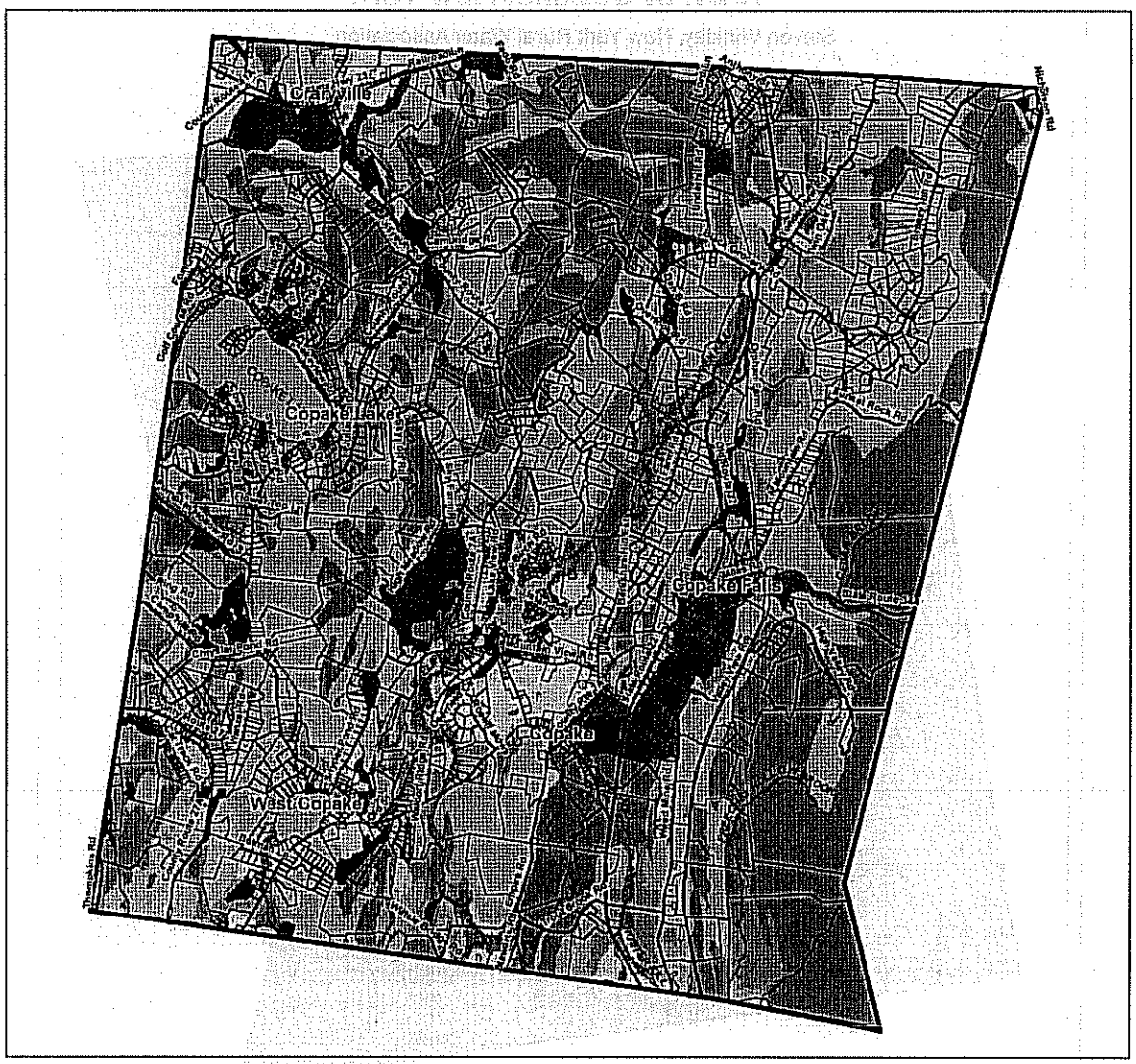
Surficial Geologic Materials
Town of Copake, New York

Steven Winkley
2008



Legend

Surficial Geologic Materials

- Water
- Wetland deposits
- Alluvium
- Alluvial fan deposits
- Outwash deposits
- Ice contact deposits
- Till
- Bedrock

Scale

0 0.5 1 2 3 4 Miles

N

Figure 4

Alluvial fans consist of post-glacial stratified silt, sand, and boulders that accumulate in fan shaped landforms at the bottoms of steep slopes and at mouths of valleys. Several alluvial fans occur at the base of the Southern Taconic Mountains (Plate 1 and Figure 4). These fans coalesced into a blanket-like deposit in the valley of Bash Bish Brook between Copake Falls and Copake. A related deposit is alluvium. It is sand, gravel, and silt recently deposited on flood plains and stream beds. Both alluvial fan deposits and alluvium can grade vertically and laterally into glaciofluvial deposits. Finally, peat, silt, clay and/or sand accumulate in depressions and other poorly drained areas.

3.0 GROUNDWATER UTILIZATION

3.1 Public Water Supply Wells

There are several public water systems in Copake. All rely upon groundwater wells for their source of supply. A public water system is an entity that provides water to the public for human consumption through pipes or other constructed conveyances. Any system having at least 5 service connections or that regularly serves an average of at least 25 people daily for at least 60 days out of the year is considered a public water system. Public water systems are classified as one of three types: community, non-transient non-community, or transient non-community. A community water system is a public water system that serves the same people year-round. It has the most regulatory requirements of the three system types, including the need for a certified operator and more extensive monitoring. A non-transient non-community water system water system does not serve year-round residents, but does regularly serve at least 25 of the same people more than six months per year. It now requires a certified operator, but has less monitoring and reporting requirements than a community system.

Wells for community and non-transient non-community public water systems in Copake are listed below in Table 1. These wells are plotted on Figure 5. A 1,500-foot radius protection area has been mapped around each of these sources on Figure 5 except as noted below.

Name	Population Served	Well ID	Depth (feet)	Yield (gpm)	Diameter (inches)
Camphill Village USA Inc.	235		12		
Hamlet Apartments	25	Well 2			
Hamlet Apartments	25	Well 1	200		
Taconic Hills Central School District	2,500	Well 2	60	110	8
Taconic Hills Central School District	2,500	Well 1	47	72	8
Taconic Mobile Home Park LLC	40	Driven Point #1			
Taconic Shores Property Owners Association	1,191	Well 1	80	80	10
Taconic Shores Property Owners Association	1,191	Well 1A	120	140	

Table 1. Community and Non-Transient, Non-Community Public Water System Wells.

The Taconic Shores Property Owners Association is the largest community water system in Town. The primary sources of water for Taconic Shores are two drilled wells, 80 and 120 feet respectively. These high-yielding wells presumably produce water from outwash sand and gravel deposits south and east of Robinson Pond. A 1,750-foot radius protection area has been mapped for the more productive of the two wells. This protection area is based upon the calculated fixed radius equation rather than an arbitrary fixed radius.

New York Rural Water Association
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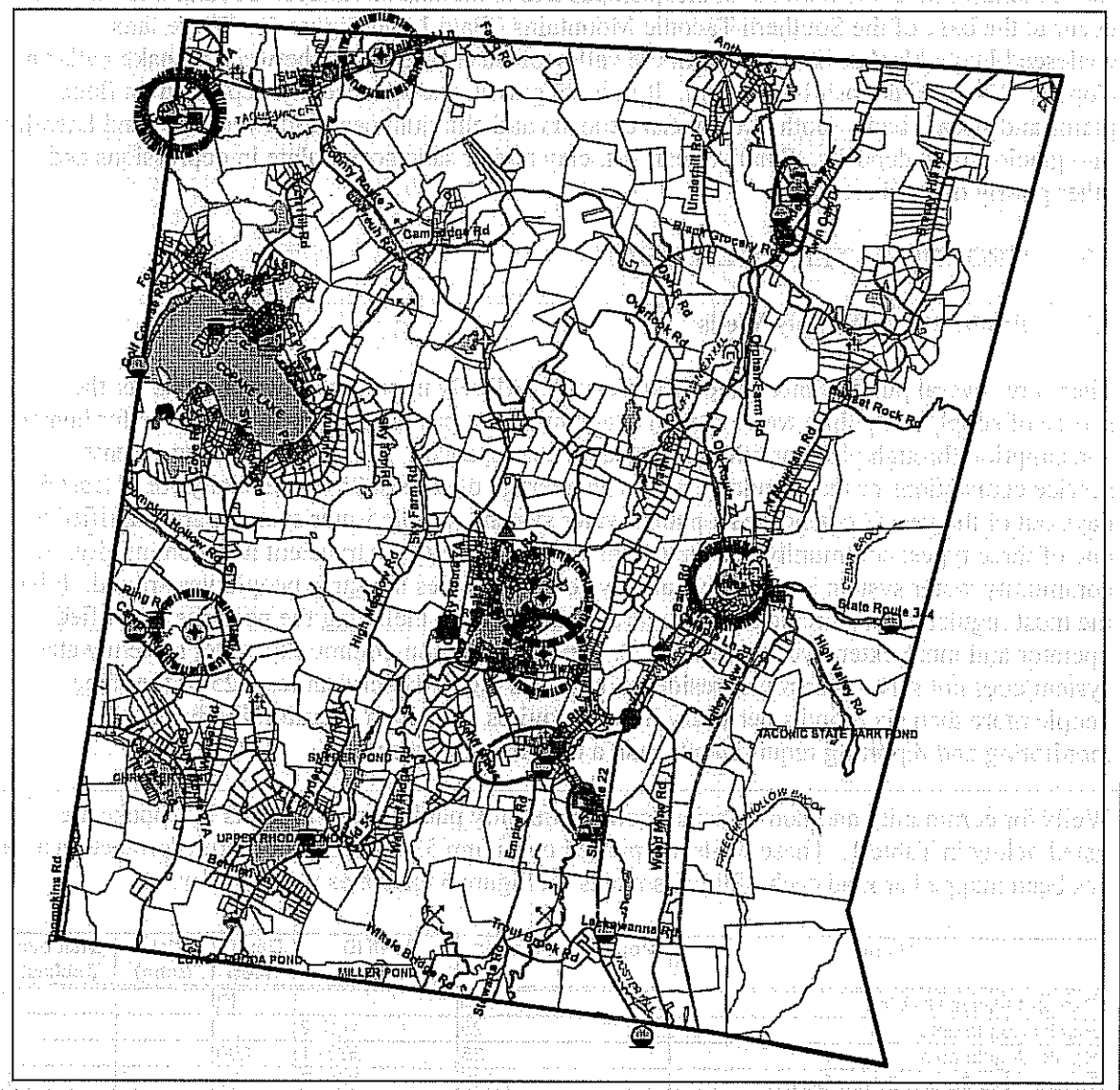
Web Site: http://www.nyruralwater.org

Public Supply Wells and Potential Sources of Contamination

Town of Copake, New York

Steven Winkley



Legend

Higher Risk Land Use Descriptio

- Auto Body, Tire Shops, Other Related Auto Sales
- Auto Dealers - Sales and Service
- Cemeteries
- Highway Garage
- Landfills and Dumps
- Manufacturing and Processing
- Marinas
- Minimart
- Motor Vehicle Services
- Service and Gas Stations
- Solid Wastes Incinerators and waste compacting facilities.

Open Spill Case

Higher Risk Area

EPA Regulated Facility

- Concentrated Animal Feeding Operation
- RCRA Waste Facility
- Regulated Wastewater Facility

NYSDEC Permitted Septic System (>= 1,000 GPD)

Regulated Petroleum Bulk Storage Facility

NYSDEC Permitted Gravel Pit

Community or NTNC PWS Well

Public Well Protective Buffer

Public supply wells mapped are community and non-transient, non-community systems.

Scale

0 0.375 0.75 1.5 2.25 3 Miles

N

Figure 5

The campus of Taconic Hills Central School District relies upon two high-yielding wells completed in sand and gravel deposits along the Taghkanic Creek Valley west of Craryville.

A third type of public water system exists that are not mapped on Figure 5, transient, non-community water systems. A transient non-community water system does not regularly serve at least 25 of the same people over six months per year. It does not require a certified operator and monitoring is largely limited to bacteria, nitrate, and nitrite. There are at least 18 businesses that have wells and were regulated as a transient non-community water system in the Town of Copake (see Table 2 below).

SYSTEM NAME	POPULATION SERVED
TACONIC STATE PARK	600
BERKSHIRE HILLS EMANUEL ADULT CAMP	160
TACONIC WAYSIDE INN	50
CAMP WAUBEEKA	1000
OLEANA FAMILY CAMPGROUND	325
ST. BRIDGETS OFA	25
BERTS INN	26
DANCERS MARINE	48
JOHANNAS MOTEL AND RESTAURANT	46
THE GREENS RESTAURANT AT COPAKE CC	50
CAMP PONTIAC	500
UNDERMOUNTAIN GOLF	25
COPAKE LAKE BOAT AND SKI,LLC	25
CHURCH STREET DELI	75
DEPOT DELI	25
COPAKE SUNOCO	25
COPAKE DINER	57
XTRA MART #1479	30

Table 2. Transient, Non-Community Public Water Systems.

Based upon a search of the United States Environmental Protection Agency's Safe Drinking Water Information System (SDWIS), no public water system in Copake has had a health-based violation. The 2004 Source Water Assessments conducted by the NYSDOH did indicate levels of nitrate above 5 mg/l for St. Bridget's and the Church Street Deli. Although below the drinking water Maximum Contaminant Level (MCL) of 10 mg/l, these levels are above the action level of 5 mg/l that often leads to more extensive monitoring.

3.2 Individual Homeowners

Outside of community water systems, landowners in Copake receive their drinking water from individual wells. The majority of these homeowner wells have drilled wells completed in the bedrock. Figure 6 is a map of where water wells have been drilled since 2000. Drilling activity peaked in 2005. Wells have been drilled all across Town, but the heaviest concentration of recent drilling seems to be in the vicinity of Copake Lake and Copake hamlet.

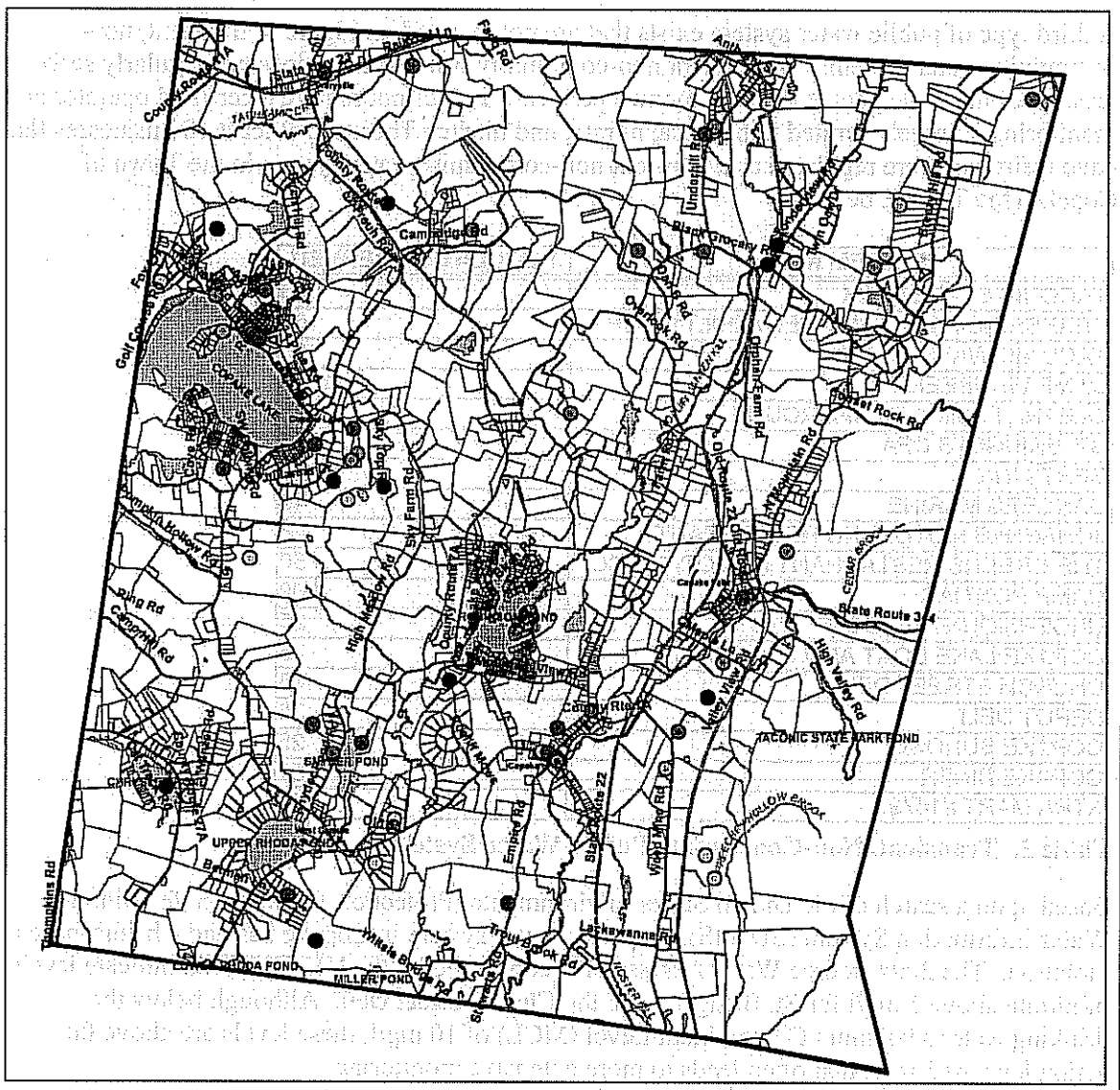
Based upon data collected by NYRWA, the median yield of residential water wells in Copake is 10 gallons per minute (gpm) (see Figure 7). Twenty-two percent of wells yield less than the 5 gpm required by the Federal Housing Administration for insured loans for new construction.

New York Rural Water Association
Address: P.O. Box 487, Claverack, NY 12513
Phone: 518-828-3155
Web Site: http://www.nyruralwater.org

Well Drilling Activity 2000-2008

Town of Copake, New York

Steven Winkley



Legend

Water Well (from NYSDEC)

Year

- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008 (through May only)

Scale

0 0.375 0.75 1.5 2.25 3 Miles

N

Figure 6

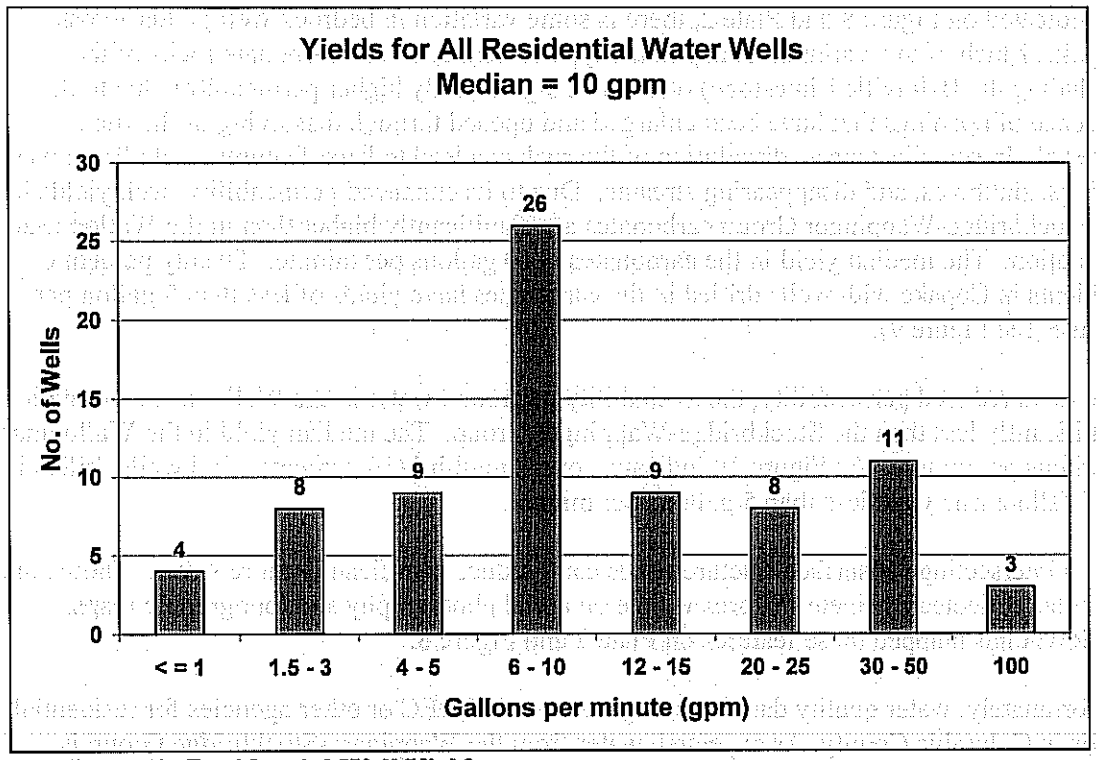


Figure 7. Residential Well Yields.

4.0 GROUNDWATER OCCURRENCE

Ground water is subsurface water that fills (saturates) all the voids in the rock or soil. Ground water is found between in the pore spaces between individual grains that range in size from clay to gravel. This is referred to as primary porosity. Ground water also occurs in cracks (fractures) found in rock. This is known as secondary porosity. Most of the water in bedrock is found in fractures.

4.1 Bedrock

Bedrock in the Town of Copake is the source of ground water for the majority of residents and businesses (particularly for those situated outside of the Roeliff Jansen Kill Valley). In bedrock, steel casing is set through the overburden (unconsolidated deposits) and into the first few feet of sound rock. The remainder of the well is left as an open borehole in the rock. Although the median depth of bedrock wells in Copake is 285 feet, well depths range from 61 to 867 feet. The median depth of casing is 30 feet. Casing depths range up to 174 feet. Note that water well drilling regulations promulgated by the NYSDOH now specify a minimum of 19 feet of casing below grade.

The median yield of bedrock wells in Copake is 8 gallons per minute (gpm) and 28 percent of wells yield less than the 5 gpm required by FHA for new home loans. Eight percent of drilled wells in Copake yield 1 gpm or less. NYSDOH does not recommend the use of wells with yields of 1 gallon per minute or less for any homes with four or more bedrooms.

As indicated on Figure 8 and Plate 2, there is some variation in bedrock well yields across Copake. Much of this variation is due to the type of bedrock. The carbonate rocks of the (including the Balmville Limestone) often have significantly higher permeability due to the presence of openings that have been enlarged and opened through dissolving of the rock material. In some instances, dissolution of the rock can lead to karst features, including caves, springs, sinkholes, and disappearing streams. Due to its enhanced permeability, well yields in the Stockbridge-Wappinger Group carbonates are significantly higher than in the Walloomsac Formation. The median yield in the carbonates is 10 gallons per minute. Twenty percent of residents in Copake with wells drilled in the carbonates have yields of less than 5 gallon per minute (see Figure 9).

Due to its reduced permeability, the availability of ground water in the Walloomsac Formation is significantly less than the Stockbridge-Wappinger Group. The median yield in the Walloomac is 6 gallons per minute. As Figure 10 indicates, over one-third (36 percent) of all wells drilled in the Walloomsac yield less than 5 gallons per minute.

Wells intersecting subsurface fracture zones can produce significantly more water. These zones are often reflected by linear features visible on aerial photography and topographic maps. NYRWA has mapped these features on Plate 2 and Figure 8.

Unfortunately, water quality data is not reported to NYSDEC or other agencies for residential wells in Columbia County. As expected, water from the Wappinger-Stockbridge Group is characteristically hard. Sixty-eight percent of residents in nearby Ancram that were surveyed and utilized the carbonates for their water supply source report hard water. Arnow (1951) had reported that well water from the shaly rock in Columbia County (including the Walloomsac) is relatively soft. However, a majority of residents in Ancram reported hard water from the Walloomsac Formation. This could be due to the presence of sulfate minerals in the water. Accordingly, a higher percentage of residents in Ancram also reported odor problems with water from the Walloomsac Formation.

4.2 Unconsolidated Aquifers

Comparatively fewer wells in Copake have been completed in unconsolidated (sand and gravel) aquifers. Unconsolidated aquifers are largely restricted to valleys in Copake and many household well drillers are not as experienced in completing sand and gravel wells. Wells that are completed in the unconsolidated deposits for private, residential use are typically left as open ended casing. The casing is terminated in the water-bearing material. Such construction is sufficient for many purposes. The median yield for these types of wells in Copake is 4 gpm.

However, unconsolidated deposits are capable of producing very high yields if wells are finished with a properly sized and developed screen. A well screen is a filtering device that permits water to enter the well but prevents the unconsolidated material (sand, etc.) from entering the well. Screening is placed in the well and the casing is generally pulled back to expose the screen to the unconsolidated material. Screens are typically made of stainless steel and have openings referred to as slots. Public water supply wells in sand and gravel are typically fitted with screens. The median yield of such wells in Copake is 76 gpm.

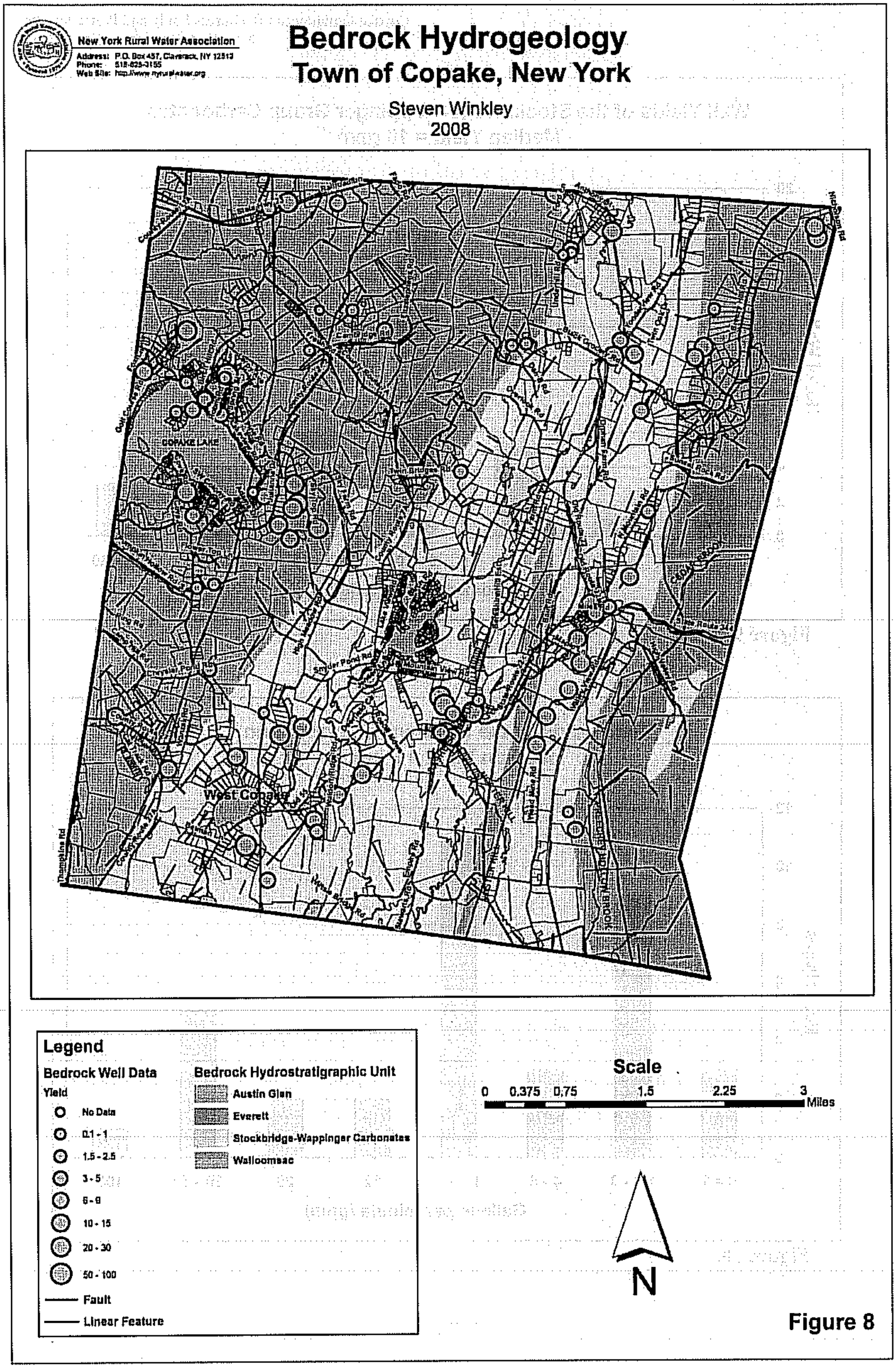

New York Rural Water Association
Bedrock Hydrogeology
Town of Copake, New York
Steven Winkley
2008
COPAKE LAKE
West Copake
Legend
Bedrock Well Data
Yield
No Data
0.1 - 1
1.5 - 2.5
3 - 5
6 - 9
10 - 15
20 - 30
50 - 100
Fault
Linear Feature
Bedrock Hydrostratigraphic Unit
Austin Glen
Everett
Stockbridge-Wappinger Carbonates
Walloomsac
Scale
0 0.375 0.75 1.5 2.25 3
Miles
N

Figure 8

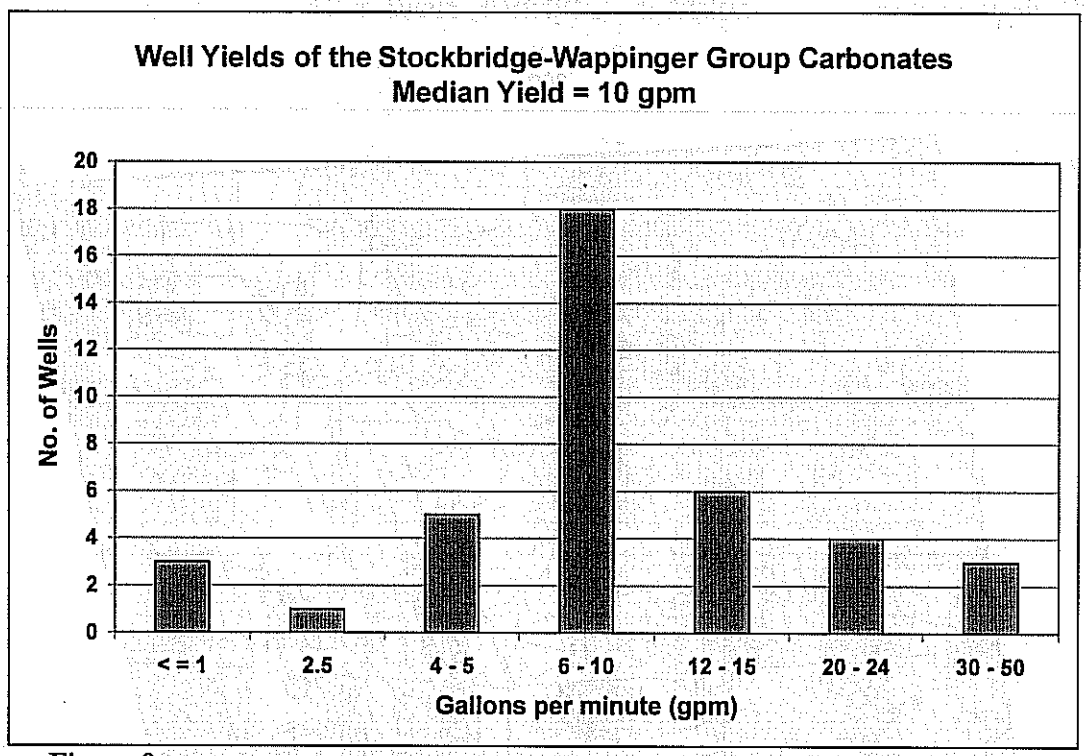


Figure 9.

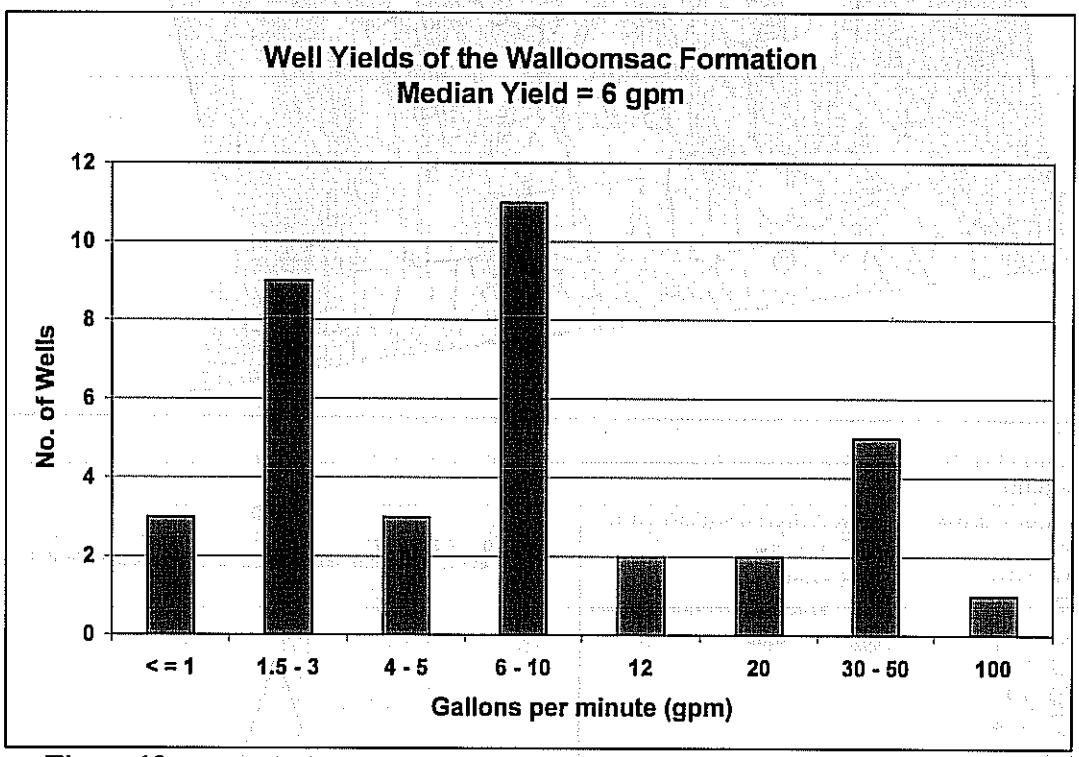


Figure 10.

Another type of sand and gravel well is the driven point. These consist of small diameter (1-¼ inch diameter) pipe equipped with a pointed screen known as a point. The pipe and point are driven into sandy deposits to a typical depth of 10-30 feet. They are fairly common in some areas of Copake, such as in the vicinity of the hamlet of Copake. Driven points can be installed with relatively simple equipment. However, since they meet the definition of water well, driven points should be installed by a contractor that is registered with the New York State Department of Environmental Conservation as a water well contractor.

The distribution of water-bearing unconsolidated deposits is generally limited to areas along or near the valleys in Copake. On Figure 11 and Plate 3, NYRWA has mapped the distribution of unconsolidated aquifers in the Town of Copake. The boundaries of these aquifers were delineated by NYRWA on the basis of surficial geologic boundaries (see Plate 1) and available subsurface data. Unconsolidated aquifers exist within the Roeliff Jansen Kill Valley and some of its tributaries, as well as the valley of Taghkanic Creek in the Craryville area.

Areas of deeper sand and gravel deposits of sufficient distance from both surface water and potential sources of contamination have the highest potential for municipal well development. These areas are indicated on Figure 11 and Plate 3 by a blue horizontal overprint. Areas of thinner sand and gravel deposits are denoted by a red diagonal overprint. Here, the thickness of sand and gravel is generally insufficient for high yield wells, but may yield enough water to shallow domestic wells or recharge underlying fractured bedrock.

In terms of quality, water from unconsolidated aquifers is very hard. Over eighty percent of Ancram residents with unconsolidated aquifer wells reported hard water. However, the water from unconsolidated aquifers has less reported problems with odor, staining, and sediment. Shallow sand and gravel wells are more prone to contamination from activities at the land surface. Such wells are also more susceptible to surface water contamination.

5.0 INVENTORY OF POTENTIAL CONTAMINANT SOURCES

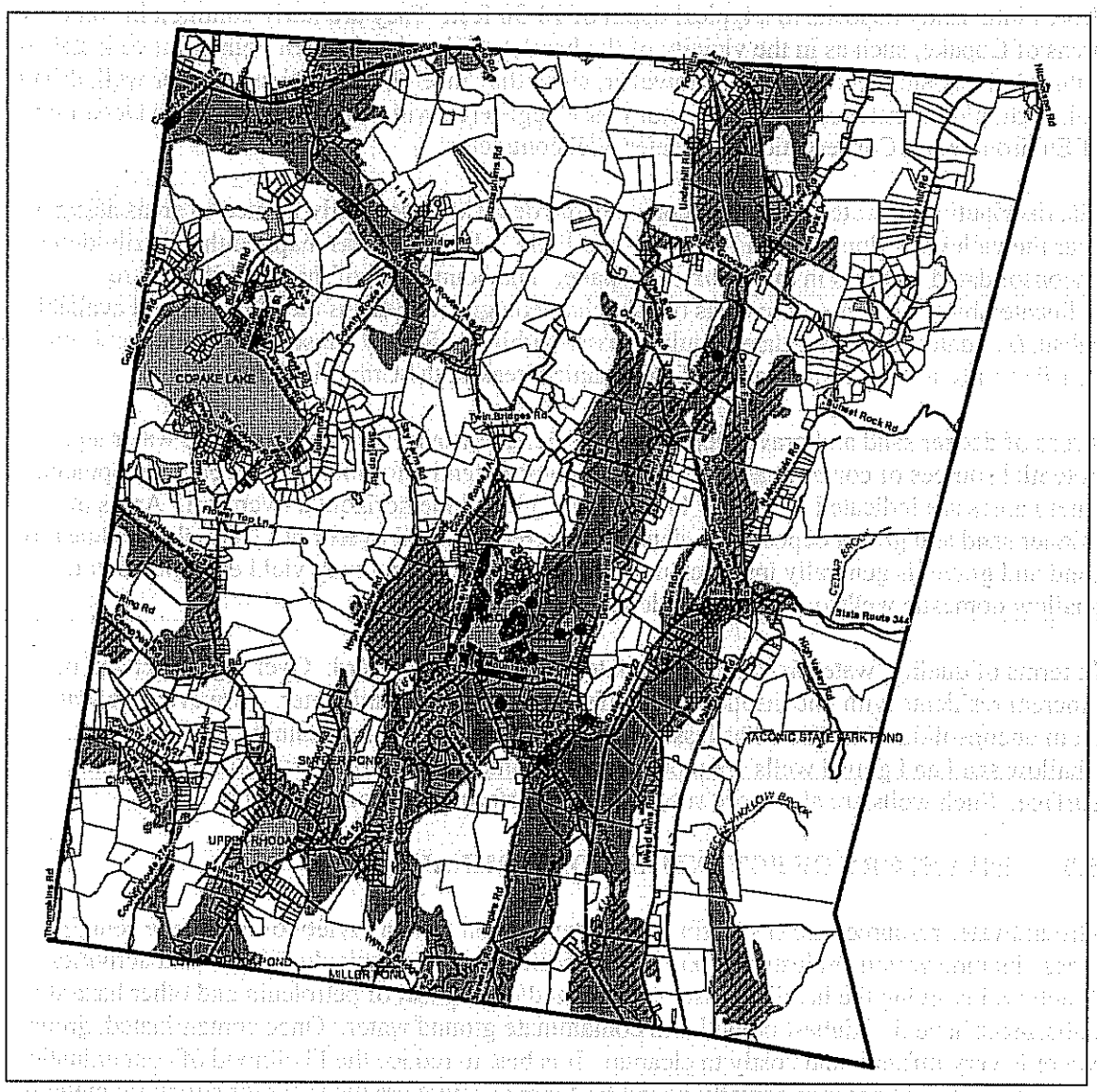
Groundwater resources are susceptible to contamination from a variety of manmade sources. These include various industrial, commercial, residential, and agricultural uses and activities. Practices involving the handling, use, storage, and/or disposal of petroleum and other hazardous substances have the highest potential to contaminate ground water. Once contaminated, ground water is very difficult and costly to cleanup. It is best to reduce the likelihood of contamination through the use of environmentally-sound best management practices and/or structural methods.

Several potential sources of contamination are regulated by government agencies such as the NYSDEC. Some others are not. NYRWA has conducted an inventory of potential sources of contamination and Figure 5 is the result of this effort. Inclusion on this map does not mean that a particular use has resulted in groundwater contamination. It simply means that it has the potential to do so. As part of the inventory NYRWA used databases available from the NYSDEC and USEPA on regulated activities such as: wastewater dischargers (SPDES facilities); waste generators, transporters, and storers (RCRA); hazardous waste sites (Superfund); petroleum bulk storage facilities; active spills; and mines/quarries.

New York Rural Water Association
Address: P.O. Box 487, Cleverdale, NY 12513
Phone: 518-828-3155
Web Site: http://www.nyruralwater.org

Unconsolidated Aquifers
Town of Copake, New York

Steven Winkley
2008



Scale

0 0.5 1 2 3 4 Miles

Legend

Wells within unconsolidated aquifer area

- Bedrock
- Unconsolidated
- Unconsolidated Aquifer Area
- Area With Enhanced Potential for High-Yield Supply Well(s)
- Thin sand & gravel (< 20 ft.)

N

Figure 11

NYRWA also used property classification codes from the New York State Office of Real Property Services to identify largely non-regulated uses that could be considered as potential contamination sources. These higher risk land uses such as gas stations, motor vehicle services, manufacturing, etc. are plotted on Figure 5 according to the property classification.

It is evident on Figure 5 that the number of potential sources of contamination coincides with the Rt. 22 corridor through the Town of Copake. Fortunately, most of the potential contaminant sources are not located in the vicinity of public supply wells. However, there are some areas with a concentration of higher-risk land uses in the areas of private well use. These are labeled as "higher risk areas" on Figure 5 and include two areas in the vicinity of Copake hamlet and an area along Rt. 22 between Copake and Hillsdale.

6.0 HYDROGEOLOGIC ANALYSES

In addition to inventorying groundwater resources, it is also very important to conduct analyses to determine the potential impacts of future development. With the aid of GIS, NYRWA utilized detailed groundwater resource mapping and digital elevation data to determine: (1) what areas of Copake have hydrogeologic settings that are sensitive to future development; (2) what intensity of development is appropriate to preserve groundwater quality; and (3) what concentration of development can be sustained without seriously impacting related surface waters.

6.1 Hydrogeologic Sensitivity

The *hydrogeologic sensitivity* of a location is a relative measure of the ease and speed with which a contaminant could migrate into and within the upper-most water-bearing unit. High to very high hydrogeologic sensitivity ratings indicate that, in general, ground water could be readily impacted by surface activities. Development activities that could contaminant ground water include nitrates and bacteria from septic systems, nutrients from fertilization and irrigation of lawns, salts from deicing, and volatile organics and other contaminants from leaks and improper disposal of petroleum and other fluids. If possible, higher-risk land uses should be steered away from areas of high to very high hydrogeologic sensitivity.

The hydrogeologic sensitivity is a function of the naturally occurring hydrogeologic characteristics of an area. The nature and extent of potential sources of groundwater contamination are not factored into hydrogeologic sensitivity ratings. Instead, the two factors controlling the hydrogeologic sensitivity are the site's geologic materials (the hydraulic characteristics of the uppermost water-bearing unit and the overlying soils) and the site's topographic position (the topographic factors influencing the vertical migration of ground water). Resultant hydrogeologic sensitivity ratings based upon geologic materials and topographic position ratings are mapped on Figure 12. NYRWA has detailed the methodology used to calculate hydrogeologic sensitivity ratings in Appendix A.

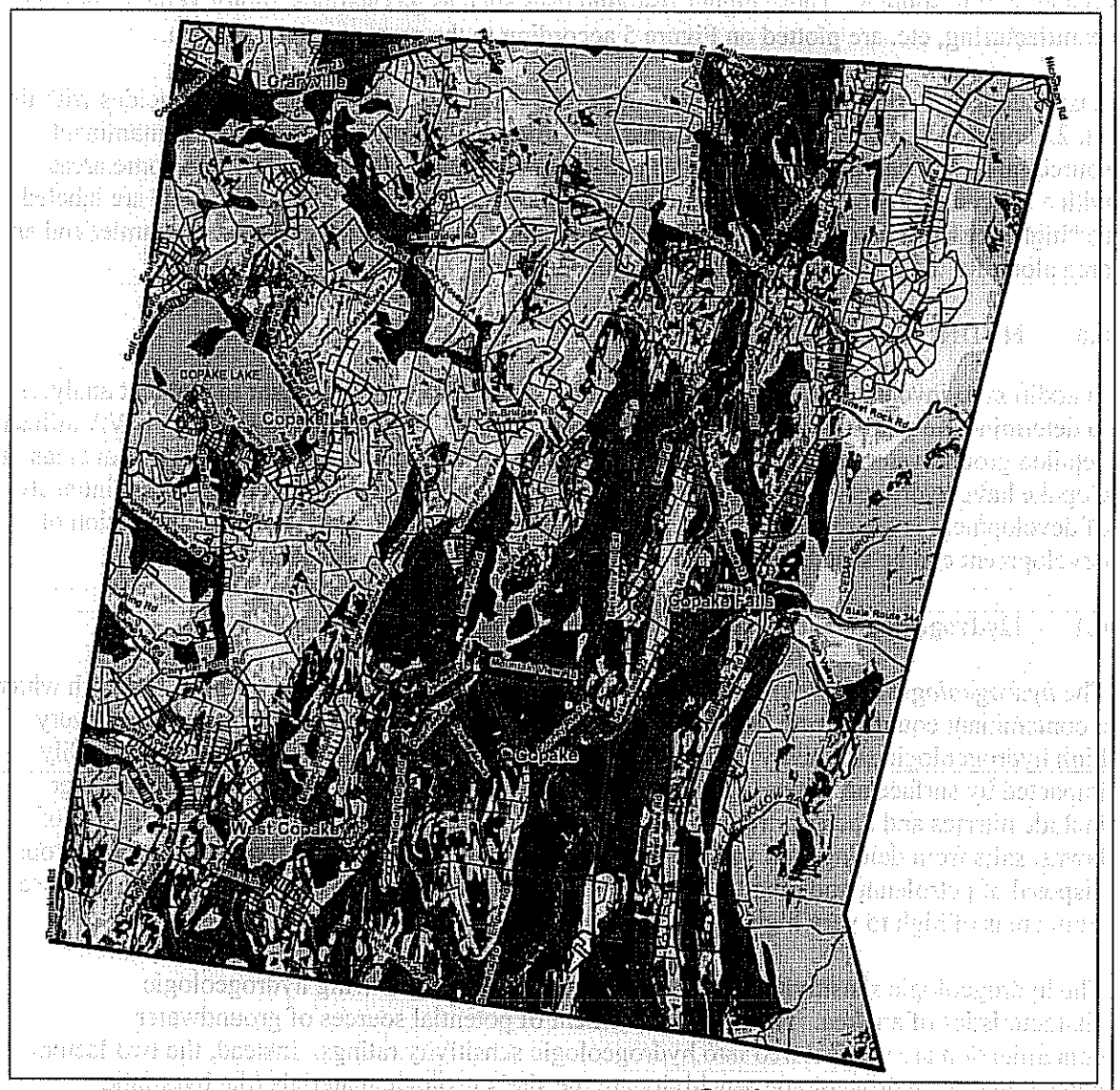
High to very high sensitivity is found chiefly in areas with coarse-grained soils with underlying unconsolidated or limestone/dolostone aquifers. Much of the Roeliff Jansen Valley area has high to very high hydrogeologic sensitivity. The exception is the streamlined, lower hills across the valley. These are covered by steep, less permeable till soils. Much of the Slate Hills and

New York Rural Water Association
Address: P.O. Box 487, Claverack, NY 12513
Phone: 518 828 3155
Web Site: http://www.nyruralwater.org

Hydrogeologic Sensitivity

Town of Copake, New York

Steven Winkley
2008



Legend

Hydrogeologic Sensitivity

- Very High
- High
- Medium-High
- Medium
- Low

Scale

0 0.375 0.75 1.5 2.25 3 Miles

N

Figure 12

Southern Taconic Mountains regions have lower hydrogeologic sensitivity due to the lower permeability of the bedrock, the poor infiltration rates of the till soils, and the steeper slopes.

6.2 Recommended Housing Densities to Minimize Nitrate Loading (Dilute Wastewater)

Much of the recent development in Copake is in the form of residential development with individual septic systems and private wells. Excessive nitrate loading of ground water can occur if there is too high a density of septic systems in a given area. To avoid excessive nitrate loading, the spacing of homes must be large enough for natural groundwater recharge to adequately dilute the effluent from septic systems to acceptable levels. NYRWA has calculated the maximum density of residential development across Copake that would not cause levels of nitrate to exceed a level of 5 mg/l. This density is referred to in this report as the recommended housing density to minimize nitrate loading. The methodology to calculate this density is detailed in Appendix B.

The chief variable in determining the recommended housing density to avoid nitrate loading is the annual groundwater recharge rate. NYRWA has calculated the estimated annual groundwater recharge rate across Copake based upon the methodology outlined in Appendix C. This approach calculates realistic recharge values based on base flow estimates, surficial geology, and means annual runoff rates in the region. Base flow is the component of stream flow that can be attributed to groundwater discharge into streams. The commonly-held assumption is that water that discharges to a stream as base flow originated as local shallow groundwater recharge. Calculated recharge rates range from as much as 18.75 inches for higher elevation coarse-textured sediments to as little as 2 inches per year in poorly-drained areas.

Based upon the calculated recharge rates, NYRWA calculated the recommended housing densities across Copake in order to avoid excessive nitrate loading. These densities are presented on Figure 13.

How do the recommended densities compare to the actual density of housing present today? Using the centroid of each existing residential lot, NYRWA calculated the existing density of residential development across Copake. It was then possible to compare the two densities. Figure 14 is the result. It shows where the existing housing density exceeds the recommended density for septic systems. For most of the Town, it appears that the density of residential development has not surpassed levels that could result in excess nitrate loading. However, the density of existing development has exceeded the recommended maximum density for septic systems around both Copake Lake and Robinson Pond. Some excess septic system development has also appeared to have occurred in parts of the hamlets of Craryville, West Copake, and Copake Falls.

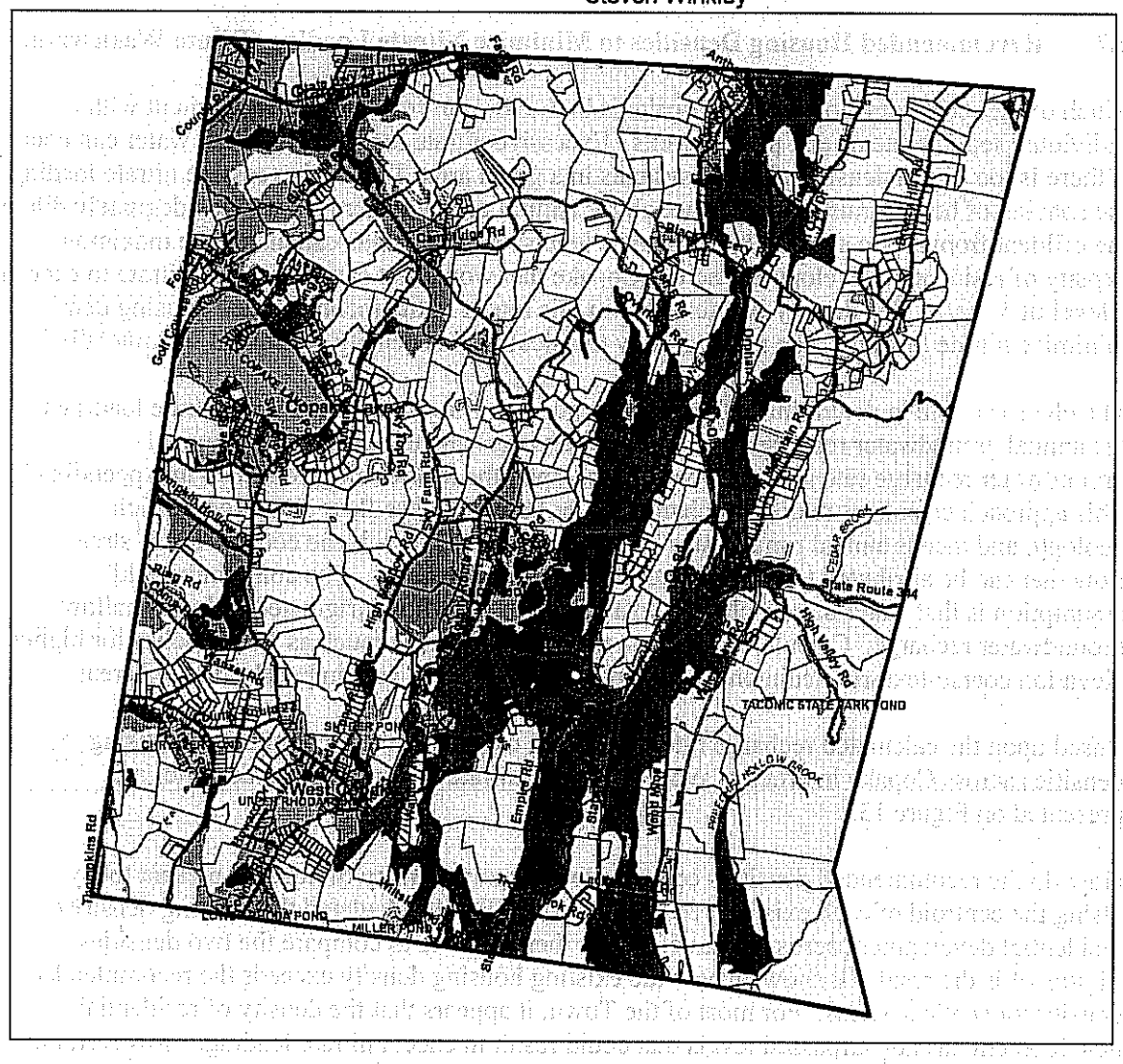
Second, how do the recommended densities compare to the maximum density of housing that is allowed by zoning? Using the minimum lot size permitted by zoning, NYRWA prepared Figure 15. If land were to be developed to the maximum extent permitted by zoning, it is apparent that the hamlets of Copake, West Copake, Copake Falls, and Craryville as well as some other areas would face excessive nitrate loading from septic systems.

New York Rural Water Association
Address: P.O. Box 487, Claverack, NY 12513
Phone: 518-828-3153
Web Site: http://www.nyruralwater.org

Recommended Housing Densities Based Upon Dillution of Septic Effluent

Town of Copake, New York

Steven Winkley



Legend

Scale

0 0.5 1 2 3 4 Miles

Recommended Housing Density

Homes/acre

- < 0.1
- 0.1 - 0.25
- 0.25 - 0.33
- 0.33 - 0.5
- 0.5 - 0.67

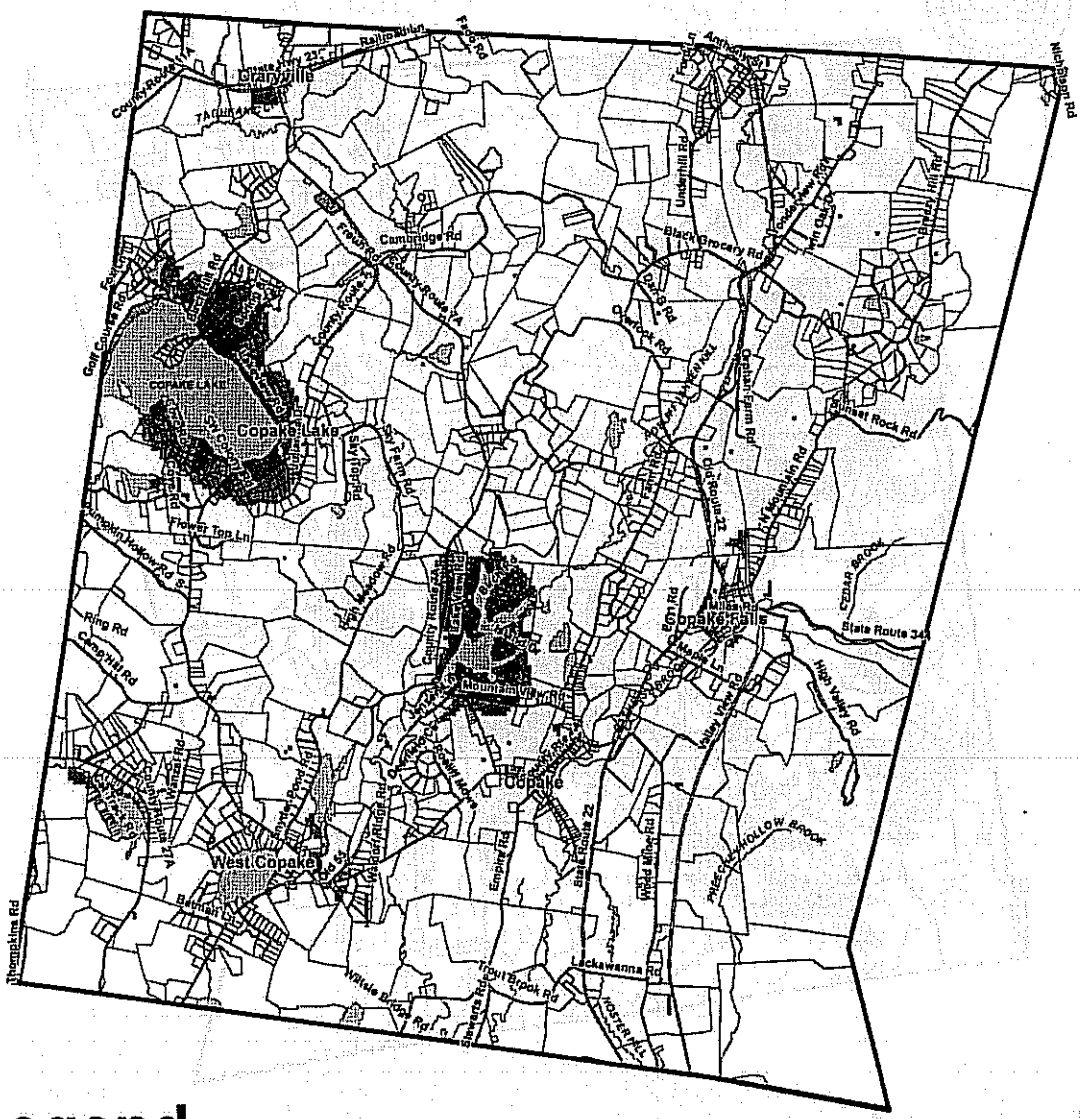
N

Figure 13

Actual Housing Density vs. Calculated Housing Density to Minimize Nitrate Loading

Town of Copake, New York

Steven Winkley, New York Rural Water Association



Legend

Actual Density > Density to Minimize Nitrate Loading

N

New York Rural Water Association • Founded 1979 •

Scale

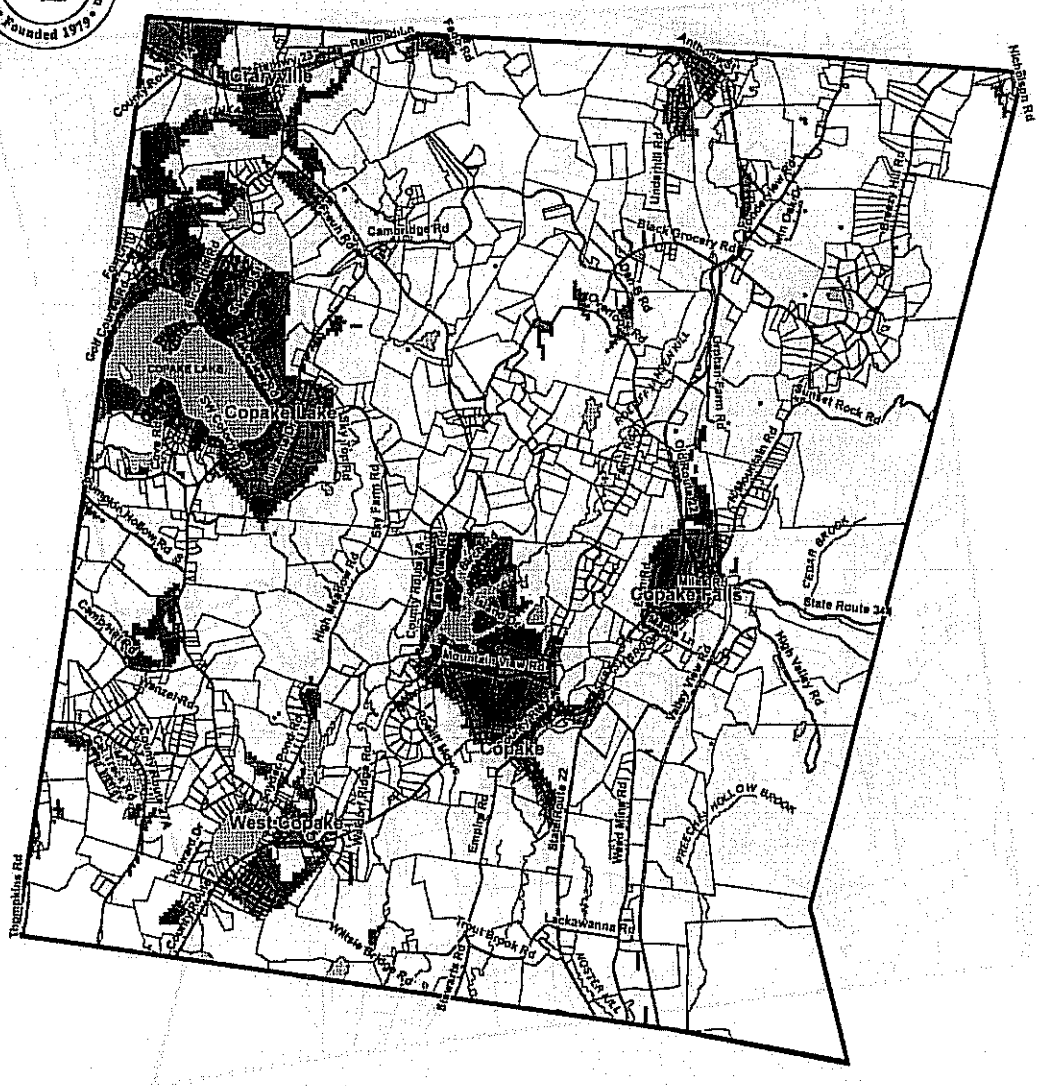
0 0.75 1.5 2.25 3 Miles

Figure 14

Housing Density Allowed By Zoning vs. Recommended Housing Density to Mininize Nitrate Loading

Town of Copake, New York

Steven Winkley, New York Rural Water Association



Legend

Zoning Density > Density to Minimize Nitrate Loading

N

Scale

0 0.75 1.5 2.25 3 Miles

Figure 15

6.3 Recommended Housing Densities to Conserve Drought Baseflow

Excess withdrawal of ground water can lead to unacceptable consequences. These consequences could be a reduction of ground water held in storage and/or a decrease of natural groundwater discharge to streams and other surface water bodies. This discharge to streams, known as baseflow, sustains streamflow in the absence of precipitation.

With time, the percentage of water that is delivered to the well is increasingly from surface water. The most critical time to study the impact of pumping upon surface water is during drought. During prolonged dry periods, surface water flow is drastically reduced and the reduction in baseflow would be most noticeable. During drought, it is critical that sufficient streamflow is maintained for ecological resources and to dilute possible wastewater discharges.

In Copake, NYRWA has used the conservation of drought baseflow as a standard to measure the sustainable yields of cumulative residential well pumping. In Appendix D, NYRWA details a methodology used to calculate a sustainable housing density (SHD). The SHD is the equivalent number of residential households that can be developed per acre without the loss of more than 50 percent of the 7Q10 flow for the principal stream in the area. The 7Q10 flow is statistically the lowest 7-day average flow that occurs (on average) once every 10 years. Calculated sustainable housing densities across Copake are depicted on Figure 16.

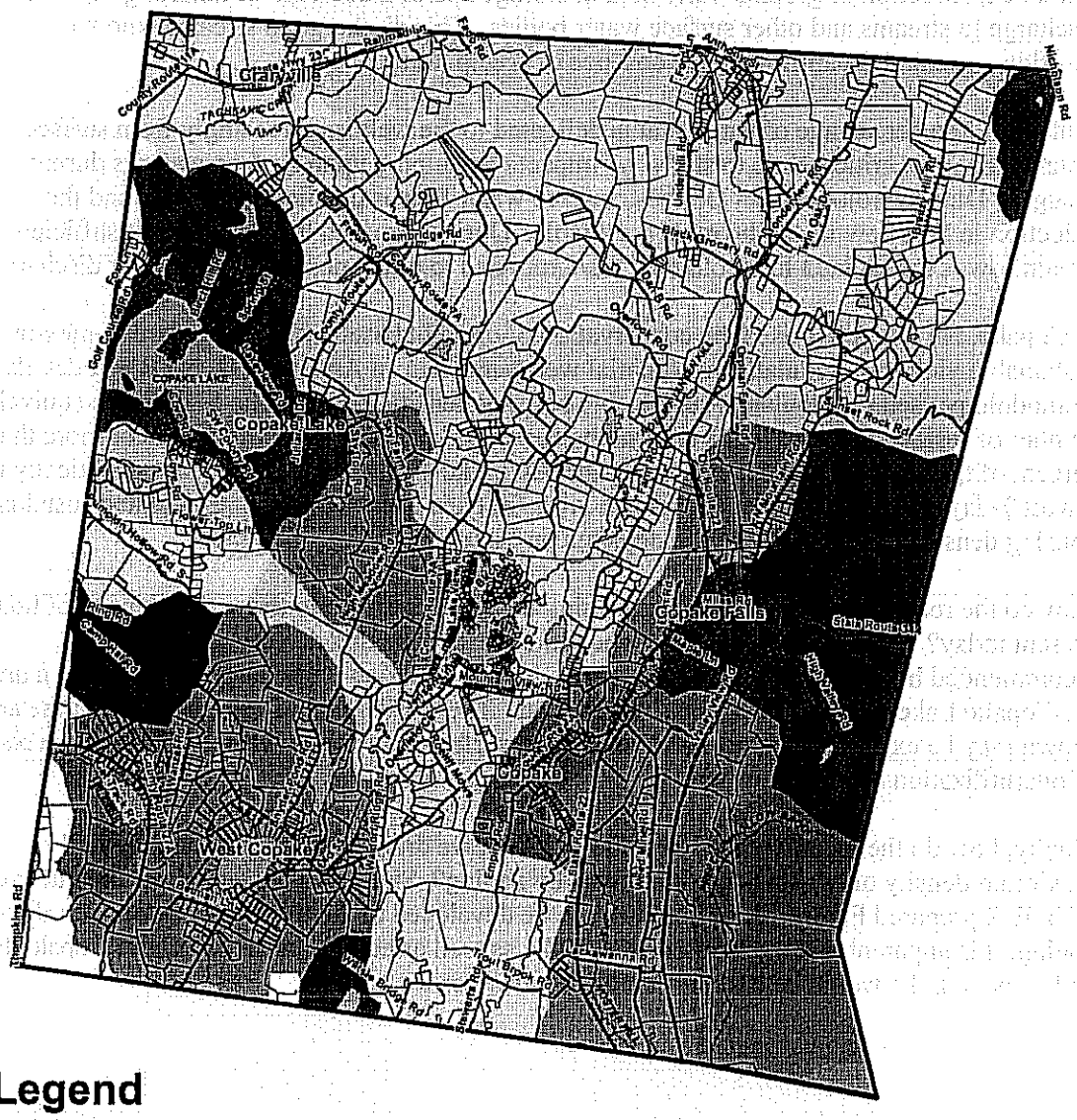
How do the recommended sustainable housing densities compare to the actual density of housing present today? Figure 17 shows areas where the present housing density exceeds the recommended housing density for conserving drought baseflow. The largest areas shown are in the Copake Lake area and the Copake Falls areas. The implication of Figure 17 is that the areas shown may be experiencing localized declines in surface water and well water levels as a result of overutilization of ground water.

Finally, how do the recommended densities to conserve drought baseflow compare to the maximum density of housing that is allowed by zoning? Similar to the technique used above, NYRWA prepared Figure 18. If land were to be developed to the maximum extent permitted by zoning, it is apparent that the hamlets of Copake as well as additional areas around Copake Falls and Copake Lake would be over utilizing ground water.

Calculated Sustainable Housing Densities Based Upon Conservation of Drought Baseflow

Town of Copake, New York

Steven Winkley, New York Rural Water Association



Legend

Sustainable Housing Density

Households per Acre

- < 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5 - 2.9

Scale

0 0.75 1.5 2.25 3 Miles

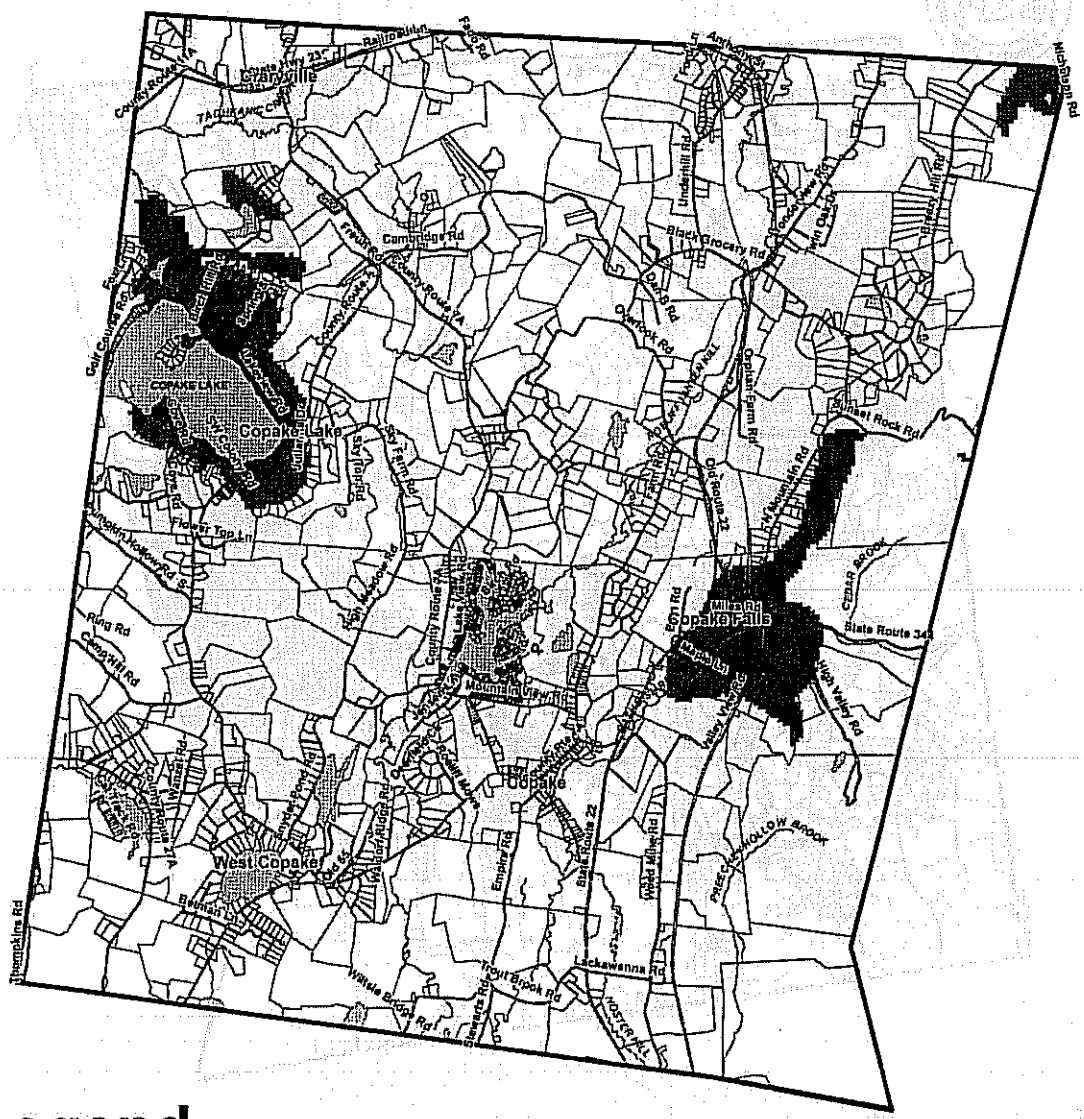
N

Figure 16

Actual Housing Density vs. Calculated Housing Density to Preserve Drought Baseflow

Town of Copake, New York

Steven Winkley, New York Rural Water Association



Legend

Actual Density > Density to Conserve Drought Baseflow

N

Scale

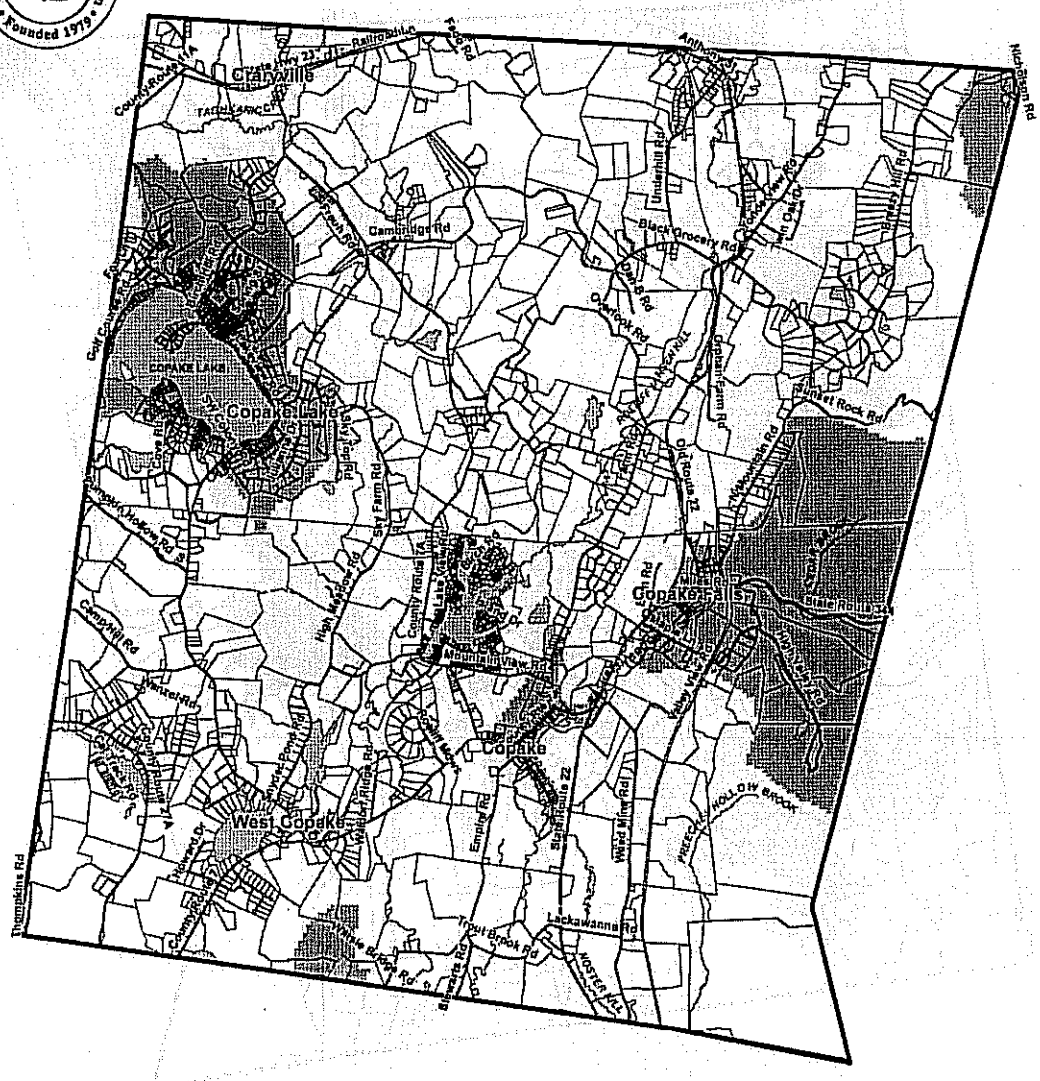
0 0.75 1.5 2.25 3 Miles

Figure 17

Housing Density Allowed By Zoning vs. Recommended Housing Density to Conserve Baseflow

Town of Copake, New York

Steven Winkley, New York Rural Water Association



Legend

Zoning Density > Density for Drought Baseflow Conservation

N

Scale

0 0.75 1.5 2.25 3 Miles

Figure 18

7.0 GROUNDWATER PROTECTION STRATEGIES

It is important to develop and implement effective groundwater protection measures in order to protect water resources and encourage future development where it is best suited. There are a number of groundwater protection measures that can be chosen. Some of these are regulatory in nature. Others are non-regulatory. The Town of Copake must determine which measures are acceptable given local socioeconomic and political conditions. These measures could include: promulgation or amending of land use regulations, environmental review, open space planning, further studies, and education.

7.1 Land Use Regulations

The Town of Copake does have a comprehensive set of land use regulations, including subdivisions regulations, site plan review, and zoning.

Subdivision Regulations

Subdivision regulations relate to how land is to be divided into lots and what improvements such as streets, lighting, fire protection, utilities, drainage, and parks are made to service the lots. Subdivision regulations were adopted by the Town in 1971 and were amended completely in 1996.

Subdivision regulations in Copake could be further amended to optimize protection of groundwater resources. For example, the following elements could be required for conditional approval of a subdivision:

- Location of any existing wells onsite and other proposed lot wells in relation to: local topography, lot lines, roads, on-site sewage system components or sewer lines, petroleum storage tanks, surface water and other drainage features, stormwater conveyance systems, and other applicable features.
- Copies of New York State Department of Environmental Conservation Well Completion Reports for completed well(s) (including the well log and pump test data).
- Any and all water quality testing results.
- Proposed individual water supply system details such as pumps, storage, treatment, controls, etc.
- A completed hydrogeological study, if required.

Such details would be in the plats and documents for final approval as well.

A hydrogeological study could be required for new subdivision involving a certain number of lots that relies upon either on-site groundwater withdrawals and/or on-site sewage disposal. In addition, standards may be added to subdivision regulations that specifically cover wells. These standards can specify the following:

A. Well locations. Existing and proposed wells are located at minimum separation distances from on-site and off-site potential sources of contamination as specified in Appendix 5-B of 10 NYCRR Part 5.

B. Supply suitability. A representative number of well(s) indicate that the available quantity and quality of on-site groundwater resources are suitable for household purposes.

C. Adverse impacts. For proposed subdivisions requiring a hydrogeological study, the determination has made that the subdivision avoids adverse impacts to existing or future groundwater users and/or surface waters within 1,500 feet of the subdivision. If adverse impacts cannot be avoided, the applicant must provide adequate mitigation of such impacts. An adverse impact to ground water can be defined as any reductions in groundwater levels or changes in groundwater quality that limit the ability of a groundwater user to withdraw ground water. An adverse impact to surface water would be any reductions in the level of flow or water quality needed for beneficial uses such as protection of fish and wildlife habitat, maintenance of waste assimilation, recreation, navigation, cultural and aesthetic values, drinking water supply, agriculture, electric power generation, commercial, and industrial uses.

Many communities are now encouraging the use of so-called conservation subdivisions. A conservation subdivision is essentially a cluster-type development that is planned around the open space protection of conservation areas such as steep slopes, mature woodlands, prime farmland, meadows, wildlife habitats, stream corridors, historic and archeological sites, scenic views, and of course groundwater features.

In 1996, Copake amended its zoning regulations to allow for "flexible lot subdivisions". These regulations are similar with conservation subdivisions in that the density allowed for residential units is calculated by a formula based upon unconstrained acreage and a conservation analysis is then completed. Unconstrained acreage does not include areas of wetlands, a one-hundred foot buffer of watercourses/water bodies; one-hundred-year floodplains, and any slopes over 25% that are at least 2,000 square feet or more in area. A conservation analysis identifies site features with conservation value on the parcel and those areas that are potentially suitable for development. At least 60 percent of the total acreage is to be protected by conservation easement. Features in the conservation analysis include documented aquifers and aquifer recharge areas as well as unique geological features.

Recharge areas are areas where the flow of groundwater is directed downwards. Typically 70 to 95 percent of the landscape is situated within recharge areas. The most direct method of identifying recharge areas is to map groundwater elevations. Unfortunately, there are insufficient numbers of wells to map such levels and to conclusively determine recharge areas. Therefore, NYRWA recommends that the term *documented aquifers and aquifer recharge areas* in the flexible lot subdivision regulations be changed to *areas of high or very high hydrogeologic sensitivity.* Very highly sensitive hydrogeologic areas cover ten percent of the Town of Copake. Highly sensitive hydrogeologic areas cover 23 percent of Town.

In addition, it may desirable to better define the term unique geological features. There is no standard definition or inventory of unique geological features that exists. Unique geological

features generally have scientific, educational, cultural, aesthetic, and/or economic significance. Scientifically and educationally significant sites consist of rock or mineral type sections, geologic structures, landscapes, etc. that represent the best examples of their kind (e.g. type section for the Copake Limestone, etc.). Culturally significant sites are places where cultural or historical events have occurred due to a geologic feature or landscape (e.g. Copake Iron Works and associated mines). Aesthetically significant sites include landscapes that are visually appealing (e.g. Taconic State Park). Similarly, economically significant features are important tourism destinations due to their characteristics.

Conservation subdivisions also use the similar principles of low-impact development and better site design. In the case of the ground water, the guiding design standard is to maintain or replicate the predevelopment hydrologic functions of storage, infiltration, and groundwater recharge. This can be done by using stormwater retention and detention areas, reducing impervious surfaces, lengthening flow paths and runoff time, and preserving environmentally sensitive site features. In the Scenic Corridor Overlay Zone (SCOZ), the maximum allowable impervious surface coverage on any parcel proposed for subdivision or development is 20 percent. The Town should consider extending this impervious surface limit to other areas such as unconsolidated aquifers and other highly to very highly sensitive hydrogeologic areas.

Low-impact development and better site design are primarily stormwater management concepts. Wastewater management is also a very important consideration. On-site septic systems recharge ground water. Properly located, installed, and operated on-site septic systems should be encouraged in order to return water to the subsurface. Sewers not only export wastewater away that can be recharged, they also export ground water and storm water as well since most sewers are prone to inflow from these sources.

Conservation subdivisions do pose a concern with respect to onsite wastewater disposal. By clustering homes on smaller lots, there is the possibility that the density of individual disposal systems will lead to excess nitrate loading. If individual disposal systems and wells are planned, the density of households across the parent parcel or parent tract should not exceed those indicated on Figure 13. Alternatively, a small on-site centralized wastewater disposal facility could be constructed for the subdivision as long as it is carefully located with respect to ground water and surface water. If there are existing wastewater discharges in the area, these should be considered in order to prevent excess nutrient loading.

Site Plan Review

Site plan review is a local regulatory process that involves municipal review and approval of how development is to occur on a *single* parcel of land. In this way, site plan review differs substantially from subdivision regulations. Site plan review does not prohibit certain land uses. However, it does regulate how development will take place by specifying the arrangement, layout and design of the proposed use.

NYRWA has reviewed the Town of Copake Site Plan Review requirements that are included in § 232-23 of the zoning law and recommends the following site plan elements are added to the site plan submission requirements:

- Copies of New York State Department of Environmental Conservation Well Completion Reports for completed well(s) (including the well log and pump test data).
- Any and all water quality testing results.
- The location(s) of all public water systems and other groundwater users within 1,500 feet of the proposed development boundaries;
- The proposed means of storage, distribution, use, treatment, and/or disposal of wastewater, other wastes, chemicals, etc.
- The proposed means of water supply, including if applicable an estimate of the total daily groundwater withdrawal rate;
- A list of all petroleum, chemicals, pesticides, fuels and other hazardous substances/wastes to be used, generated, stored, or disposed of on the premises;
- A description of the pollution control measures proposed to prevent ground water or surface water contamination; and
- A statement as to the degree of threat to water quality and quantity that could result if the control measures failed.

Submittal of a site plan *and* a hydrogeological study could be required for any proposed project in Copake that has projected on-site groundwater withdrawals and/or on-site sewage disposal flows equal to or exceeding a certain amount (1,000 or 2,000 gallons per day (gpd) perhaps). Alternatively, such thresholds could be reserved for just those areas where existing development exceeds recommended densities (Figures 14 and 17). These types of projects could include, but are not limited to, recreational developments (golf courses, water theme parks, etc.), multi-family housing (apartments, condominiums, townhouses, etc.), industrial, or commercial developments. Proposed requirements for a hydrogeological study are indicated in Appendix E.

The basis and standards for approval of a site plan could include the following additional criteria:

- ◻ Adequacy of control measures to prevent ground water or surface water contamination.
- ◻ The proposed use will not result in reductions in groundwater levels or changes in groundwater quality that limit the ability of a groundwater user to withdraw ground water.

<u>Zoning</u>

Zoning regulates land uses, the density of land uses, and the siting of development. There are several zoning points that the Town of Copake should consider with respect to groundwater resources. First, the Town may wish to consider adjusting minimum lot sizes for those areas where the density permitted by zoning exceeds recommended densities (see Figures 15 and 18). Relatively undeveloped areas indicated on Figures 15 and 18 include areas north of Copake Lake, between Copake hamlet and Robinson Pond, and south and west of Copake Falls. Second, uses of land with a higher-risk of groundwater contamination should be "steered-away" from areas of high hydrogeologic sensitivity (Figure 12) and areas that may be suitable for high-yield well development (Figure 11 and Plate 3). This could be accomplished using overlay

zoning. Overlay zoning creates a set of regulations for a given area that are in addition to the regulations in the standard "underlying" zoning districts. Third, overlay zoning could be specifically used to protect sources of drinking water for Copake Shores Homeowners Association and possibly other public water suppliers. In this case, a wellhead protection plan is recommended.

7.2 Environmental Review

In New York, all state and local government agencies are required by the State Environmental Quality Review Act (SEQR) to consider environmental impacts prior to making decisions to approve, fund, or directly undertake an action. Types of decisions or actions that are subject to SEQR include approval or direct development of physical projects, planning activities that require a decision, and adoption of rules, regulations, procedures and policies. Note that so-called Type II actions do not require environmental review because they either do not significantly impact the environment or are specifically precluded from environmental review under SEQR. However, all other so-called Type I or Unlisted Actions do require a determination of significance. If an action is determined to have potentially significant adverse environmental impacts, an Environmental Impact Statement (EIS) is required.

One way to insure that agencies take an area of critical environmental importance into account when making discretionary decisions is for a local municipality to designate a specific geographic area within its boundaries as a critical environmental area (CEA) under SEQR. An aquifer, watershed, wetland, etc. would meet the SEQR criteria for a CEA. The consequence of designating a CEA is that all government agencies (local or state) must consider the potential impact of any Type I or Unlisted Action on the environmental characteristics of the CEA when determining the significance of a project.

The Town of Copake may wish to consider naming unconsolidated aquifer areas, sensitive hydrogeologic areas, etc. as CEAs.

7.3 Open Space Planning

As growth continues in the Hudson River Valley, the Town of Copake should consider developing an open space preservation plan. Open space is defined as land that is not intensively developed for residential, commercial, industrial or institutional use. An open space preservation plan would identify parcels that have certain features or serve particular functions. The plan would also recommend short-term and long-term actions to initiate open space preservation. Groundwater resources would be one of several open space needs that would be addressed.

In some instances, a community may wish to purchase the full interest in a particular parcel(s) in order to conserve its natural or scenic resources. A more common method of land preservation is the purchase of an interest in the land, called a conservation easement. The easement places deed restrictions on property uses to assure that the property is not developed in an inappropriate manner. Typical easements permit agriculture, forestry, recreation, etc. but restrict or prohibit industrial, commercial, and residential development. Communities may purchase conservation easements or individuals can donate the easements and thus qualify for possible tax advantages.

Alternatively, non-profit land trusts may purchase conservation easements or work with local governments to facilitate conservation easements.

7.4 Further Study

In the plan, NYRWA has identified several areas in Copake that may merit further study. Potential water quality concerns include areas with a number of high-risk land uses (Figure 5) and areas where the density of housing using septic systems exceeds recommended levels (Figure 14). Private wells in these areas could be tested for volatile organic compounds (VOCs), nitrate, bacteria, etc.

Potential water quantity concerns include the areas where existing development exceeds recommended levels for the conservation of drought baseflow (Figure 17). Questionnaires could be circulated to residents here to determine if there are any well quantity problems in the area and to gauge the potential interest in public water.

7.5 Education

Public education can be an excellent non-regulatory tool to minimize potential contamination and conserve water resources. There are several instances where education may be effective. These include:

- Informing residents about the results of this study;
- Educating homeowners on proper operation and maintenance of onsite wastewater treatment systems and wells;
- Encouraging the use of water saving devices within homes;
- Promoting natural landscaping and other lower demand vegetation;
- Educating homeowners on proper fertilizer/pesticide application rates and practices; and
- Supporting proper waste disposal (i.e. recycling).

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Appendix A.

Determining Hydrogeologic Sensitivity

Town of Copake Hydrogeologic Sensitivity Ratings

In this plan, the *hydrogeologic sensitivity* of a location is a relative measure of the ease and speed with which a contaminant could migrate into and within the upper-most water-bearing unit. A rating of low hydrogeologic sensitivity indicates that local ground water is naturally well protected from contaminants at or near the land surface. High to very high hydrogeologic sensitivity ratings indicate that, in general, ground water could be easily and quickly impacted by surface activities.

The hydrogeologic sensitivity is a function of the naturally occurring hydrogeologic characteristics of an area. The nature and extent of potential sources of groundwater contamination are not factored into hydrogeologic sensitivity ratings. Instead, the two factors controlling the hydrogeologic sensitivity are the site's geologic materials (the hydraulic characteristics of the uppermost water-bearing unit and the overlying soils) and the site's topographic position (the topographic factors influencing the vertical migration of ground water). Resultant hydrogeologic sensitivity ratings based upon geologic materials and topographic position ratings are given below.

Hydrogeologic Sensitivity

The relative ease and speed that a contaminant on or near the land surface at a given location can migrate into and within the upper-most water-bearing unit.

Geologic Materials Rating	Low	Medium	High
High	Medium	High	Very High
Medium	Medium	Medium	Medium-High
Low	Low	Low	Medium

Topographic Position Rating

Geologic Materials Rating

The geologic materials ratings used to define the overall hydrogeologic sensitivity are based upon the following rating matrix:

Geologic Materials Rating

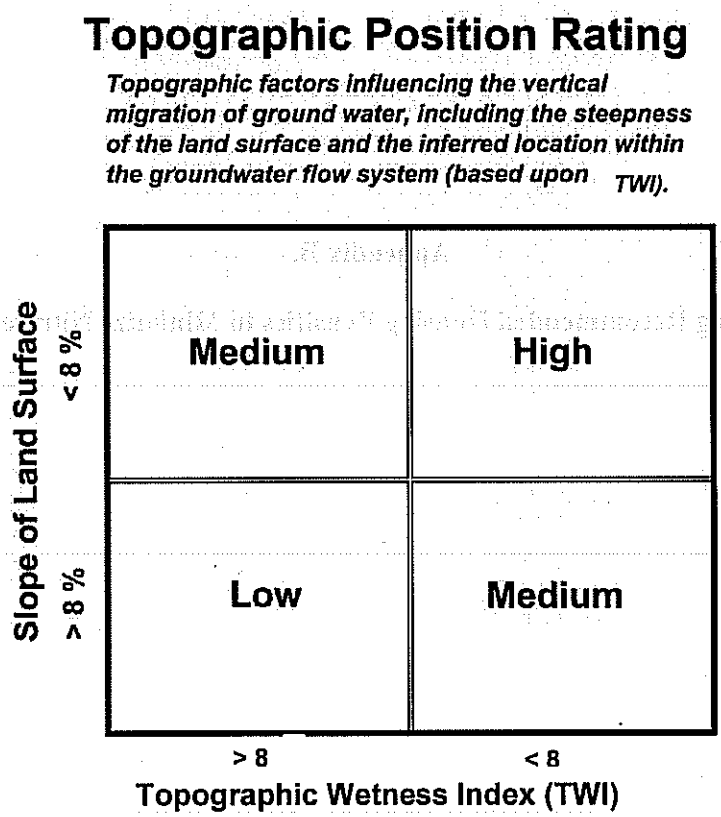
The hydraulic characteristics of the uppermost water-bearing unit as well as the overlying soils.

Potential Water-Bearing Unit	Thick & Finer-Grained	Thin & Finer-Grained	Coarse-Grained
Sand, Gravel, Limestone, or Conglomerate	Medium	High	High
Shale	Low	Medium	High

Type of Soils

Topographic Position Rating

Topography is an important, often overlooked factor related to the vertical groundwater flow. Areas with a low compound topographic index (CTI) (or wetness index) are situated in upland areas where typically there is a downward component of groundwater flow. Similarly, areas with lower slopes can promote greater downwards percolation of water.



Appendix B.

Determining Recommended Housing Densities to Minimize Nitrate Loading

The basis of the recommended housing density is to minimize nitrate loading so that there is sufficient area for groundwater recharge to dilute effluent to acceptable levels.

The effluent dilution area can be calculated from an equation known as the modified Trela-Douglas nitrate dilution equation (Hoffman and Canace, 2001). This equation is:

$$R = 4.4186HM / (C_q A(1-0.179A^{-0.5708}))$$

Where: H equals persons per home;
M equals pounds per person per year
Cq is the target concentration in mg/L of nitrate-nitrogen;
A is the effluent dilution area in acres per home; and
R equals the groundwater recharge rate in inches per year.

Since A is difficult to directly solve for, various values of A are chosen in order to match the recharge rate, R, in the area. The recharge rate was calculated as shown in Appendix C. Note that the following constants are used:

H = 3 persons per home
M = 10 pounds per person per year
C_q = 5 mg/L (½ of the nitrate MCL).

The effects of impervious cover were taken into account using a relationship between estimated impervious cover and lot size that was developed by the Soil Conservation Service. The modified Trela-Douglas equation was solved using a Microsoft Excel spreadsheet program.

The density is the inverse of A.

Recharge Rate (inches/year)	Acres per home	Density (Homes per acre)
1.71	13.2	0.076
1.89	12	0.083
2.07	10.9	0.092
2.25	10.1	0.099
6.27	3.77	0.265
6.65	3.56	0.281
6.93	3.43	0.292
7.35	3.24	0.309
7.59	3.145	0.318
8.05	2.975	0.336
8.25	2.905	0.344
8.75	2.75	0.364
14.25	1.747	0.572
15.75	1.597	0.626
17.25	1.464	0.683
18.75	1.359	0.736

Appendix C.

Calculation of Annual Groundwater Recharge Rates

Groundwater Recharge Estimates

Rates of shallow groundwater recharge in Copake have been estimated by based on base flow estimates and mean annual runoff in the region. Base flow is the component of stream flow that can be attributed to groundwater discharge into streams. The commonly-held assumption is that water that discharges to a stream as base flow originated as local shallow groundwater recharge. The United States Geological Survey (USGS) has calculated a variable known as the base flow index (BFI) for the watersheds of each of its stream gages. BFI is the ratio of base flow to total flow, and values were computed using an automated hydrograph separation computer program called the BFI program. BFI values for current and historical USGS stream gages in the conterminous U.S. are available from Wolock (2003a).

Working in the Great Lakes Basin, Neff et al. (2005) developed an empirical relation between measured base flow characteristics at gaging stations and the surficial geologic materials in the surrounding drainage area. In this study, a value of BFI was assigned to each surficial geologic material. The BFI for the gage watershed was calculated by the following equation taken from Neff et al. (2005):

$$y_{g,i} = \sum_j A_{g,i,j} x_{g,j},$$

where:

$y_{g,i}$ is the value of BFI for watershed i that results because of geological factors,
$A_{g,i,j}$ is proportion of geology class j within watershed i, expressed as a decimal between 0 and 1, and
$x_{g,j}$ represents ground-water discharge to the stream and is the value of BFI assigned to geology class j.

The value of BFI for each different surficial geologic material, x_{gj}, is indicated below from Neff et al. (2005):

Table 1. Values of $x_{g,j}$, the value of BFI assigned to geologic class j, used in equations 1 and 2 to calculate base-flow index used in this study.

Surficial-Geologic Material	$x_{g,j}$
Bedrock	0.78
Coarse-textured sediments	.89
Fine-textured sediments	.25
Till	.52
Organic sediments	.09

The surficial geologic materials for the Neff et al. (2005) study were taken from a 1:1,000,000-scale map of Quaternary deposits developed by Soller (1993) and digitized as Soller and Packard (1998). By studying watersheds in the region that have BFI data and iteratively comparing the surficial geology percentages of these watersheds using more detailed mapping, the following mean values of x_{gj} were found:

Surficial Material	Mean x_{gj}
Thin till and bedrock	0.33
Till	0.35
Coarse-textured sediments	0.75
Wetland deposits	0.09

The smaller value of x_{gj} for bedrock & till compared with the findings of Neff et al. (2005) is likely due to the lower permeability of local till and bedrock, as compared with that found in the Great Lakes Basin.

Mean annual groundwater recharge can be calculated by multiplying a grid of local base flow index (BFI) values by a grid of local mean annual runoff values. This approach is consistent with that of Wolock (2003b) to estimate mean annual natural groundwater recharge. The approach assumes that: (1) long-term average natural groundwater recharge is equal to long-term average natural ground-water discharge to streams, and (2) the BFI reasonably represents, over the long term, the percentage of natural groundwater discharge in stream flow. NYRWA constructed a grid of BFI values in Copake using the detailed surficial geology dataset that was derived for the Town. Note that in Copake, coarse-grained stratified sediments were assumed to include alluvium, glaciolacustrine sand, ice-contact, and outwash deposits. Mean annual runoff is long-term average stream flow expressed on a per-unit-area basis. A USGS GIS dataset by Cohen and Randall (1998) was used to define a grid of mean annual runoff across the Town.

The resulting grid of estimated mean annual groundwater recharge is depicted below.

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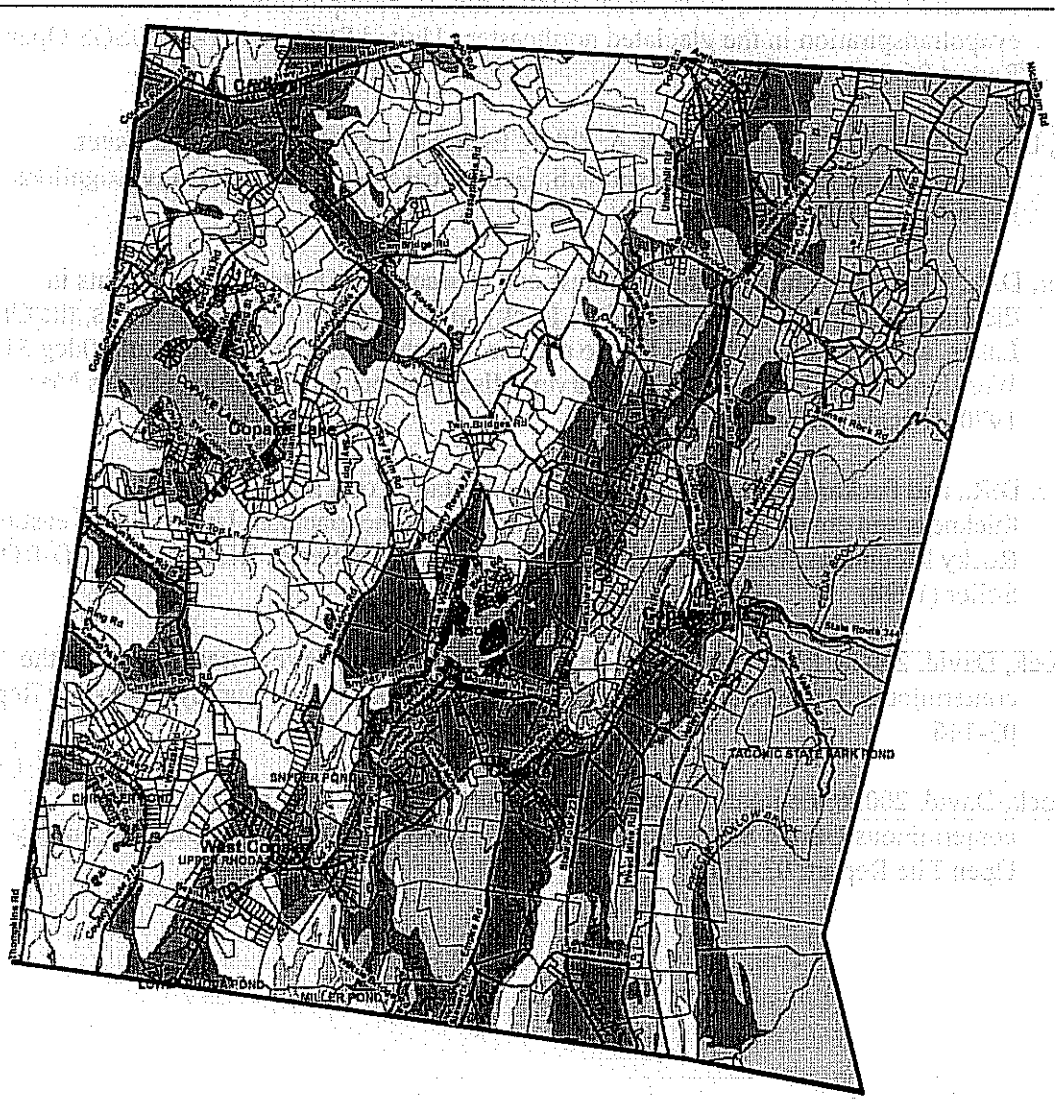
New York Rural Water Association

Calculated Groundwater Recharge Rates
Town of Copake, New York

Steven Winkley



Legend

Scale

0 0.375 0.75 1.5 2.25 3 Miles

Groundwater Recharge Rate

Inches Per Year

- 0 - 3
- 3 - 8
- 8 - 12
- 12 - 18.75

N

Appendix D.

Calculating Housing Densities to Conserve Drought Baseflow

Calculation of Sustainable Housing Densities Based Upon Conservation of Baseflow

By
Steven Winkley
New York Rural Water Association

Background

One of the fundamental questions that communities ask while planning for the future is: how much future development can be safely sustained? In rural areas there must be sufficient groundwater resources to successfully sustain development. Excess withdrawal of ground water can lead to unacceptable consequences. These consequences could be a reduction of ground water held in storage and/or a decrease of natural groundwater discharge to streams and other surface water bodies. This discharge to streams, known as baseflow, sustains streamflow in the absence of precipitation and may represent up to 50 percent of the total annual streamflow. A loss of baseflow means that some streams would not flow during dry periods. Other streams would not flow sufficiently to maintain aquatic life. Water quality would also suffer with insufficient dilution.

As indicated in Figure 1, most ground water produced by pumping is initially from water held in storage between the grains of unconsolidated material or within fractures of rock. With time, the percentage of water that is delivered to the well is increasingly from surface water. This source of surface water could either be decreased discharge to the surface water body (stream, lake, pond, and/or wetland) or increased recharge from the surface water body to ground water. In the case of a stream, the resulting reduction in streamflow is referred to as streamflow capture. The timeframe depicted on Figure 1 could be measured in weeks to years depending upon aquifer characteristics, the nature of the surface water/groundwater interaction, and pumping history.

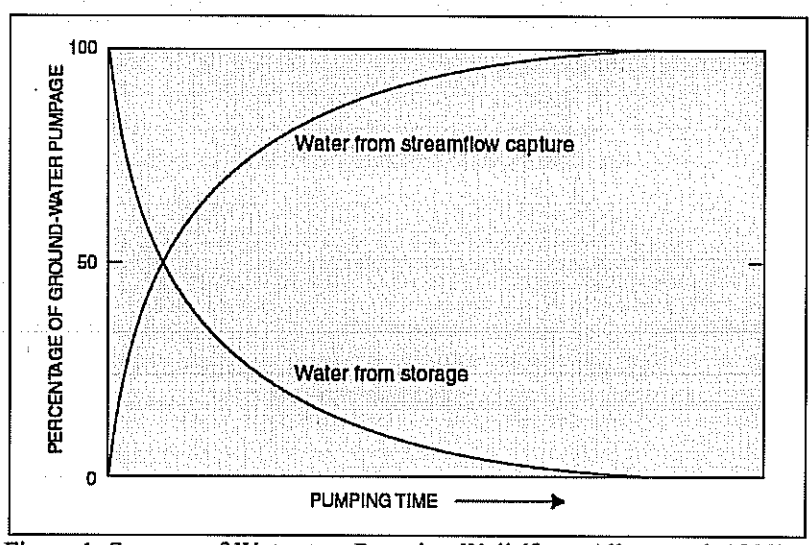


Figure 1. Sources of Water to a Pumping Well (from Alley et. al, 1999).

The most critical time to study the impact of pumping upon surface water is during drought. During prolonged dry periods, surface water flow is drastically reduced and the any reduction in baseflow would be most noticeable. During drought, it is critical that sufficient streamflow is maintained for ecological resources and to dilute possible wastewater discharges. One of the key stream flows to note during drought is the 7Q10 flow. Statistically, this is the lowest 7-day average flow that occurs (on average) once every 10 years. The 7Q10 flow is used by NYSDEC in designing and regulating wastewater discharges.

The conservation of baseflow is a reasonable standard against which to measure the sustainable yields of cumulative well pumping. To ensure that pumping does not produce an undesirable reduction in streamflow, even during drought periods, the following planning standard should be considered for the Town of Copake: *the net loss of ground water as a result of consumptive use in each drainage basin should not exceed 50 percent of the 7Q10 flow for the principal stream draining the basin.*

Consumptive Use

In Copake, most water that is withdrawn by wells is eventually returned to the environment through septic systems or discharges to streams. However, some water is consumed. Consumptive use refers to water that evaporates or is incorporated into a product during use and, therefore, is removed from the immediate environment. For residential areas, consumptive use is largely from evaporation losses during summer outside water use. Averaged over an entire year, the USGS National Handbook of Recommended Methods for Water Data Acquisition estimates that this consumptive water use is approximately 14 percent of an average total daily water use of 80 gallons per day per person. (Templin et al, USGS). A recent quantitative use of water use in Southeastern NH (Horn et al., 2007) indicated water evaporated during domestic water demand averaged 16 percent of annual per capita water demand (75 gallon per person per day).

The household consumptive use rate in the Town of Copake is calculated by the following:

Household consumptive use rate (gallons/day/household) =
0.15 · 80 gallons/day/person · 2.45 person/household (U.S. Census) = 29.4 gallons/day/household.

Drainage Basins

In order to determine 7Q10 flows for streams in Copake, the Town was divided into two drainage basins and 25 sub-basins. A drainage basin (i.e. watershed) is an area of land drained by a particular stream and its tributaries (see Figure 2). A large drainage basin such as the Roeliff Jansen Kill can be divided into a number of sub-basins (Figure 3). As Figure 4 indicates, drainage basins and sub-basins are nested, with two or more 1st-order sub-basins composing 2nd-order sub-basin(s), and a variety of 1st-order, 2nd-order, and higher sub-basins composing the overall drainage basin.

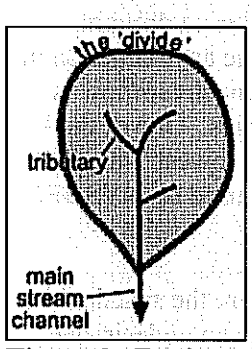


Figure 2. Drainage Basin.

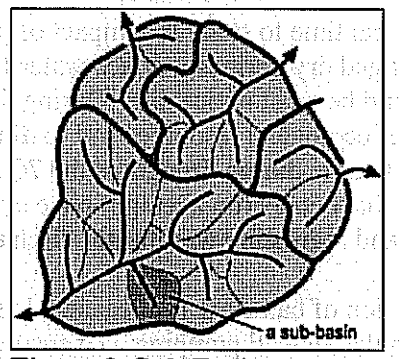


Figure 3. Sub-Basin.

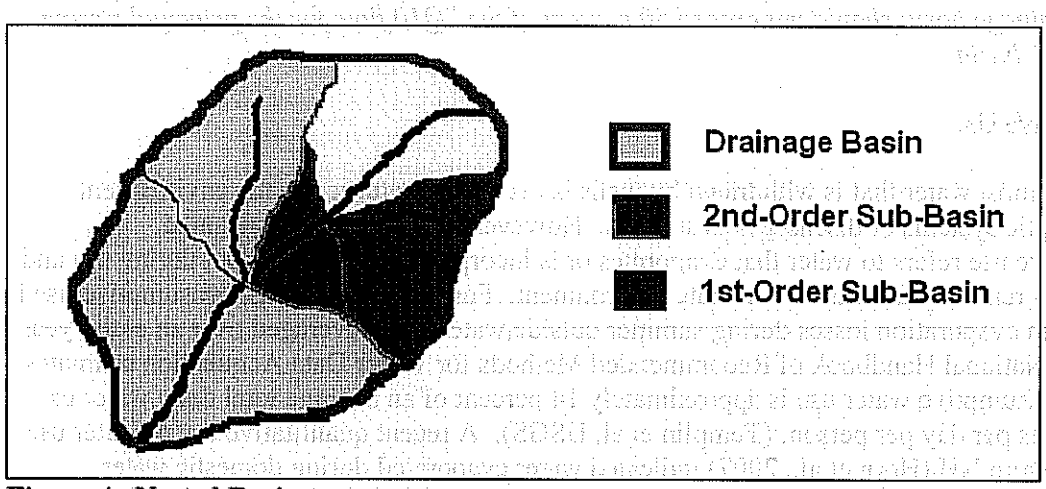


Figure 4. Nested Basins.

Figure 5 is a map of the various nested basins mapped in Copake. As indicated, some of these areas lie outside of Town boundaries.

Calculating 7Q10 Flows

Using multiple regression analysis, Barnes (1986) formulated an equation estimating the 7Q10 flow for ungaged streams in the Lower Hudson River Basin (from Troy south to New York City). For the 7Q10 flow, the two basin characteristics Barnes (1986) found to most significant are the percentage of basin underlain by stratified drift and mean basin elevation. Barnes (1986) counted stratified drift as unconsolidated material other than till and lacustrine deposits. To accurately determine the basin percentage underlain by stratified drift, the 1:24,000 surficial map of Copake that NYRWA developed was utilized. Outside of the Town of Copake, the parent material of NRCS SSURGO soils mapping was used. The mean elevation of the basin was calculated by Barnes (1986) as 34 percent of the range between minimum and maximum basin elevations maps added to the minimum basin elevation.

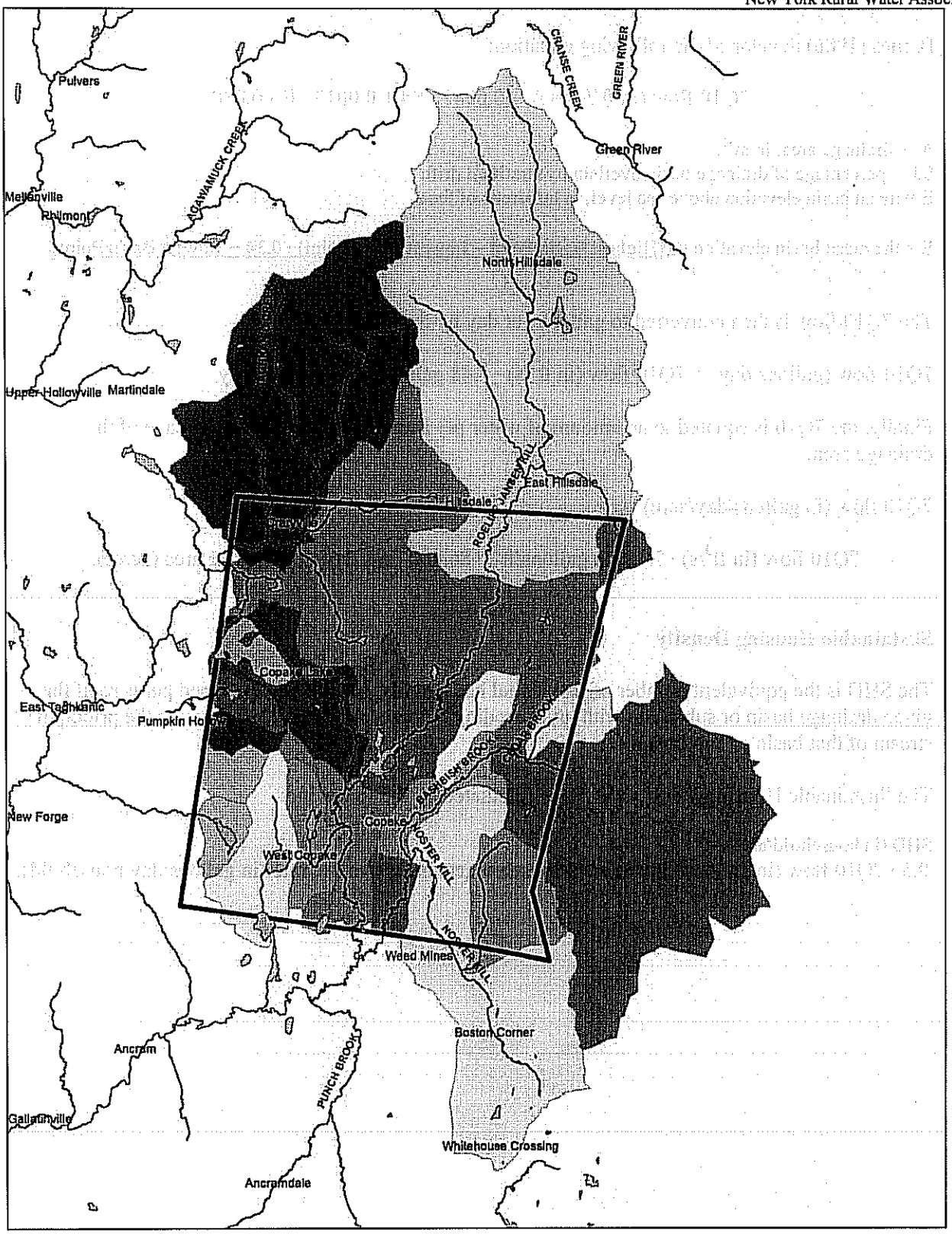


Figure 5. Nested Basins in Copake.

Barnes (1986) developed the following equation:

$$7Q10 \text{ flow (in ft}^3\text{/s)} = A \cdot (0.0047 \cdot Sd + 0.0013 \cdot E - 0.030)$$

A = drainage area, in mi^2.
Sd = percentage of drainage basin overlain by stratified drift.
E = mean basin elevation above sea level, in hundreds of feet.

$$E = \text{the mean basin elevation} = \frac{((\text{Highest Basin Point} - \text{Lowest Basin Point}) \cdot 0.34 + \text{Lowest Basin Point})}{100}$$

The 7Q10 flow is then converted to gallons per day by the following:

$$7Q10 \text{ flow (gallons/day)} = 7Q10 \text{ flow (in ft}^3\text{/s)} \cdot 7.48 \text{ gallons/ft}^3 \cdot 86{,}400 \text{ s/day}$$

Finally, the 7Q10 is equated to an amount of water per acre by dividing by the acreage of the drainage area.

7Q10 flow (in gallons/day/acre) =

$$7Q10 \text{ flow (in ft}^3\text{/s)} \cdot 7.48 \text{ (in gallons/ft}^3\text{)} \cdot 86{,}400 \text{ (in s/day)} \div \text{Drainage area (acres)}.$$

Sustainable Housing Density

The SHD is the equivalent number of residential households that can be developed per acre of the given drainage basin or sub-basin without exceeding 50 percent of the 7Q10 flow for the principal stream of that basin or sub-basin.

The Sustainable Housing Density (SHD) is calculated by the following:

SHD (in household/acre) =
$0.5 \cdot 7Q10$ flow (in gallons/day/acre) ÷ Household consumptive use rate (in gallons/day/household).

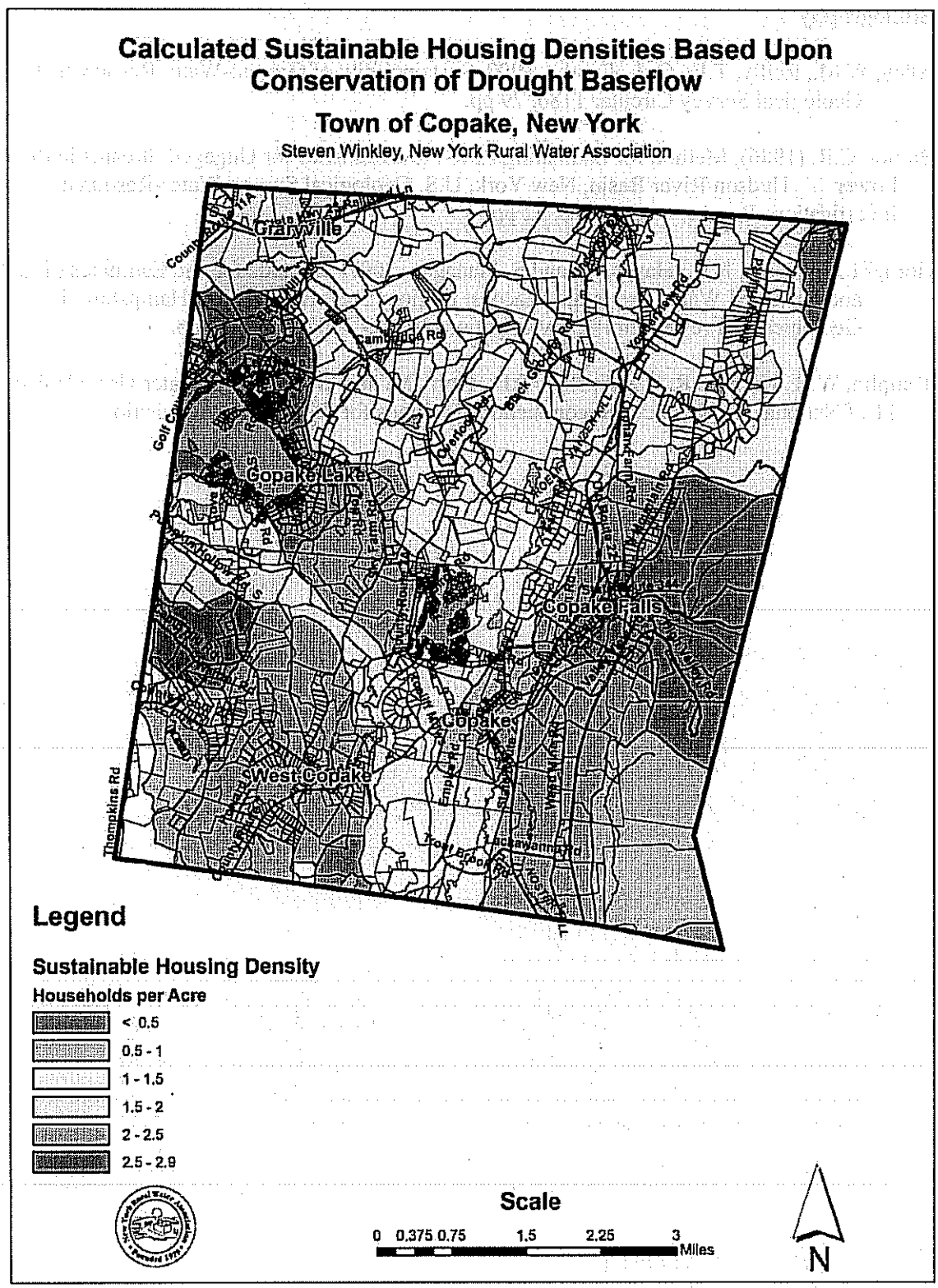


Figure 6. Calculated Sustainable Housing Densities.

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Appendix E.

Proposed Requirements for a Hydrogeological Study

TOWN OF _____
HYDROGEOLOGICAL STUDY REQUIREMENTS

SECTION 1.0 INTRODUCTION

Hydrogeological studies are required for certain development activities as specified below. The purposes of such hydrogeological studies are to: (1) assess the adequacy of the available groundwater supply to support the proposed development; and (2) evaluate the potential impacts for adverse impacts upon any nearby groundwater users and surface waters. Hydrogeological studies as set forth in this document are based on both on-site testing, and existing and readily available information.

Hydrogeological testing and evaluation shall be performed by a qualified consultant approved by the Town of _____ Planning Board. Work shall be performed or directly supervised by a licensed or certified professional geologist who has related project experience in _____ County. Alternatively, work may be performed or directly supervised by a licensed professional engineer who is experienced in performing groundwater studies and has related project experience in _____ County. Where not specifically defined in this document, the methodology used for testing and evaluation shall follow generally accepted professional hydrologic and hydrogeologic practices and standards.

SECTION 2.0 APPLICABILITY

Hydrogeological studies are required for two general types of land development projects: (1) certain residential subdivisions utilizing on-site ground water and/or on-site sewage disposal; and (2) other types of development that utilize relatively large amounts of on-site ground water and/or dispose of a high volume of sewage on-site (see specific thresholds below).

A hydrogeological study must be performed for any new subdivision involving _____ or more lots that relies upon either on-site ground water withdrawals and/or on-site sewage disposal. A hydrogeological study must also be performed for any new subdivision involving ____ or more lots that relies upon on-site ground water withdrawals and overlies a low well yield area identified in the Town of _____ Groundwater Protection Plan prepared by New York Rural Water Association. Eight (8) copies of a hydrogeological study for such a subdivision must be submitted to the Town of _____ Planning Board in conjunction with submission of the preliminary plat. The hydrogeologic study must be formally approved prior to approval of the preliminary plat.

A hydrogeological study is also required for any type of proposed development project with on-site groundwater withdrawals and/or on-site sewage disposal flows potentially equal to or exceeding an average of _____ gallons per day (gpd) during any single thirty (30)-day period. These types of projects could include, but are not limited to, recreational developments (golf courses, water theme parks, etc.), multi-family housing (apartments, condominiums, townhouses, etc.), industrial, or commercial developments. Ten (10) copies of a hydrogeological study for such a development project is required to be submitted to the Town of _____ Planning Board as part of the site plan review process indicated in the Town's zoning regulations.

SECTION 3.0 BACKGROUND EVALUATION

A background evaluation and analysis of the regional and site specific hydrogeologic conditions should be conducted using readily available existing resources such as publications and/or data from the U.S. Geological Survey, U.S. Environmental Protection Agency, U.S. Department of Agriculture's Natural Resources Conservation Service (formerly the Soil Conservation Service), New York State Geological Survey, New York State Department of Environmental Conservation, New York State Department of Transportation, New York State Department of Health, _____ County Health Department, etc. At a minimum, the evaluation shall include the area within approximately one (1) mile beyond the project boundary.

The evaluation and analysis shall include the following:

- Topographic information from USGS mapping and other sources.
- Property maps, aerial photographs, and land use data (for example from real property classifications).
- Geologic maps and data reports (well logs, water quality analyses, geologic information, soils data, etc).
- Existing well data and descriptive statistical summary of the same (e.g. minimum, maximum and mean of well data, etc.)
- Existing research reports, hydrogeologic reports, etc.
- Locations and identifications of all wells within a minimum of 1,500 feet of the proposed development boundaries, including public water supplies.
- Existing and potential contaminant sources of record or those observed on site and within a minimum of 1,500 feet of the project site boundary. An attempt shall be made to verify sources of record by field reconnaissance.
- Preliminary field verification of existing geologic information including rock outcrops, bedrock fractures, karst features, linear features, photo linears, etc.
- At sites with bedrock outcrops, fracture orientations (strike and dip measurements) shall be measured and documented in the report. The number and orientations of linear features or photo lineaments shall be analyzed and correlated with documented bedrock fractures.
- Evaluation of the site hydrogeology and the occurrence, quality, and quantity of ground water.

SECTION 4.0 TESTING REQUIREMENTS

Section 4.1 Water Supply Testing for Applicable Subdivisions

A. Wells

1. The applicant must submit a plan to the Town of _____ Planning Board showing the locations and construction details of proposed test wells. The Town of _____ may approve, approve with conditions, reject, or request more information within 45 days of receipt of such a well plan.

2. Well construction and testing shall be performed by a certified water well contractor (NYS Environmental Conservation Law 15-1525) in accordance with Appendix 5-B of 10 NYCRR Part 5 (Standards for Water Wells).

3. Pumping tests should be conducted during a period of time of average or below average seasonal stream flow conditions (typically not during the months of March, April, and May).

4. Where individual wells are proposed for each lot, test wells shall be installed and tested on at least twenty percent (20%) of the proposed lots and on at least forty percent (40%) of the lots having a portion of the lot situated in a Low well yield area identified in the Town of _____ Groundwater Protection Plan prepared by New York Rural Water Association. The purpose of these wells is to provide evidence that the hydrogeologic system is capable of furnishing and sustaining the potable water needs of the proposed development.

5. Test wells may be used as designated lot wells if they meet all requirements of Appendix 5-B of 10 NYCRR Part 5 (Standards for Water Wells).

6. For wells that will be used for public water systems, all test wells shall also be located, constructed, and protected in accordance with Appendix 5-D of 10 NYCRR Part 5 (Special Requirements for Wells Serving Public Water Systems) as well as other applicable portions of Subpart 5-1 of 10 NYCRR.

7. Where individual wells are proposed for each lot, test well locations should provide a representative geographic distribution across the proposed subdivision.

8. Where individual wells are proposed for each lot, test well sites shall include wells in each bedrock and/or unconsolidated geologic unit in which wells are proposed.

9. Where individual wells are proposed for each lot, test wells shall be situated in each topographic setting that wells are proposed on the subdivision (i.e. high areas, low areas, sloping areas, etc.).

10. Where individual wells are proposed for each lot, an adequate number of test wells should be installed on adjacent lots in the proposed subdivision in order to evaluate potential adverse impacts to adjacent wells.

11. If there are existing, off-site wells within 1,500 feet of the subdivision, test well(s) should be located in order to evaluate the potential for adverse impacts to these existing wells.

12. If any portion of the subdivision is located within 100 feet of a surface water body or wetland, and individual wells are proposed for each lot, at least one well should be located between 25 and 100 feet of such surface waters in order to determine potential adverse impacts and groundwater quality issues.

13. A well log must be submitted to the Town for each well drilled, along with a copy of the New York State Department of Environmental Conservation Well Completion Report.

14. Where individual wells are proposed for each lot, physical or chemical alteration of geologic materials or structures (e.g., hydraulic fracturing, use of explosives, or addition of chemicals) to increase yield of test wells will not be permitted prior to the pumping test.

B. Formation Sampling

1. During all drilling, representative samples shall be collected for each unconsolidated and consolidated geologic formation encountered. The applicant shall retain these samples and provide them to the Town if requested.

2. A well driller certified in accordance with NYS Environmental Conservation Law (ECL) 15-1525 or a certified/professional geologist shall complete and submit to the Town a well log for each test well constructed for the investigation. The log shall describe materials encountered during drilling (unconsolidated and consolidated materials), and indicate the depth below ground surface of each material change. The log should be indicated on the New York State Department of Environmental Conservation Well Completion Report.

C. Pumping Tests

1. The applicant must submit a plan to the Town of _____ Planning Board showing the wells that are to be pump tested, along with water level monitoring locations, surface water bodies and wetlands, possible pumping rates, discharge locations, schedules, and laboratory water quality testing details. The Town of _____ may approve, approve with conditions, reject, or request more information within 45 days of receipt of such a testing plan.

2. No pumping should be conducted at or near the test well site for at least 24 hours

prior to the test.

3. A pumping rate shall be used that reasonably stresses the aquifer but does not result in excessive drawdown in the well. The minimum acceptable pumping rate for the test shall be two (2) gallons per minute. However, a water well that yields a pumping rate of at least 5 gallons per minute is usually necessary to safely meet peak and daily needs of most residences.

4. A test pump capable of providing a minimum of 2 to 5 gallons per minute at the required head must be used to perform the test. Any pump failure must have no significant effect on the data or a similar termination and restart is necessary.

5. The pumping rate shall be measured using a flow meter installed in the discharge line along with a control valve. The flow meter shall be calibrated at the beginning of the pumping period (all calibration measurements shall be recorded). The discharge flow rate shall be monitored and recorded at least once every 15 minutes during the first hour of the test and every 60 minutes thereafter.

   For relatively low flow rates, (< 5 gallons per minute), the flow rate may be obtained by determining the time required to fill a container of known volume (e.g., a 5-gallon bucket). The number of seconds/minutes to fill the container and the exact time of day shall be recorded.

6. The pumping test should include a minimum four-hour period of stabilized drawdown while pumping occurs at a constant flow rate. During the period of stabilized drawdown the stabilized water level shall not fluctuate more than plus or minus 0.5 foot (i.e., within a vertical tolerance of one foot) for each 100 feet of water in the well (i.e., initial water level to bottom of well) over the duration of constant flow rate of pumping. During the duration of constant flow rate pumping, the pumping rate shall not vary by more than 10 percent.

7. Water level measurements must be made to the nearest 0.01 foot. Preferred measurement methods include electronic sensors and pressure transducers.

8. Water level measurements in the pumping well and in at least two (2) of the closest available test wells are required immediately before the start of the test and during the pumping test at the following intervals:

Time After Pumping Started	Time Intervals
0 to 15 minutes	5 minutes
15 to 120 minutes	15 minutes
120 to 360 minutes	30 minutes

Note that all wells within a minimum distance of 500 feet of the pumping well shall be monitored, including any off-site wells (if practicable).

9. The water height of any bodies of water within 500 feet of the pumping well shall be monitored prior to the test, hourly during the pumping test, and at the end of the recovery period (see item 11).

10. Water discharged from the pumping well must be discharged a sufficient distance from the pumping well and other measured wells to avoid possible impacts from re-circulating the water. The water should be discharged to a drainage ditch or swale that will direct the water away from the well(s) if possible. If necessary, a temporary water storage tank can be used.

11. Upon completion of the pumping portion of the test, water level measurements should be recorded at the pumped well until the water level recovers back to at least 90 percent of the initial water level or for a period of 24 hours, whichever occurs first. If the water level does not recover to 90 percent of the initial water level after 24 hours, the tested flow rate may not be sustainable for an extended period of time.

12. A check valve must be installed at the base of the pump column pipe in the pumping well to eliminate backflow of water into the well during the recovery period.

13. For public water systems, all test wells shall be tested in accordance with Appendix 5-D of 10 NYCRR Part 5 (Special Requirements for Wells Serving Public Water Systems) as well other applicable portions of Subpart 5-1 of 10 NYCRR. In addition for community water systems, pump tests will follow NYSDEC Appendix 10, TOGS 3.2.1 (Recommended Pump Test Procedures for Water Supply Applications).

D. Laboratory Testing for Water Quality.

1. Water quality samples should be collected at the conclusion of the pumping test.

2. Water quality samples should be analyzed for the following: coliform bacteria, lead, nitrate, nitrite, iron, manganese, sodium, chloride, pH, hardness, sulfate, alkalinity and turbidity.

3. Additional tests for petroleum products or solvents may be necessary if the pumping well is located in the vicinity of a spill, petroleum storage facility, or other similar land use.

4. Tests for hazardous substance list metals, PCBs, and pesticides may be necessary if the pumping well is located adjacent to a landfill, junkyard, etc.

5. Analyses for specific chemicals may be necessary if the pumping well is located near an industry that stores and/or uses particular chemicals.

6. For public water systems, all test wells shall be tested for water quality in accordance with Subpart 5-1 of 10 NYCRR including Appendix 5-D of 10 NYCRR Part 5.

Section 4.2 Water Supply Testing For Other Developments with Groundwater Withdrawals and/or On-Site Sewage Disposal Flows ≥ 1,000 GPD

A. Geology

1. During all drilling, representative samples shall be collected for each unconsolidated and consolidated geologic formation encountered. The applicant shall retain these samples and provide them to the Town if requested.

2. A well driller certified in accordance with NYS Environmental Conservation Law (ECL) 15-1525 or a certified/professional geologist shall complete a well log for each test well constructed for the investigation. The log shall describe materials encountered during drilling (including unconsolidated materials), and indicate the depth below ground surface of each material change. The log should be indicated on the New York State Department of Environmental Conservation Well Completion Report.

B. Wells

1. The applicant must submit a plan to the Town of _____ Planning Board showing the locations and construction details of proposed test wells. The Town of _____ may approve, approve with conditions, reject, or request more information within 45 days of receipt of such a well plan.

2. Well construction and testing shall be performed by a certified water well contractor (NYS Environmental Conservation Law 15-1525) in accordance with Appendix 5-B of 10 NYCRR Part 5 (Standards for Water Wells).

3. For water wells that will serve a public water system, the location, protection, construction, yield, etc. of such wells shall be in accordance with Appendices 5-D and other applicable portions of Subpart 5-1 of NYCRR Title 10.

4. A well log must be submitted to the Town for each well drilled, along with a copy of the New York State Department of Environmental Conservation Well Completion Report.

C. Pumping Tests

1. The applicant must submit a plan to the Town of _____ Planning Board showing the wells that are to be pump tested, along with water level monitoring locations, surface water bodies and wetlands, possible pumping rates, discharge locations, schedules, and laboratory water quality testing details. The Town of

_____ may approve, approve with conditions, reject, or request more information within 45 days of receipt of such a testing plan.

2. A pumping test shall be performed on each well that is to be utilized by the proposed development in order to determine that the water supply adequately meet the needs of the applicant without adversely affecting others who may rely on the same aquifer.

3. For public water systems, all pumping tests shall be conducted in accordance with Appendix 5-D of 10 NYCRR Part 5 (Special Requirements for Wells Serving Public Water Systems) as well other applicable portions of Subpart 5-1 of 10 NYCRR. In addition for community water systems, pump tests will follow NYSDEC Appendix 10, TOGS 3.2.1 (Recommended Pump Test Procedures for Water Supply Applications).

3. Pumping tests should be conducted during a period of time of average or below average seasonal stream flow conditions (typically not during the months of March, April, and May).

4. No pumping should be conducted at or near the test well site for at least 24 hours prior to the test.

5. Pumping tests should be done when nearby wells normally in operation are running. Pumping of such other wells in the test area should be monitored.

6. A test pump capable of providing the design flow rate at the required head must be used to perform the test. Any pump failure must have no significant effect on the data or a similar termination and restart is necessary.

7. The pumping rate shall be measured using a flow meter or circular orifice weir installed in the discharge line along with a control valve. The flow meter or weir shall be calibrated at the beginning of the pumping period (all calibration measurements shall be recorded). The discharge flow rate shall be monitored and recorded manually at least once ever 15 minutes during the first hour of the test and every 1 to 4 hours thereafter.

   For relatively low flow rates, (< 5 gallons per minute), the flow rate may be obtained by determining the time required to fill a container of known volume (e.g., a 5-gallon bucket). The number of seconds/minutes to fill the container and the exact time of day shall be recorded.

8. The pumping test(s) shall be conducted at a pumping rate at least equal to the design pumping rate. If multiple wells are to be pumped simultaneously to achieve the necessary yield, the test should incorporate such a pumping plan.

9. Water discharged from the pumping well must be discharged a sufficient distance from the pumping well and other measured wells (minimum 200 feet) to avoid

possible impacts from re-circulating the water. The water should be discharged to a drainage ditch or swale that will direct the water away from the well(s) if possible.

10. Water from the pumping well cannot be discharged into any water body or wetland if such discharge results in turbidity or erosion leading to turbidity or down stream flooding. If it is anticipated that discharged water will create flooding, erosion and/or turbidity, water must be directed to a holding area and released in a controlled manner to prevent such problems.

11. The selected pumping rate shall not vary by more than ten (10) percent during the test. Pumping rates should be frequently measured and recorded, following the schedule of the water level measurements (see below).

12. Pumping tests shall be conducted for a minimum of 72 hours at a constant pumping rate. A minimum of six hours of stabilized drawdown must be displayed at the end of the test. Stabilized drawdown is defined as a water level that has not fluctuated by more than plus or minus 0.5 foot for each 100 feet of water in the well. If stabilized drawdown is not achievable, the test period may be extended or semi-log extrapolation of drawdown versus time (or other similar methods) may be employed to demonstrate the ability of the aquifer to supply a pumping rate equal to the desired yield.

13. Water level measurements must be made to the nearest 0.01 foot. Preferred measurement methods include electronic sensors and pressure transducers.

14. Periodic water level measurements in the pumping well and in the observation wells are required immediately before the start of the test and during the pumping test at the following intervals:

Time After Pumping Started	Time Intervals
0 to 15 minutes	1 minute
15 to 50 minutes	5 minutes
50 to 100 minutes	10 minutes
100 to 500 minutes	30 minutes
500 to 1000 minutes	1 hour
1000 to 5000 minutes	4 hours

15. At least three (3) observation wells should be monitored on-site during the pumping test. Note that all site wells shall be monitored, as well as any off-site wells within 1,500 feet (if practicable). Observation wells should be located at varying distances from the pumping well in order to characterize the well's zone of pumping influence. Observation wells should be large enough to allow

accurate and rapid measurement of the water levels. Observation wells should be screened in, or open to, the same formation as the pumping well.

16. The water height of any bodies of water within 1,500 feet of the pumping well shall be monitored before the pumping test, every four hours during the test, and at the end of the recovery period (see item 17).

17. Water level measurements should be collected during the recovery period for all wells using the same procedure and time pattern followed at the beginning of the pump test (see item 14). Measurements at the pumping well should continue for at least 24 hours or until the well recovers to 90 percent of the original water level.

18. A check valve must be installed at the base of the pump column pipe in the pumping well to eliminate backflow of water into the well during the recovery period.

19. Rainfall should be measured to the nearest 0.01 inch and recorded for one day preceding the pump test, during the test, and during the recovery period.

D. Laboratory Testing for Water Quality.

1. Water quality samples should be collected at the conclusion of the pumping test.

2. Water quality samples should be analyzed for the following: coliform bacteria, lead, nitrate, nitrite, iron, manganese, sodium, chloride, pH, hardness, sulfate, alkalinity and turbidity.

3. Additional tests for petroleum products or solvents may be necessary if the pumping well is located in the vicinity of a spill, petroleum storage facility, or other similar land use.

4. Tests for hazardous substance list metals, PCBs, and pesticides may be necessary if the pumping well is located adjacent to a landfill, junkyard, etc.

5. Analyses for specific chemicals may be necessary if the pumping well is located near an industry that stores and/or uses particular chemicals.

6. For public water systems, all test wells shall be tested for water quality in accordance with Subpart 5-1 of 10 NYCRR including Appendix 5-D of 10 NYCRR Part 5.

SECTION 5.0 REPORTING REQUIREMENTS

The detailed hydrogeologic report shall include, at a minimum, the items described below. Note that the all data shall be organized by either "type" (well completion reports, pumping test data and analyses, water quality reports, etc.) or by well, in tabbed appendices clearly marked showing the content of the tabbed section.

A. Description of the Proposed Development

The proposed development project must be summarized including information on property acreage; projected water demand; means of wastewater disposal; stormwater runoff control; parking areas and other impervious surfaces; fuel storage; and the number, size and distribution of proposed residential lots (if applicable).

B. Discussion of Site and Regional Hydrogeology

A written discussion of the site and regional hydrogeology shall be included. Items to be included in this discussion include:

1. Geologic setting;
2. Local drainage and watershed(s);
3. Lateral and vertical distribution of local unconsolidated and consolidated hydrogeologic units as well as their hydraulic properties;
4. Land surface elevation and relief;
5. Occurrence and flow characteristics of surface water and ground water;
6. The relationship between local ground water and surface water;
7. Well yield and depth data;
8. Local groundwater use and quality; and
9. Known or potential contamination sources.

Appropriately-scaled maps and cross-sections should be used to depict the hydrogeologic setting (see below).

C. Maps

A set of maps at appropriate scales covering the proposed development should be enclosed. The maps shall contain all existing planimetric features, topography, all proposed roads, proposed lot lines, proposed lot sites, proposed house sites, proposed septic systems, surface water features, proposed and existing wells, bedrock outcrops, karst features, linear features, springs, hydrogeologic units, etc. In addition, map(s) of static groundwater elevations shall be illustrated, along with maps showing drawdown contours and pumping groundwater elevations.

D. Cross-Sections

The report shall contain one or more cross-sections, at true horizontal scale and vertical scale (exaggerated as appropriate). The location of each cross-section shall be shown on the plan view map(s) and the cross-section shall contain the following information:

1. Geologic data including bedrock contacts and structural features if present.
2. Well site locations showing well casings, total depths, and specific capacities.
3. Elevations of ground surface, bedrock depths, and static water surfaces.
4. Final water level in each pumped well and observation well(s) at the end of the pumping tests with the corresponding pumping rate of the well.

E. Well Completion Reports

For each well drilled for the investigation, a New York State Department of Environmental Conservation Well Completion Report will be completed and enclosed. This will include a log of materials encountered that is completed by a certified well driller or a licensed/certified professional geologist. Well construction details will also be noted on each Well Completion Report, including the well number, date of construction, well location coordinates (lat/long, UTM, or State Plane), land surface elevation, total depth, well casing depth, grout depth, bentonite seal thickness, top and bottom of well screen, height of casing above land surface, static water level and date, etc.

F. Well Construction Summary

For all wells constructed for the investigation, a summary table will be provided that includes, at a minimum, the well number, completion date, land surface elevation, well diameter, total well depth, well casing depth, screened interval (if applicable), depth to bedrock, static water level (all on the same date), well yield, and aquifer.

G. Well Testing Summary

In a separate table(s), well testing results shall be summarized, including at a minimum: the well number (and pumping well number if different); date tested; duration of pumping; pumping rate; pre-pumping (static) water level; maximum observed water level drawdown; distance to pumped well; percent of available drawdown used (assume maximum available drawdown is 40 feet above well bottom or use more stringent criteria if appropriate); specific capacity; transmissivity; storativity (if available); and time to achieve 90 percent recovery (or the percent recovery after 24 hours) in the pumped well. Note that the analytical method used to calculate the aquifer transmissivity and storativity should be noted. All pumping test data will be included in the appendices.

H. Groundwater Quality

For all wells tested for the investigation, provide a table summarizing the groundwater quality and include the maximum contaminant levels (MCLs) for each tested parameter. Copies of the laboratory reports shall be included in the appendices.

I. Water Balance

The report shall contain groundwater mass balance and recharge estimates for the area. Applicable calculations and references shall be included as well as assumptions and limitations of the methods used. The report shall include a discussion of the following information, including appropriate supporting calculations and diagrams, which shall include, at a minimum:

1. Identification of the source or sources of recharge, using recharge from rainfall for normal conditions and for drought conditions (assume 60% of average annual precipitation), and the average outflow from the development area.

2. Comparison of calculated recharge to projected withdrawals associated with the development.

J. Potential Impacts to Water Quality

The report shall contain an analysis of potential impacts to groundwater and/or surface water quality that may result from the development. For example, this could include a discussion of impacts from fuel storage, stormwater runoff, nitrate loading associated with septic system effluent, etc.

Calculations should be developed and discussed in the report to estimate the overall loading of inorganic nitrogen to ground water from the development's subsurface wastewater disposal systems (if applicable). In general, the nitrate entering the ground water can be computed for a given area by dividing the annual nitrate load from the area by the annual amount of groundwater recharge (see above). Both normal and drought conditions should be assumed. In order to prevent cumulative degradation of groundwater quality in the region, the resultant projected nitrate level in ground water at the project boundary should not exceed ½ of the MCL (5 mg/L).

K. Potential Impacts of Pumping

The report will present an analysis of the magnitude and extent of water level drawdown that will result from groundwater withdrawals at the project as well as an evaluation of potential impacts of drawdown on groundwater and surface waters within a minimum of 1,500 feet from the development boundary. This analysis will be developed using standard methods and will include an analysis of potential conditions during normal and drought periods. The possibility of other adverse affects of pumping such as altering the flow direction of groundwater from potential pollution sources, introducing zones of poor water quality, etc. must be discussed as well. For community water system wells, the zone contributing ground water (zone of contribution) for such wells must be delineated.

L. Suitability of Groundwater Resources

The consultant must prepare a preliminary written conclusion regarding the suitability of groundwater resources to support the proposed development. A comparison of projected water demands to available source capacity should be included. If applicable, mean and median yields of lot wells must be presented and compared to the 5 gallons per minute usually necessary to

safely meet peak and daily needs of a typical residence. In addition, the possibility of wells on the remaining (non-tested) individual lots having inadequate yield must be discussed. Plans on how to overcome potential inadequacies must be addressed.

The adequacy of the development's drinking water quality should be evaluated. The possibility of contamination from on-site and off-site sources must be assessed. Any necessary treatment options should be identified.

M. Investigation and Mitigation Plan

The report must include a plan for investigating and mitigating existing water supply wells or surface waters in the event that either experience reductions in water level or water quality during and/or after construction of the development.