Appendix B
Hydrogeologic Study of Proposed Arkwright Summit Wind Farm

SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

Hydrogeologic Study of Proposed Arkwright Summit Wind Farm Chautauqua County, New York

CHA Project Number 18582

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PROPOSED ARKWRIGHT SUMMIT WIND FARM
SUPPLEMENTAL HYDROGEOLOCIAL STUDY

TOWN OF ARKWRIGHT
CHAUTAUQUA COUNTY, NEW YORK

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1.0 INTRODUCTION

Arkwright Summit Wind Farm LLC has proposed development of a wind-powered generating facility consisting of up to 44 wind turbine generators (WTGs) with a total maximum capacity of between 79.2 and 79.8 megawatts (MW). The Project is proposed to be developed on leased, private land in the towns of Arkwright and Pomfret in Chautauqua County, New York (Figure 1- *Project Area*). In addition to the wind turbines, the Project will involve construction of up to four permanent meteorological towers, a system of gravel access roads, a buried and overhead electrical collection system, an operation and maintenance building, and an inter-connection substation facility.

In February 2008, Tetra Tech EC, Inc. (Tetra Tech) prepared a Draft Environmental Impact Statement (DEIS) to describe the potential environmental impacts and mitigation measures associated with the construction and operation of the proposed Arkwright Summit Wind Farm as required under the New York State Environmental Quality Review Act (SEQRA) (6 NYCRR 617).

The DEIS (Tetra Tech, 2008) was intended to facilitate the environmental review process and to provide a basis for informed public comment and decision-making. This process is in accordance with the requirements of SEQRA. The town of Arkwright is acting as Lead Agency to provide a coordinated review under SEQRA. Various support studies have also been performed for the Project, which provide detailed information on discrete topical areas in furtherance of the SEQRA evaluation.

During the public review of the DEIS, environmental concerns relating to the potential effects of the proposed Project on groundwater were raised by affected landowners. As a result, Clough, Harbour and Associates, LLP (CHA) was retained by Arkwright Summit Wind Farm LLC to undertake a desktop hydrogeological investigation as a supplement to the DEIS.

The objective of this Supplemental Environmental Impact Statement (SEIS) was to review available information pertinent to the actual hydrogeologic conditions in the Project Area, and determine both the short term and long term potential impacts, if any, from the project on the quantity and quality of groundwater used for drinking water. Mitigation measures were identified that could be implemented to address any impacts if necessary.

The review of available hydrogeologic information and groundwater resources was based on a desktop study obtaining information from published sources, knowledgeable individuals, and available GIS data. The information obtained during the analysis has been used to better determine the potential impacts of the proposed project as discussed above.

As part of the review of available information, the following sources of information were researched:

- Draft Environmental Impact Statement
- Surficial and bedrock geologic mapping;
- USGS publications;
- Local aquifer and recharge information;
- Published geologic/hydrogeologic reports;
- County soil surveys;
- USGS and NYSDEC well records;
- Local well drillers;
- Department of Health officials;
- Local Village officials;
- Topographic mapping

The potential impacts from the project include:

- Changes in groundwater recharge due to construction of impervious surfaces
- Changes to shallow groundwater flow and springs due to construction
- Changes in groundwater flow patterns due to blasting
- Changes in groundwater quality associated with petroleum spills during construction

The potential mitigation measures identified include:

- Preparation and implementation of appropriate spill plans
- Minimization of blasting during construction

2.0 PROJECT SITE TOPOGRAPHY AND GEOLOGY

2.1 Site Setting and Topography

The proposed Arkwright Summit Wind Farm Project Area is located in Chautauqua County, southwestern New York, comprising approximately 5,879 acres of leased private land in the town of Arkwright and 82 acres within the town of Pomfret (Figure 1). The Area is bounded to the north by the Arkwright-Sheridan town line and Straight Road, to the east by Arkwright-Villenova town line, to the south by the Arkwright-Charlotte town line and to the west by State Highway 60 (approximately 0.5 miles (mi) west of the Arkwright-Pomfret town line). Within these boundaries, the Project Area forms an irregularly shaped polygon generally within the northeastern half of the region (Figure 2- *Site Plan*). As measured from its geographic center, the Project Area is located approximately 9.5 mi southeast of Lake Erie, eight (8) mi southeast of the City of Dunkirk, six (6) mi southeast of the Village of Fredonia, 6 mi southwest of the Village of Forestville, and 5.5 mi northeast of the Village of Cassadaga (Tetra Tech, 2008). No WTGs will be located within Pomfret, which is the proposed site for the Project substation and point-of-interconnect (POI) switchyards (Figure 2).

The Project Area is located on the northwestern edge of the Allegheny (Appalachian) Plateau, bordering the lower, generally flat Lake Erie Plain (Tesmer, 1963; Isachsen et al., 2000). Topography in this region of New York is highly modified by Pleistocene glaciation, reflecting the combined effects of scouring of the bedrock surface and deposition of glacial sediments (Tesmer, 1963). Chautauqua County is characterized by large (greater than 15 mi long) northwest-southeast trending valleys such as those that house Chautauqua Lake and Cassadaga Creek in addition to the northeast-trending escarpment that bounds the northwestern limit of the Allegheny plateau. The Project Area is located on the very edge of the plateau between the northern extensions of two such valley systems (Cassadaga and Conewango). The highest elevations within the Project Area are approximately 1900 feet (ft) above sea level (ASL), located in the southeast corner on Dibble Hill, while lowest elevations (approximately 850 ft ASL) are located in the northwest corner of the project near the plateau edge. The overall slope of the project area and surrounding region is towards Lake Erie to the northwest, although the Project Area topography is dominated by local hills and surrounding creek valleys. Most of the proposed Project construction is along a central, high, relatively flat ridge that trends north and northwest across the Project Area. This area is drained and bounded by three major creeks systems: Canadaway Creek, Walnut Creek, and the West Branch of Conewango Creek. Canadaway Creek and Walnut Creek drain the western and northern regions of the project area, respectively, and both are tributary to Lake Erie. These drainage systems both include very steep sections, sometimes with nearly vertical walls over 100 ft (Lumia and Johnston, 1979; Tesmer, 1963). Along the western and southwestern portions of the Project area there are broader, flatter regions which are swampy and feed the West Branch of Conewango Creek, a tributary of the Allegheny River (Tesmer, 1963).

2.2 Surficial Geology

The exposed surface geology of the Project Area and greater Chautauqua County largely reflects the processes and deposits associated with the last glaciation of New York during Wisconsinan time (13,000 to 14,000 years ago) (Muller and Calkin, 1993). Southeastward advance of the glacier(s) scoured the preexisting landscape, smoothing hilltops and enlarging river valleys into the broad, flat-bottomed, southeast trending valleys now present (Chautauqua Lake's valley, Cassadaga Valley and Conewango Valley). These features are particularly well-developed where the preexisting valleys were parallel to the direction of ice flow (generally southeast). The glacial advance and retreat also left behind regional-scale terminal moraines which form a discontinuous northeast trending line roughly parallel to the Lake Erie shore (till moraine (tm), Figure 3- *Surficial Geology*) (Muller, 1963). Multiple surges and retreats of glaciers through the valleys (and over intervening highlands) produced a complex spatial juxtaposition of glacial sediments of different types in and adjacent to these valleys. The glacial deposits include glacial till, kames (ice-contact deposits), glaciofluvial deposits, (outwash sands and gravels), and glaciolacustrine deposits (fine-grained, layered, lake deposits) (Muller, 1963; Miller, 1998; Waller and Finch, 1984). The total thickness of sediment within these valleys can be quite large, in excess of 200-300 ft, and thin towards valley walls (Waller and Finch, 1982). Within the Project Area, higher elevations are generally glacial till (t), or till moraine (tm), while in valleys and lower elevations, the valley fill deposits include outwash sand and gravels (og), kame deposits (k), lacustrine silt and clay (lsc), and other undifferentiated glacial drift deposits (usd) and recent alluvium (al) (Cadwell, 1986) (Figure 3- *Surficial Geology*). Cadwell (1986) mapped the glacial till that covers the crest of the central higher elevation region of the Project Area as a relatively thin (one (1) to three (3) meters thick) deposit on top of the bedrock, based on sporadic outcropping of rock and/or variable mantle of rock debris and glacial till. Glacial till is an unsorted deposit of glacial sediments ranging in size from clay to boulders, often supported in a dense clay matrix that creates a relatively low permeability deposit. Other major deposits in the Project Area include a till moraine, part of the regional terminal moraine, which is generally better sorted and more permeable than the till (Cadwell, 1986). Kame deposits (deposited directly on the ice and left behind after glacier retreat) are generally better sorted and more permeable than till. In contrast, glacial lake deposits are fine-grained and generally lower permeability. The three-dimensional geometry and stratigraphy of these deposits is often complex and affects the hydrogeologic properties of aquifers depending on how deposits are hydrologically connected.

2.3 Bedrock Geology

Beneath its blanket of variable glacial sediments, Chautauqua County is underlain by approximately 2,000 ft of Late Devonian (ca. approximately 370 million years ago) marine shales, siltstones and conglomerates (Tesmer, 1963). The rocks mapped within the Project Area are the shales and sandstones of the Chadakoin Formation and older Canadaway Group (Rickard and Fisher, 1970; Rickard, 1964; Tesmer, 1963) (Figure 4- *Bedrock Geology*). These rocks are nearly flat-lying to gently southward-dipping (Tesmer, 1963), with the youngest, stratigraphically highest, rocks located in the highest elevation regions and the oldest rocks present at lower elevations. Actual exposure of bedrock within the Project Area occurs in the northwestern region (Figure 3). The youngest rocks in the Project Area, underlying much of the central region and many turbine sites (Figures 4,2), are in the Chadakoin Formation, which includes the Ellicott and Dexterville members. The uppermost unit is the 270 ft thick Ellicott member, mostly relatively soft shale, while the 150 ft thick Dexterville member is a fossiliferous gray siltstone (Tesmer, 1963; Tetra Tech, 2008). Beneath these formations are the various shale members of the Canadaway Formation which together are approximately 650 ft thick and contain gray shales containing lesser amounts of siltstone beds. The Northeast member of the Canadaway Fm., a 470 ft thick gray shale and siltstone underlies the vast majority of the Project Area where the Chadakoin Formation is not the surface unit (Tesmer, 1963; Tetra Tech, 2008) (Figure 4).

2.4 Depth to Bedrock

Few wells with recorded depths to bedrock were located by a search of the NYSDEC and USGS well databases within the immediate project area (Table 1, Figure 5- *Well Locations*). Therefore, CHA contacted local well drillers and the local health department officials with experience in the Project Area. Personal communication with local well drillers Jim Dillenburg (Dillenburg Drilling, Forestville NY) and Fritz Ehmke (Ehmke Well Drillers, Inc., Silver Creek NY) and Chautauqua County Department of Health Assistant Director Bill Boria all indicate that bedrock depths are quite variable across the expanse of the Project Area, as expected for the multiple glacial deposits present. Jim Dillenburg indicated that 11 residential wells in the north-central region of the project area (near the intersection of Center and Weaver Roads), near the boundary between the till (t) and till moraine (tm) units, were between 100-140 ft deep and do not reach bedrock (J. Dillenburg, personal communication, October 15, 2008). Fritz Ehmke reviewed records kept by Ehmke Well Drillers, Inc. within the general Project Area and found that the majority of wells did not encounter shallow (less than approximately 20 ft) bedrock (F. Ehmke, personal communication, October 16, 2008). One relatively shallow example included the Dibble Hill region (25 ft), while an example from Griswold (immediately south of Project Area) was approximately 44 ft. In the central Project region, at Center Arkwright near the intersection of Route 83 and Center Road, bedrock was at a depth of approximately 64 ft. Other regions commonly had recorded depths greater than 89 ft. Mapping by Cadwell (1988) suggested that the approximately one (1) mi wide crest of the hill in the central project area (covered in till) may have local bedrock depths of one (1) to three (3) meters beneath the surface. This is based on the general expectation that the higher elevation, till-covered regions have shallower bedrock depths than the valley-fill deposits because of the underlying bedrock structure and processes by which they originate.

3.0 SITE HYDROGEOLOGY

3.1 Regional and Local Aquifers

Groundwater resources in Chautauqua County are derived from both the glacial deposits and bedrock. Aquifers with the highest potential yields are in glacial deposits, but there is much variation due to the variability of the hydrogeologic properties of the individual deposits. The largest aquifers of southwestern New York are confined and unconfined valley-fill aquifers (sand and gravel sediments deposited with in scoured bedrock valleys) (Miller, 1988). For example, south-southeast of the Project Area in Chautauqua County, the Jamestown aquifer is a confined sand and gravel aquifer overlain by till, fine-grained sands, silt or clay, yielding within the five (5) to 500 gallons per minute (gpm) range (Miller, 1988). There are no sole-source or primary aquifers within the Project Area (Tetra Tech, 2008).

Within the town of Arkwright, an unconsolidated, unconfined aquifer with a potential yield greater than 100 gpm is mapped southwest of the Project Area (New York State GIS Data Clearinghouse, 2008; Miller 1988) (Figure 6- *Aquifer Mapping*). Immediately north of this aquifer, including portions of the central Project Area, Miller (1988) identified moraine deposits that are mostly till and lake sediments, which contain scattered confined aquifers of sand and gravel. Most of the Project Area is sited on till, till moraine, kame deposits, undifferentiated stratified drift, bedrock and some outwash and gravel deposits (Figure 3). In general, it is expected that glacial outwash sand and gravels and kame deposits, which are typically more sandy and porous, make better aquifers than finer to very finely grained tills and other clay-rich drift units that can be highly impermeable. Much of the central ridge of the Project Area is overlain by till (Cadwell, 1986). Personal communication with Fritz Ehmke suggested that residential wells are set within this till, and coarser grained layers and lenses (similar to the description in Miller (1988)) yield adequate water for residential purposes. Bill Boria also indicated that water is available within the till deposits (B. Boria, personal communication, October 15, 2008). This till is bounded on its north side by a till moraine deposit (Figure 3), which is more variably sorted than till and generally more permeable (Cadwell, 1986). The eleven residential wells (110 to 140 ft deep) set by Jim Dillenburg (near the intersection of Center and Weaver Roads) supply satisfactory quantities of water and are located very near the boundary between the till and till moraine deposits.

Examination of well records indicates that many wells are also set in the bedrock locally (Table 1). Relative to the unconsolidated aquifers in the area, few hydrogeologic studies of the bedrock have been preformed in the region. The shales are relatively impermeable, and often form the bottom of confined aquifer systems within the region (Lasala, 1968). However, coarser layers and fractures increase the hydrologic conductivity. Local well drillers (J. Dillenburg, F. Ehmke, personal communication, October 2008), and the well records in Table 1 suggest that wells set in bedrock have relatively lower (less than 10 gpm) potential yields, but are adequate for residential purposes.

3.2 Local Well Data

A search of the New York State Department of Environmental Conservation (NYSDEC) Water Well Information database (NYSDEC, 2008) provided a list of wells within the Project Area and surrounding region. A similar search was also conducted in the United States Geological Survey (USGS) National Water Information System (USGS, 2008).

Table 1. Wells located in Project Area and surrounding region.

Well Name	Well Depth (ft)	Rock Depth (ft)	Ground Water Depth (ft)	Yield (gpm)	Data Source	Depth to top of geohydro unit	Latitude	Longitude
CU 816	141	NA	NA	NA	USGS	141	42.442500	79.193611
CU 815	41	NA	NA	NA	USGS	34	42.441944	79.304444
CU 812	27	NA	NA	NA	USGS	NA	42.428333	79.294444
CU 811	NA	NA	NA	NA	USGS	NA	42.427778	79.296944
CU 807	100	NA	NA	NA	USGS	95	42.418611	79.187222
CU 803	165	NA	NA	NA	USGS	NA	42.415556	79.204167
CU 795	324	NA	NA	NA	USGS	324	42.394722	79.189167
CU 780	86	NA	NA	NA	USGS	NA	42.364444	79.313056
CU 2695	52	30	15	10	DEC	NA	42.377083	79.322917
CU 2573	45	20	25	20	DEC	NA	42.341389	79.290167
CU 2557	75	48	48	10	DEC	NA	42.362444	79.264333
CU 2397	96	24	56	6	DEC	NA	42.364472	79.330389
CU 2297	365	351	3	2	DEC	NA	42.376722	79.313917
CU 2275	130	60	22	5	DEC	NA	42.411000	79.206000
CU 2262	60	47	10	10	DEC	NA	42.437889	79.287278
CU 2232	81	NR	40	15	DEC	NA	42.367222	79.313944
CU 2204	50	25	12	7	DEC	NA	42.362000	79.200167
CU 1905	93	NR	20	40	DEC	NA	42.368472	79.294694
CU 1885	88	NR	20	40	DEC	NA	42.367444	79.294806
CU 1806	70	30	30	NA	DEC	NA	42.341000	79.293500
CU 1749	70	18	25	8	DEC	NA	42.361556	79.288139
CU 1669	48	NR	14	7	DEC	NA	42.426083	79.137167
CU 1654	47	NR	10	7	DEC	NA	42.433167	79.177500

Well Name	Well Depth (ft)	Rock Depth (ft)	Ground Water Depth (ft)	Yield (gpm)	Data Source	Depth to top of geohydro unit	Latitude	Longitude
CU 1631	61	NR	30	15	DEC	NA	42.349667	79.337167
CU 1012	134	NA	85	1.5	DEC	NA	42.372500	79.295000
0134 cell18	57	NA	NA	NA	USGS	NA	42.360833	79.186111

NR = No rock encountered

NA = Information not provided

These wells are set in both bedrock and glacial deposits (see locations, Figure 5) with potential yields ranging between 1.5 and 40 gpm.

3.3 Public Wells and Water Sources

In the well records presented above, there was no information available distinguishing between public water supply wells and individual residential wells, as the exact locations of public water systems are not disclosed. Personal communication with Bill Boria, Assistant Director at the Chautauqua DOH suggested several public, non-community wells are located within the Project Area. Public, non-community wells include wells connected to systems with less than five service connections and regularly serve more than 25 people on a daily basis for at least 60-days out of the year. These may include office buildings, retail stores, campgrounds, etc. In addition to the non-community wells, the Village of Forestville has several community water supply sources located approximately 1.5 to 3.5 mi south of the village itself, on 136 acres that it owns within the Town of Arkwright (Chautauqua County Department of Health (DOH), 2008). Personal communication with Village officials indicates that the Forestville springs are located in the general area of the Shaw and Putnam Roads and Mud Lake, a location that is approximately one (1) mile from the nearest turbine location. These springs appear to be the closest community source to the Project Site. This water supply, which includes two (2) wells that yield a combined 25 gpm and three (3) springs yielding an estimated 60 gpm, has a recent history of significant water shortages and problems with surface water influence (Chautauqua County DOH, 2008)

3.4 Depth to Groundwater

The published information available on depths to groundwater within the Project Area is presented in Table 1. These data indicate groundwater depths range from three (3) to 81 ft beneath the ground surface. Depth to groundwater is variable by location as it depends on the thickness of glacial sediment cover, which is highly variable, and the hydrogeologic characteristics of the aquifer in a given location.

3.5 Groundwater Recharge

Groundwater supplies are maintained from surface water recharging the aquifers. In most cases, precipitation that does not runoff to streams or returns to the atmosphere through evapotranspiration is available for groundwater recharge.

On a local scale, recharge occurs over the surficial sand and gravel deposits by direct infiltration. Direct infiltration also likely recharges the bedrock aquifer where bedrock is exposed at the surface, lies close to the surface, or is overlain by the sand and gravel deposits. Where bedrock is overlain by glacial till, which has a relatively low permeability, recharge through direct infiltration may be less prevalent.

3.6 Water Quality

Little information was available regarding existing water quality within the Project Area. Community water supplies in the region such as the Berry Road Water District (WD), Cherry Creek Village, Chestnut Road WD, and Forestville Village report few to no Safe Drinking Water Information System (SDWIS) violations within the last ten (10) years, with the exception of the Village of Fredonia, which reported various SDWIS violations including metal and organic contaminants (Environmental Protection Agency (EPA), 2008). One source for the Village of Forestville is a spring under the influence of surface water that has been required by the Chautauqua DOH to either undergo treatment or go offline by December 2008 due to the presence of E. coli bacteria (Chautauqua DOH, 2008). Other historical quality problems regionally included high barium concentrations in domestic wells set in bedrock and an overlying confined aquifer on the Cattaraugus Indian Reservation during the 1980s through 1990s (Moore and Staubitz, 1984; Miller, 1998). The Cattaraugus Indian Reservation is located near the northeastern tip of Chautauqua County. Possible contamination problems associated with natural gas wells were also reported in Chautauqua County during the late 1970s to 1980s (Bill Boria, Chautauqua County DOH, personal communication; Knudson, 1986).

3.7 Summary

Groundwater resources within the Project Area and surrounding regions include relatively high potential yield glacial valley-fill deposits and moraines, and generally lower yield glacial till deposits and bedrock sources. Available well records, indicate that many of the low yielding wells are sufficient for residential purposes, although may be inadequate for community supplies, as is the case for the Forestville Village water supply wells (Chautauqua DOH, 2008). Concerns of local residents have indicated that in some locations, installing a productive well is problematic. Bill Boria (Chautauqua County DOH) indicated that at least one resident in the vicinity of Route 83 in Arkwright had difficulty locating water. Fritz Ehmke (Ehmke Well Drillers, Inc.) also indicated that the area along Route 83 between the Pomfret town line and Arkwright Center is sometimes problematic for locating water. Taken together, the available data suggests that most of the Project Area contains modest to average groundwater availability, but due to the variable nature of the glacial deposits some locations require deeper wells and generally overlie low-yield deposits.

4.0 POTENTIAL IMPACTS

4.1 Aquifer Characteristics and Water Availability

4.1.1 Recharge

A potential impact to from the project to aquifers supplying potable water may be associated with a change in recharge rates due to paving and construction in the project area. The total surface areas of soil that will be disturbed during and after project construction are estimated in the table below. The total permanent impervious surface area (excludes gravel roads, parking lots and crane pads) is much smaller, less than 13 total acres for the turbines, substation and the estimated 5000 to 8000 ft^2 operation and maintenance building. Permanent impacts for the underground and overhead collection systems will be available once final design is completed, but are limited to pole placement areas and conversion of forested areas to grass or scrub/shrub area. Access roads that are proposed or already in existence will be gravel, and temporary leveled and compacted surfaces associated with construction areas will be de-compacted at construction completion.

Table 2. Total surface areas of disturbed soil.

Component	Temporary Impact (acres)	Permanent Impact (acres)
Wind Turbines	198	8
Access Roads	81	62
Improvements to Existing Public Roads	4	4
Underground collection system	39	0
Overhead Collection system	8	0
Substation and POI Switchyard	5	5
Laydown Yard	8	0
O&M Building	9	9
Switchgear Facility	1	1
Meteorological Towers	4	<1
Totals:	**357**	**89**

It is anticipated that changes in recharge will be negligible due to the small size of impervious surface area relative to the size of the Project Area (approximately 5,961 acres), particularly when the greater regional recharge area is considered.

4.1.2 Construction Phase Dewatering and Drawdown

A second potential impact is a temporary drawdown of the local water table due to construction phase dewatering of foundation sites. It is possible that dewatering will be required due to the shallow water table in the project area. In this context, the deepest foundations to be installed are the turbine tower foundations. While the exact specifications of these foundations are dependent on the results of the site-specific geotechnical reports that will be conducted immediately prior to construction, the currently anticipated foundation type is a spread foot foundation. These foundations have typical diameters of 58 ft, typical depths of 12 ft, and require about 330 cubic yards of concrete (Tetra Tech, 2008). Given the anticipated volume of water that will require removal and the potential drawdown depth relative to the distance to surrounding residences (minimum of 1200 ft) it is not anticipated that groundwater elevations will change significantly at residential sites. Also, the pumped water will be re-introduced and allowed to infiltrate back into the groundwater system near the pumping site, recharging the local surficial aquifer. After the construction phase, near-surface water flow paths may be slightly affected immediately downgradient of turbine foundations and by back-filled trenches emplaced for the underground collection line and other utility trenches. However, as with the case of potential drawdown, it is expected that the 1200 ft buffer is an adequate distance for shallow water flow to resume its natural flow characteristics.

4.1.3 Bedrock Blasting

Perhaps the most significant plausible effect of Project construction on groundwater flow would be due to bedrock blasting. Blasting of bedrock can create new fractures in the bedrock that temporarily or permanently change groundwater flow paths. As stated in the DEIS, the necessity of bedrock blasting for turbine footers will not be specifically determined until geotechnical reports are completed for each site, which in turn affects the foundation construction specifics for each site. Bedrock depths are variable, with the quantitative estimates available from well records and personal communications indicating depths greater than at least 25 ft at various locations in the Project Area. It is possible that bedrock is slightly shallower than these estimates (less than approximately 10 ft) along the central hillcrest in the Project Area according to regional geologic interpretation; however this possibility has not been field checked. If bedrock is encountered at shallow depths, it will not necessarily require blasting for removal. For example, less destructive means of rock removal such as localized stripping with an excavator and drilling for footer placements would be attempted first. Personal communication with Jim Dillenburg, experienced with both well drilling and construction services in the region, indicated that bedrock conditions rarely require blasting due to the soft nature of the shales. This thought was echoed by well driller Fritz Ehmke. Personal communication with CHA geotechnical staff indicates that blasting is commonly unnecessary for the approximate 12 foot depth and structural demands of turbine tower footings. Additionally, the topography of much of the Project Area, as well as construction plans to use existing roads while minimizing environmental impacts, suggests that extensive blasting for grading processes is unlikely, although construction specifics are discussed in more detail within the DEIS (Tetra Tech, 2008). A blasting plan will be prepared if it is determined that bedrock blasting is required.

4.2 Water Quality

Anticipated possible water quality impacts include: increased turbidity due to loose soils and erosion from construction, spills associated with construction equipment and turbine operation, and changes in groundwater chemistry associated with permanent installments.

The disruption of soils by grading and excavating, as well as the temporary loss of vegetative cover during construction will increase the likelihood of erosion and therefore the introduction of sediment into water bodies. Approximately 357 acres of surface soils will be disturbed during construction, although approximately 75% of this area will be restored for permanent project operation (Tetra Tech, 2008). This affect will have essentially no impact on groundwater quality, as eroded sediment entrained in runoff will be deposited in surface waters or on the ground surface itself. Springs would generally be unaffected assuming they are true springs sourced in bedrock or glacial sediments. Only surface waters like open streams would experience increased sediment levels when directly fed by Project Area runoff. A formal stormwater plan (SWPPP) for the Project site is being prepared to minimize these impacts to surface waters and wetlands.

The greatest potential for impact to aquifer water quality would be a release of a hazardous material or petroleum product during the construction activities. During construction, the re-fueling or routine maintenance of construction vehicles and equipment could result in fuel/chemical spills. This risk may continue throughout the operation phase of the project, although at a much smaller risk due to the significant decrease in equipment and vehicular traffic in the project area, and the small amounts of fuel and chemical required for a wind power project. The wind turbines themselves do not require cooling towers or generate liquid effluent, but the towers and associated equipment use lubricating and insulating oils in a closed system. Chemicals that will be present during the operation phase of the project in the turbines and substation/transformer equipment include gear oil, lubricating oil, mineral oil, and greases. There is some risk of spillage during transport or delivery of these fluids. Spills and leaks in general could occur as a result of vehicle accidents, equipment malfunction, human error, terrorism, sabotage, vandalism, or aircraft impact. Spill prevention measures will be incorporated into the final design to minimize potential impacts from fuel/chemical spills. In addition, a Spill Prevention Control and Countermeasure Plan (SPCC Plan) specific to the project will be developed in accordance with EPA requirements prior to construction.

5.0 AVOIDANCE, MINIMIZATION, AND MITIGATION OF IMPACTS

In general, potential impacts to groundwater associated with the Project are broken into two categories: those that are short-term (i.e. associated with temporary construction activities) and those that may have long-term effects.

5.1 Short Term Impacts

As discussed in Section 4.2, the greatest potential for impact to the aquifer would be a release of a hazardous material or petroleum product during the construction activities. Based on the proximity to the ground surface and permeability characteristics, the sand and gravel surficial aquifer is more susceptible to a potential release of this type than is the bedrock aquifer. As such, residents using the surficial aquifer as a drinking water source could be adversely affected should a spill occur. The most effective way to avoid or minimize the potential for a spill is to develop specific prevention and response actions.

Spill prevention measures will be incorporated into a project-specific SPCC Plan to minimize potential impacts from fuel/chemical spills. Spill prevention measures may include, but are not limited to, the following:

- Appropriate absorbent pads and media shall be kept in a staging area to clean-up minor spills and releases. These staging areas will be located in close proximity to work sites and the laydown yard to ensure quick response to potential spills.
- All fuel/chemicals on-site should be stored over an impermeable surface with secondary containment where necessary.
- Best management practices will be followed during equipment refueling operations.

- In the event of a reportable spill, the NYSDEC will be contacted immediately by dialing the NYSDEC Spill Hotline. All NYSDEC required cleanup procedures will be strictly adhered to.
- In the event of a spill, contaminated material will be excavated and temporarily stockpiled on impermeable plastic.
- In the event of a spill, contaminated materials will be removed from the site and disposed of in accordance with NYSDEC regulations.

In addition to the SPCC Plan, a SWPPP is being prepared to address any potential water quality concerns related to increased erosion and/or sedimentation. There are no other significant short-term effects anticipated as a result of the project activities. Water table drawdown associated with foundation construction dewatering is possible, but is considered a short term affect that will not affect individual drinking water wells due to 1200 ft setbacks distances.

5.2 Long Term Impacts

It is anticipated that few additional mitigation efforts beyond those already incorporated in project plans (1200 ft setback from residencies, SPCC and SWPPP plans, minimization of disturbed surface area and grading) will be required to protect groundwater resources within the Project Area throughout the operation phase of the Project. However, there are a number of recommendations to minimize the potential long-term impacts:

- Bedrock blasting should be avoided to the largest extent possible to prevent potential changes in groundwater flow and direction. Given the aquifers' characteristics, the 1200 ft setback from project sites to residences is considered more than sufficient. Any potential blasting-induced changes in groundwater flow could be compensated for by flow from surrounding areas and would not significantly affect the quality or quantity of residential wells seated in bedrock or the surficial aquifer. Furthermore, the material properties of the shales underlying most of the Project Area make it unlikely that blasting would be required, as they are generally easily stripped. However, the avoidance or minimization of blasting would provide greater protection to the existing groundwater regime. A blasting plan will be prepared if any blasting is required.

- The greatest potential for long-term impacts would be from changes in surface water run-off patterns and changes in surface water quality. Significant changes to both run-off patterns and water quality could potentially impact sensitive sources such as springs or shallow wells in the immediate vicinity of projected disturbance areas. Based on the groundwater sources identified during CHA's research, none of these sources would be particularly susceptible to impacts due to either their distance from the Project Site or the reported well depths. However, since our research has not identified all potential residential wells in the area, appropriate storm-water management and spill prevention measures should be employed during construction.

6.0 CONCLUSIONS

The proposed Project involves the construction of 44 wind-powered turbines, meteorological towers, a system of gravel access roads, a buried and overhead electrical collection system, an operation and maintenance building, and an inter-connection substation facility.

Two main aquifers, the surficial glacial deposits and shale bedrock units encompass the groundwater system in the Project Area. These aquifers are recharged locally in the Project Area. These aquifers combine to produce a generally adequate groundwater supply in the region. Local residencies and communities within and surrounding the Project Area often use wells set within both the bedrock and surficial glacial deposits in addition to surface water sources.

Potential impacts to water sources include possible spills from mechanical equipment during construction and operation, temporary water table elevation changes due to dewatering of foundation holes during construction, and possible disruptions of groundwater flow due to bedrock blasting. The risk of these impacts occurring is very low. Specific impacts on individual residencies' wells or spring sources are beyond the scope of this desktop study, however given the setbacks established for the project, specific impacts are unlikely.

Based on a review of existing hydrogeologic conditions, the Project is not anticipated to have any significant impacts on the quality or quantity of groundwater used by residents as a drinking water source. Some potential impacts have been identified but are considered minimal and can be easily mitigated for during the project.

7.0 REFERENCES

Cadwell, D.H., 1986. *Surficial Geologic Map of New York*- Niagra Sheet. New York State Museum Geologic Survey, Map and Chart Series #40.

Chautauqua County Department of Health Division of Environmental Health Services, 2008. *Municipal Water Supply Needs Assessment, Part I: Northern Chautauqua County* http://www.co.chautauqua.ny.us/health/Drinking%20Water%20Reports.htm.

Environmental Protection Agency (EPA) *Safe Drinking Water Information System (SDWIS), 2008*. Chautauqua County Water Systems. Retrieved October 13th, 2008 from http://www.epa.gov/enviro/html/sdwis/sdwis_query.html

Isachsen, Y.W., E. Landing, J.M. Lauber, L.V. Rickard, W.B. Rogers, ed., 2000. *Geology of New York: A Simplified Account*, 2nd Edition. New York State Museum/Geological Survey, Educational Leaflet 28. Albany, New York.

Knudson, T.J., 1986. *Tainted Well-Water Mystery Spoils Tranquility of Southwest New York*: The New York Times, August 18th, 1986.

Lasala, A.M., 1968. *Ground-water resources of the Erie-Niagra Basin, New York:* New York State Water Resources Comission Basin Planning Report ENB-3, 114 p.

Lumia, R. and Johnston, W.H. 1984. *Floods of August 7-8, 1979, In Chautauqua County, New York, With Hydraulic Analysis of Canadaway Creek in the Village of Fredonia.* United States Geological Survey, Water Resources Investigation Report 83-4211.

Miller, T., 1988. *Potential yields of wells in unconsolidated aquifers in upstate New York: Niagra Sheet.* United States Geological Survey, Water Resources Investigation Open File Report 87-4076.

Miller, T., 1998. *Hydrogeology and Simulation of Ground-Water Flow in a Deltaic Sand-and-Gravel Aquifer, Cattaraugus Indian Reservation, Southwestern New York.* United States Geological Survey, Water Resources Investigations Report 97-4210.

Moore, R.B. and Staubitz, W.W., 1984, *Distribution and source of barium in ground water at Cattaraugus Indian Reservation, southwestern New York*: U.S. Geological Survey Water-Resources Investigations Report 84-4129.

Muller, E., 1963. *Geology of Chautauqua County, New York: Part II, Pleistocene Geology* New York State Museum and Science Service Bulletin Number 392, 60 p.

Muller, E.H. and Calkin, P.E., 1993. *Timing of Pleistocene glacial events in New York State.* Canadian Journal of Earth Science, v. 30, p. 1829-1845.

New York State Department of Environmental Conservation (NYSDEC), 2008. *Water Well Program Information Search Wizard.* Retrieved October 13th, 2008 from http://www.dec.ny.gov/cfmx/extapps/WaterWell/index.cfm?view=searchByCounty

New York State Geographical Information Systems Clearinghouse, 2008. *Selected spatial data in New York.* Retrieved from http://www.nysgis.state.ny.us

Rickard, L.V., 1964. *Correlation of Devonian Rocks in New York State.* New York State Museum and Science Service Geological Survey, Map and Chart Series, No. 4.

Rickard, L.V., and Fisher, D.W. 1970. Reprinted 1995. *Geologic Map of New York: Niagra Sheet. Scale 1:250,000.* New York State Museum Map and Chart Series No. 15. Albany, New York.

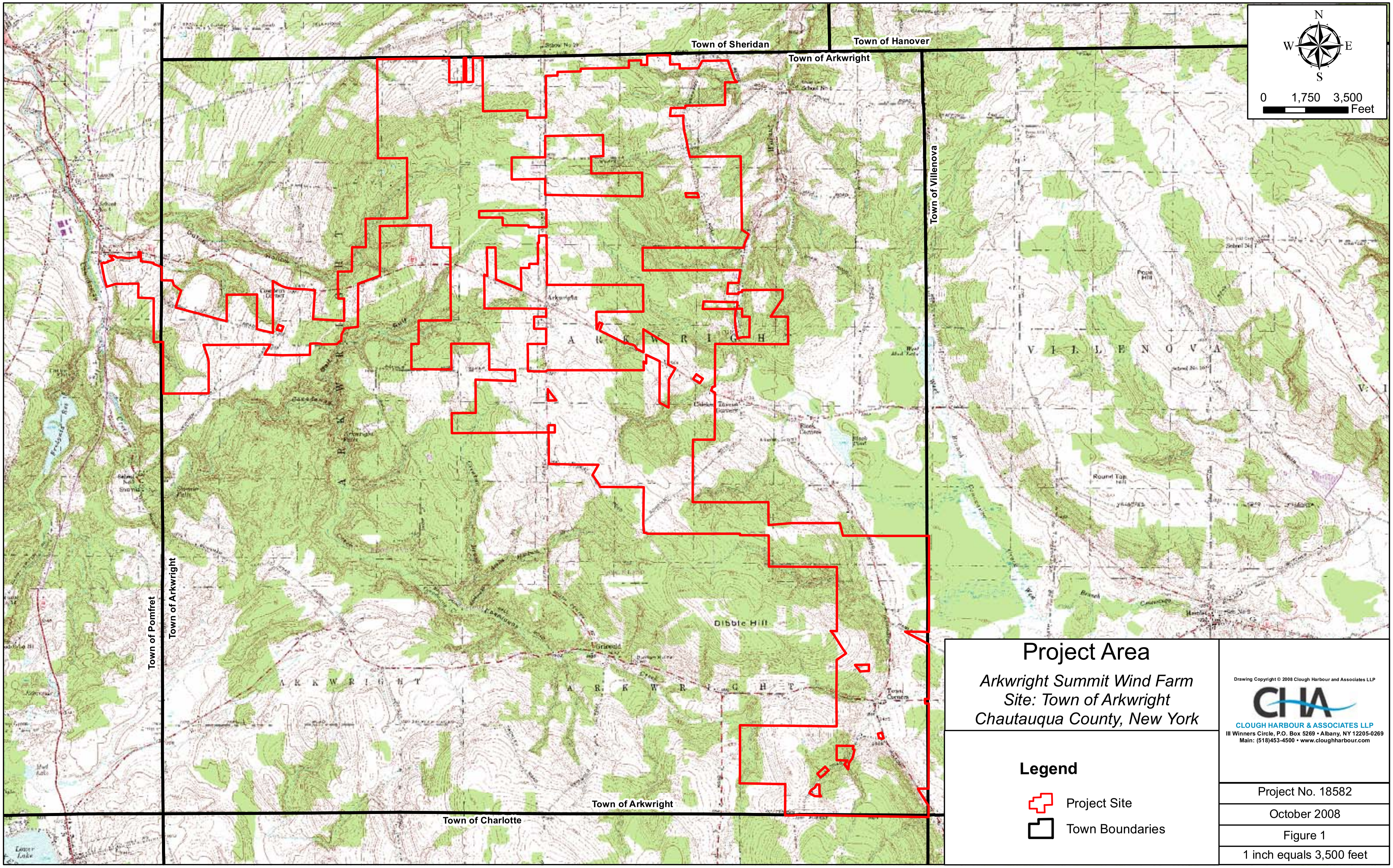
Tesmer, I., 1963. *Geology of Chautauqua County, New York: Part I, Stratigraphy and Paleontology (Upper Devonian).* New York State Museum and Science Service Bulletin Number 391, 65 p.

Tetra Tech EC, Inc., February 2008. *Draft Environmental Impact Statement, Proposed Arkwright Summit Wind Farm Project.* Prepared for Arkwright Summit Wind Farm LLC, Albany, New York.

United States Geological Survey (USGS) *Water Resources National Water Information System (NWIS), 2008. Well F-854 water level information.* Retrieved October 7th, 2008 from: http://nwis.waterdata.usgs.gov/ny/nwis/gwlevels

Waller, R.M. and Finch, A.J., compilers, 1982. *Atlas of Eleven Selected Aquifers in New York.* United States Geological Survey, Water Resources Investigation Open File Report 82-553.

FIGURES



Project Area

Arkwright Summit Wind Farm
Site: Town of Arkwright
Chautauqua County, New York

Legend

Project Site
Town Boundaries

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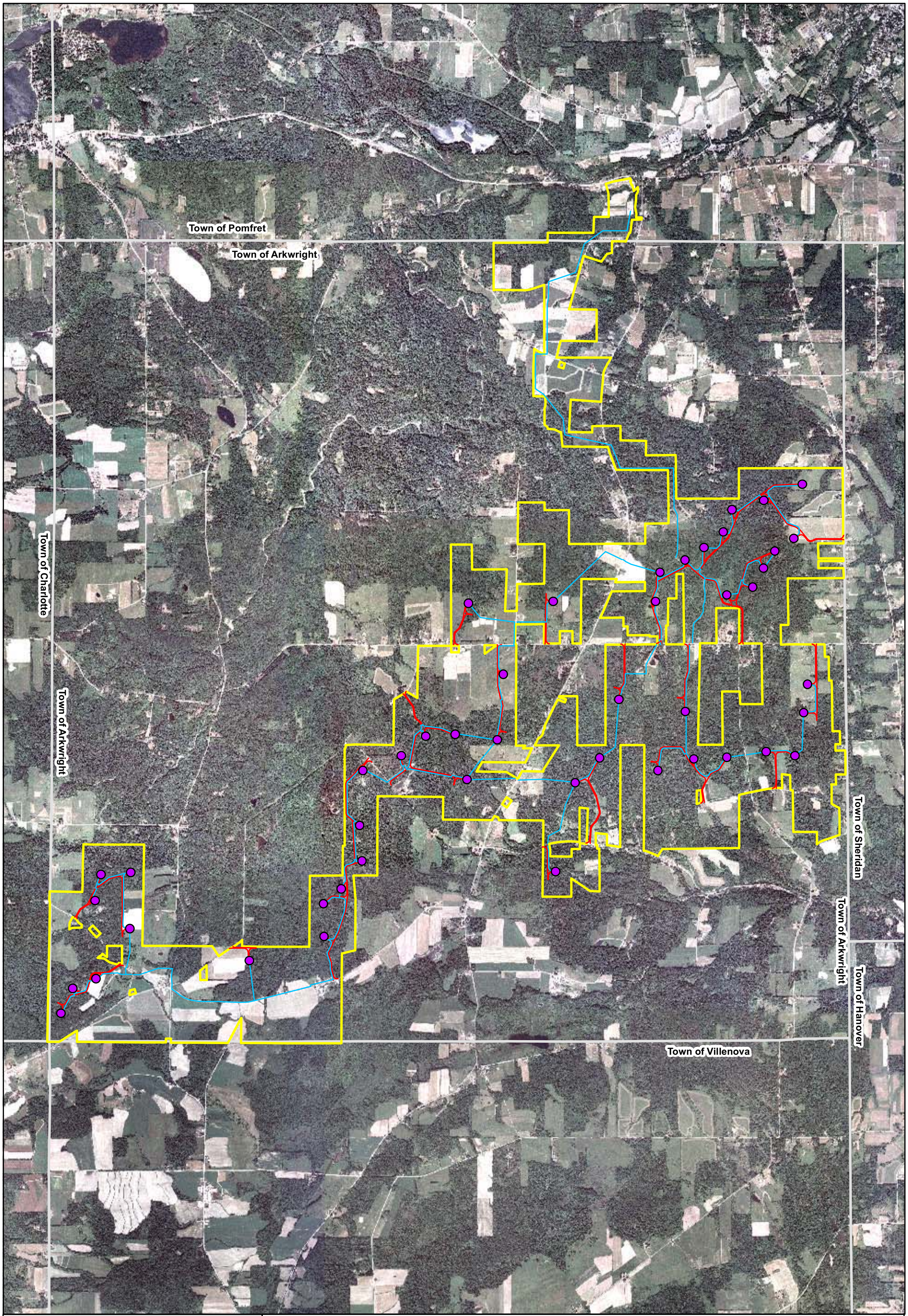
Project No. 18582
October 2008
Figure 1
1 inch equals 3,500 feet



Legend

- Turbine Location
- Collection Lines
- AccessRoad
- Project Site
- Town Boundaries

N

Site Plan

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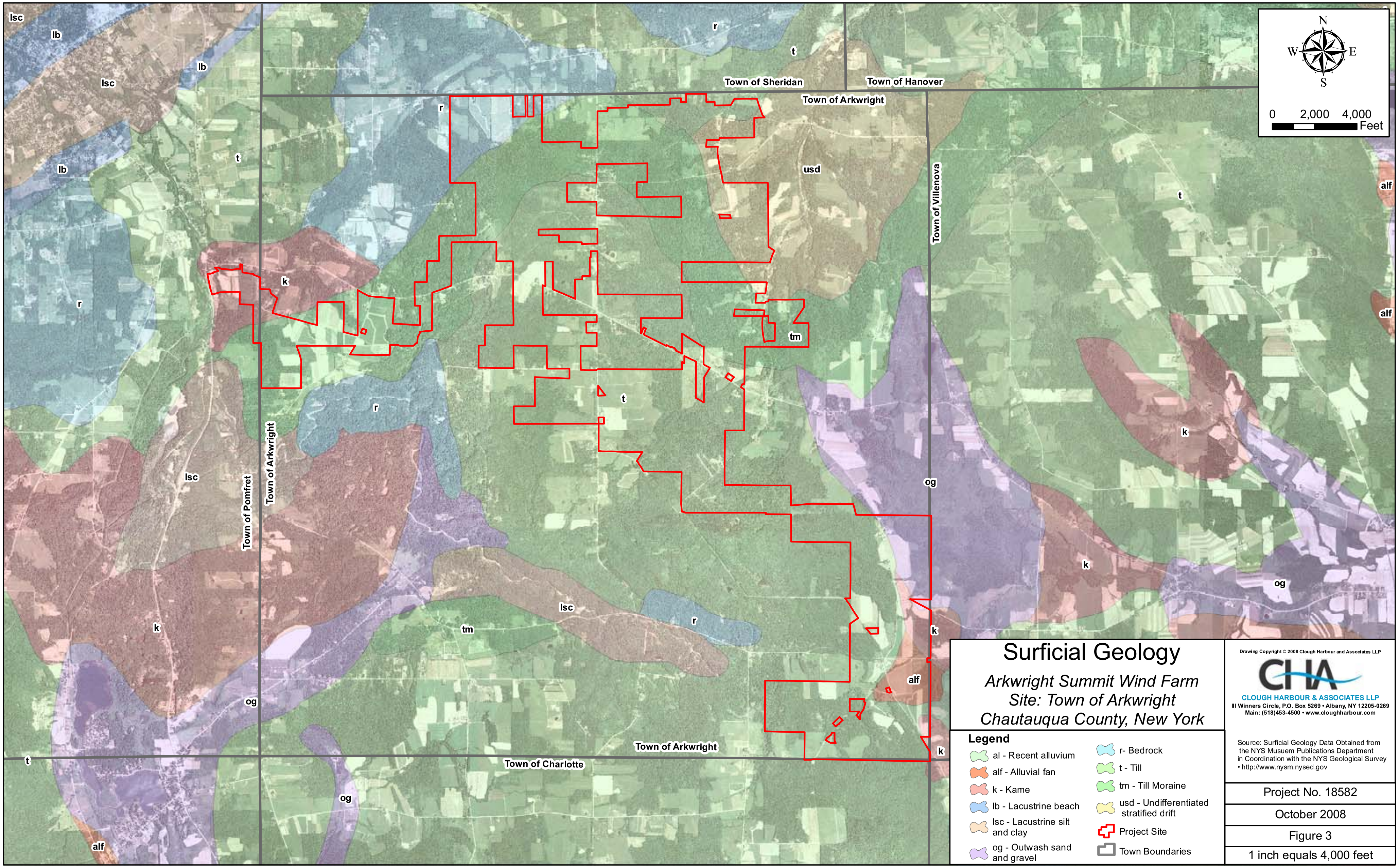
1 inch equals 3,500 feet

Figure 2

Arkwright Summit Wind Farm
Site: Town of Arkwright
Chautauqua County, New York



Surficial Geology

Arkwright Summit Wind Farm
Site: Town of Arkwright
Chautauqua County, New York

Legend

- al - Recent alluvium
- alf - Alluvial fan
- k - Kame
- lb - Lacustrine beach
- lsc - Lacustrine silt and clay
- og - Outwash sand and gravel
- r- Bedrock
- t - Till
- tm - Till Moraine
- usd - Undifferentiated stratified drift
- Project Site
- Town Boundaries

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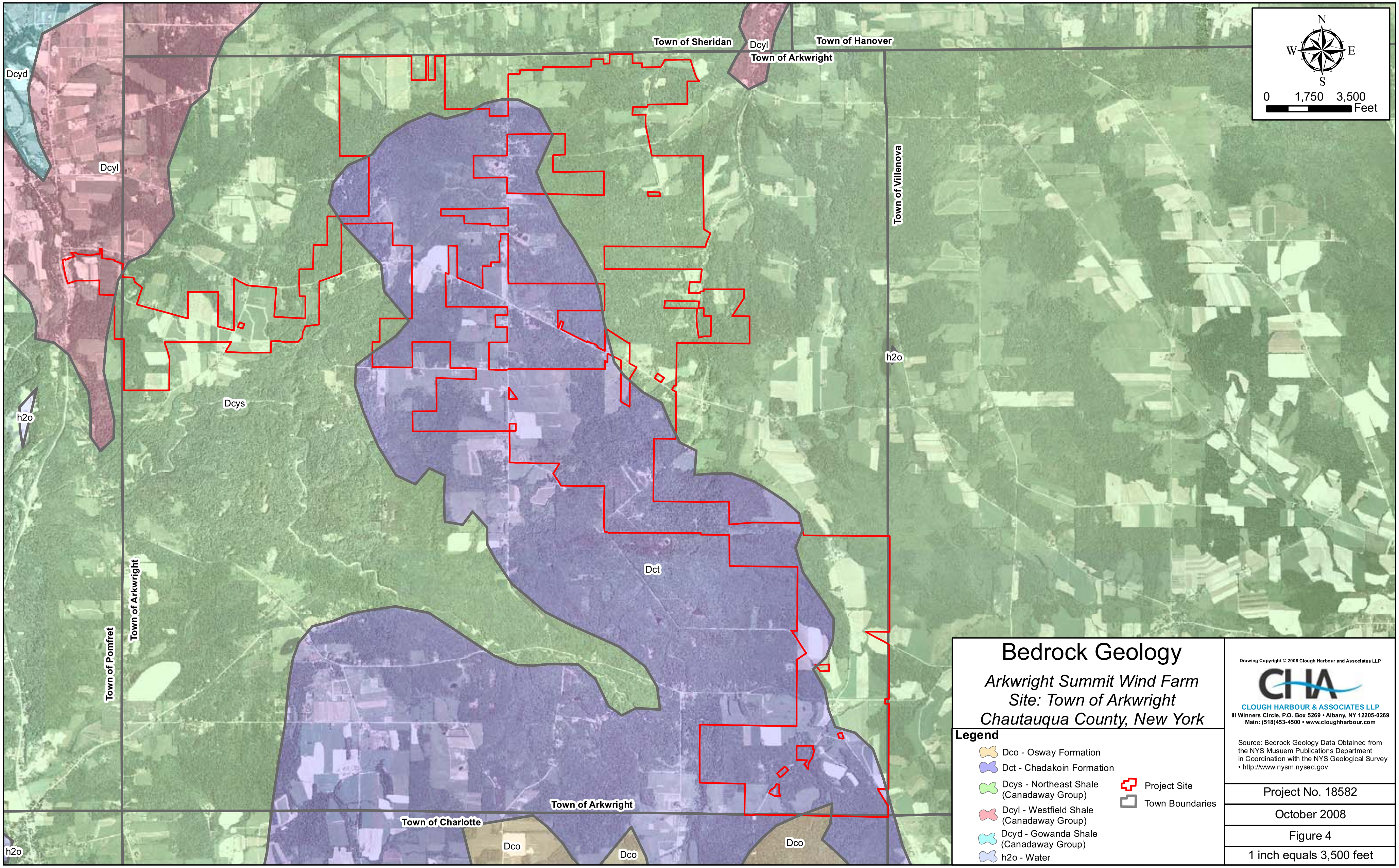
Figure 3

1 inch equals 4,000 feet



Town of Sheridan
Dcyl
Town of Hanover
Town of Arkwright
Dcyd
Dcyl
Dcys
h2o
Town of Villenova
h2o
Dct
Town of Pomfret
Town of Arkwright
Town of Arkwright
Town of Charlotte
Dco
Dco
Dco
h2o
N
W
E
S
0 1,750 3,500 Feet
Bedrock Geology
Arkwright Summit Wind Farm
Site: Town of Arkwright
Chautauqua County, New York
Legend
Dco - Osway Formation
Dct - Chadakoin Formation
Dcys - Northeast Shale (Canadaway Group)
Dcyl - Westfield Shale (Canadaway Group)
Dcyd - Gowanda Shale (Canadaway Group)
h2o - Water
Project Site
Town Boundaries
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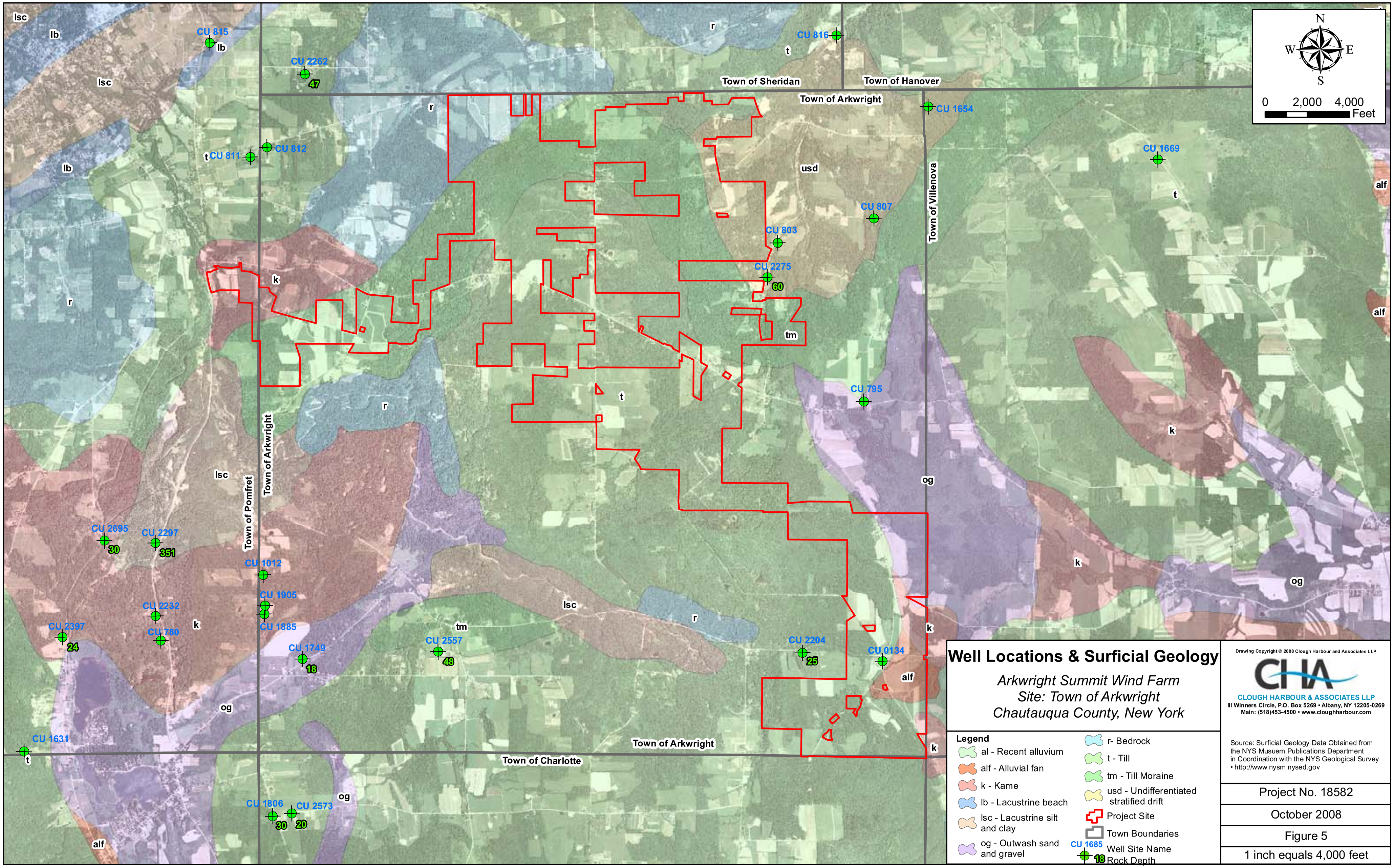
Project No. 18582
October 2008
Figure 4
1 inch equals 3,500 feet



Well Locations & Surficial Geology
Arkwright Summit Wind Farm
Site: Town of Arkwright
Chautauqua County, New York
Legend
al - Recent alluvium
alf - Alluvial fan
k - Kame
lb - Lacustrine beach
lsc - Lacustrine silt and clay
og - Outwash sand and gravel
r- Bedrock
t - Till
tm - Till Moraine
usd - Undifferentiated stratified drift
Project Site
Town Boundaries
CU 1685 Well Site Name
18 Rock Depth
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• http://www.nysm.nysed.gov
Project No. 18582
October 2008
Figure 5
1 inch equals 4,000 feet
N
S
E
W
0
2,000
4,000
Feet
Town of Sheridan
Town of Hanover
Town of Arkwright
Town of Villenova
Town of Pomfret
Town of Charlotte
CU 815
CU 2262
47
CU 811
CU 812
CU 816
CU 1654
CU 1669
CU 807
CU 803
CU 2275
60
CU 795
CU 2695
30
CU 2297
351
CU 1012
CU 1905
CU 1885
CU 2232
CU 780
CU 2397
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CU 1749
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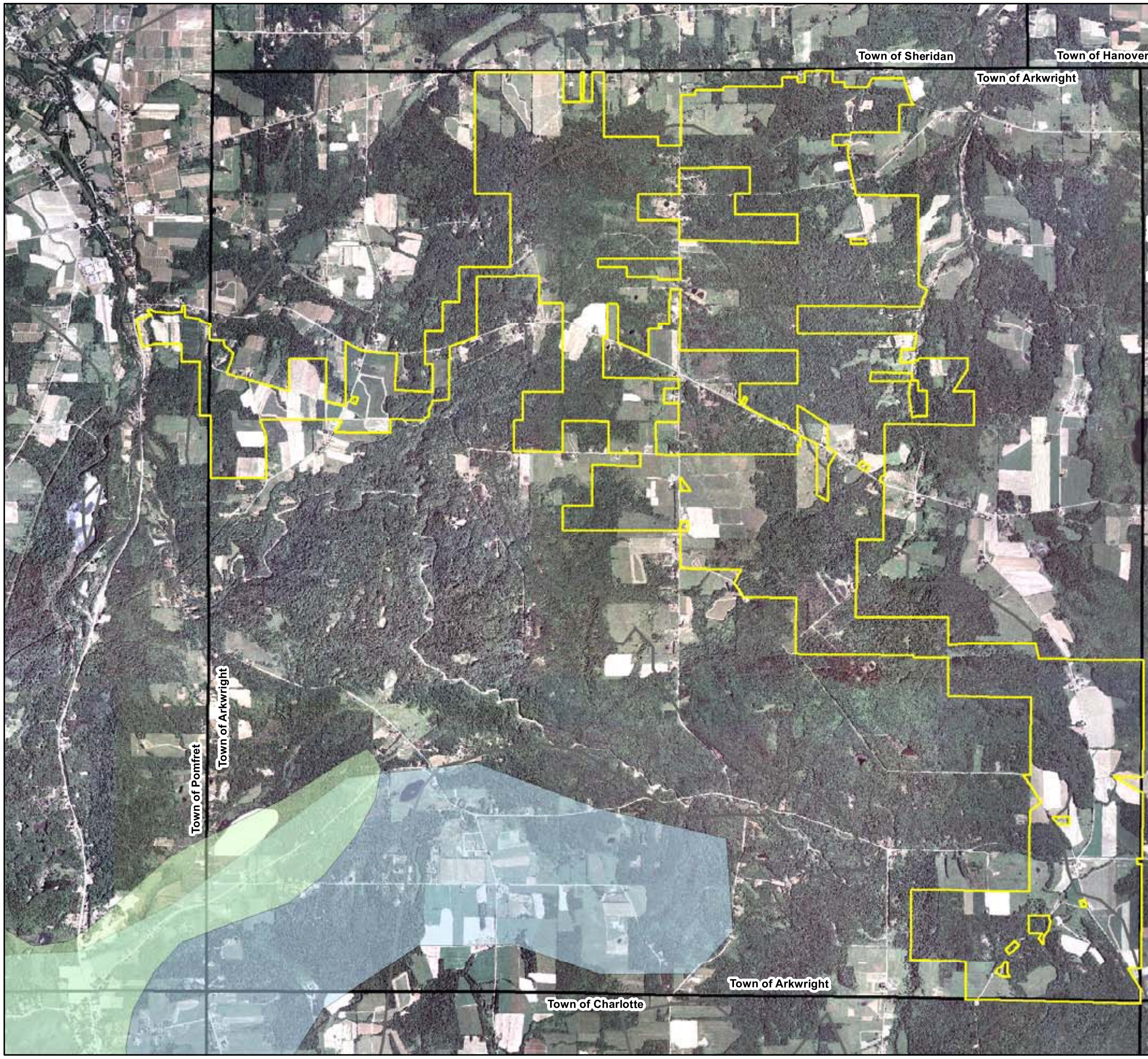
CU 2557
48
CU 2204
25
CU 0134
CU 1631
CU 1806
30
CU 2573
20



Aquifers

Arkwright Summit Wind Farm
Site: Town of Arkwright
Chautauqua County, New York

Legend

- Regional New York Aquifers
- Aquifers of Aluvial Glacial Origin
- Project Site
- Town Boundaries

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Source:
Regional New York Aquifers obtained from the NYS Department of Health via the NYS GIS Data Clearinghouse • Aquifers of Aluvial Glacial Origin obtained from The USGS via National Atlas.gov

Project No. 18582

October 2008

Figure 6

1 inch equals 3,500 feet