Horsley & Witten, Inc.
Environmental Services

GROUNDWATER RESOURCES STUDY
FINAL REPORT

TOWN OF STANFORD, NEW YORK

August, 2000

Prepared for:

Town of Stanford, New York
and
Dutchess County Water and Wastewater Authority

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EXECUTIVE SUMMARY

This Groundwater Resource Study was prepared to provide the framework to protect the Town of Stanford's drinking water supply. Currently, the Town utilizes on-site private wells to obtain drinking water and on-site septic systems for wastewater disposal.

The hydrogeology of the Stanford area is composed of a complex structure of bedrock and sand and gravel aquifers, which are probably interconnected via faults, fractures and solution channeling. Based on the data provided, the majority of the existing private drinking water supply wells are in bedrock and of those, most are in the shale, sandstone, and greywacke of the Normanskill Formation.

To evaluate existing water quality conditions Horsley & Witten reviewed data from numerous private wells. Twenty-one of the forty-eight sampled wells (44%) exhibited at least one compound at a concentration significantly above background levels. For this purpose, background levels have been qualitatively defined as those realistically expected to occur in the absence of anthropogenic contamination. In addition, seven of the forty-eight sampled wells (15%) exceeded New York State maximum contaminant levels (MCLs) for at least one of the sampled parameters (New York State Sanitary Code, 1993). Six of those exceedances are accounted for by the presence of coliform bacteria in the well sample and the seventh exceedance is due to the presence of chloride in excess of the MCL. In addition, seven samples for nitrate-nitrogen and ten samples for chloride exhibited concentrations below the respective MCL but elevated over the average concentrations observed in the majority of the sampled wells

A nitrogen loading model was used to estimate the nitrogen concentration in groundwater below the hamlet area of Stanford under various scenarios. The results show that, under current conditions with full lawn fertilization, the nitrogen concentration within the groundwater will be 1.52 mg/l (Scenario 1). This is close to the actual measured average concentration of 1.87 mg/l.

The predicted groundwater concentration decreases to 0.98 mg/l if no lawn fertilization is considered (Scenario 2). Under modeled conditions representing maximum residential buildout (Scenario 3), a predicted groundwater nitrogen concentration of 2.27 mg/l was reached. Adding a maximum agricultural fertilizer application to that scenario produced the worst-case value of 4.56 mg/l (Scenario 4). The recommended planning guideline for maximum nitrogen concentrations is 5.0 mg/l.

In summary, groundwater nitrogen concentrations in the hamlet area of Stanford - whether measured in various field samples, predicted under current development conditions, or predicted under buildout development conditions - seem generally conducive to the continued use of simultaneous on-site wastewater disposal and individual on-lot private drinking water supply wells.

Zoning controls on development density can help protect groundwater quality in areas that currently remain minimally developed. Limited areas of town that are already densely developed, however, already appear to be experiencing density-driven water quality problems. It is likely that "short-circuiting" problems between septic systems and wells located in glacial overburden aquifers begin to develop when the housing density exceeds one home per acre (Horsley Witten Hegemann, Inc., 1990). To a certain extent, the short circuiting effect can be minimized by careful mapping of groundwater flow directions and siting septic systems such that a minimum 300-foot downgradient separation is maintained between septic systems and wells in areas underlain by highly-permeable sand and gravel. The use of alternative septic system technologies that limit nitrogen output may also be utilized to minimize short circuiting problems.

Agriculture also represents a significant source of nitrogen. Available water quality data indicate that these areas exhibit the highest concentrations of nitrate-nitrogen in the town. A broad range of best management practices (BMPs) is available and should be explored to minimize the source of nitrogen. Although a sand and gravel aquifer underlies the town center, it has a limited capacity to supply water because of its generally shallow depth. Further study would be required to determine if this aquifer is capable of supporting a public water supply in Stanford.

INTRODUCTION

Horsley & Witten, Inc. was retained by the Town of Stanford Groundwater Resources Committee (SGRC) to carry out a Water Resource study of the Town of Stanford (Figure I-1), concentrating on the hamlet area of the Stanfordville-Bangall corridor. The study was intended to create a baseline assessment of the current status of the Town's drinking water resources. Funding for the study was provided by the Town of Stanford and the Dutchess County Water and Wastewater authority.

The study was divided into four Tasks and this report is divided into four chapters, one for each Task. Task 1 and chapter1 deal with a basic hydrogeologic evaluation of existing data. Task 2 and chapter 2 deal with the selection of groundwater sampling sites and subsequent water quality sampling of these sites. Task 3 and chapter 3 are concerned with a land-use analysis of the Town and potential impacts on drinking water resources. Task 4 and chapter 4 constitute a nitrogen loading study designed to roughly evaluate the average water quality in the hamlet area of Stanford under a variety of conditions.

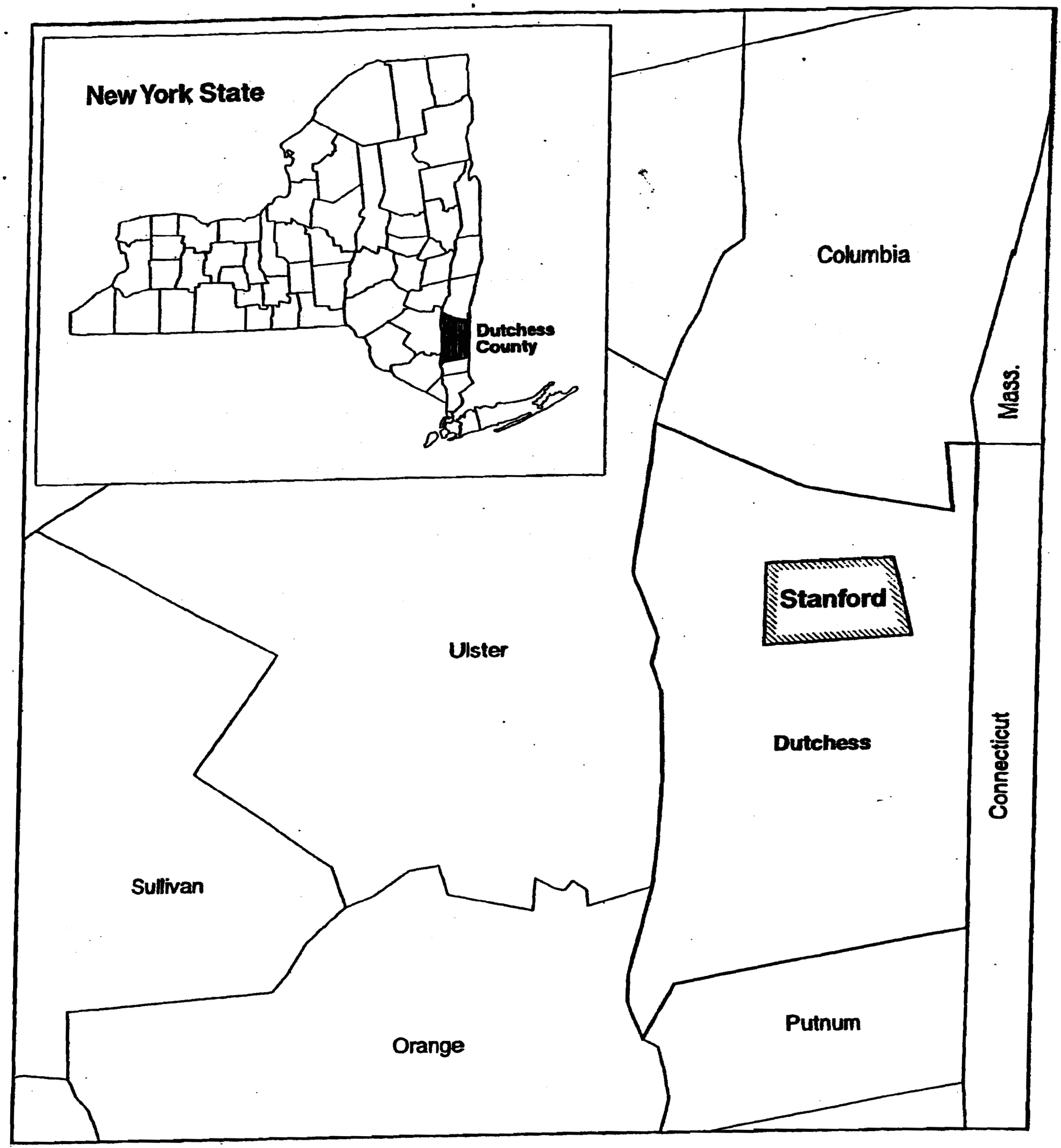


Figure I-1

Locus Map

Stanford, New York

Last Revision Date: January 7, 1999

Horsley & Witten, Inc.

I. HYDROGEOLOGIC EVALUATION AND MONITORING WELL RECOMMENDATION

INTRODUCTION

Task I consisted of a general evaluation of the hydrogeologic setting of the Town of Standord. During the completion of Task 1, H&W reviewed 231 well logs, which were provided by the Town of Stanford. These logs were evaluated on the basis of aquifer type and well yield, as well as aquifer and overburden thickness. Based on the data obtained from the logs, as well as several local, state and federal sources, a general description of the hydrogeology of the Stanford area was prepared. The final products of this Task include a tabulation of aquifer type, well yield and thickness of aquifer penetrated as well as an assessment of the proportion of wells set in bedrock to those screened in unconsolidated glacial deposits. This data will be used in Task II to select 100 wells for ground water sampling and water quality analyses. All data tables generated as part of this project will be supplied to the Town in a digital format at the conclusion of the project along with any other relevant information.

HYDROGEOLOGY

The Town of Stanford is located in the Wappinger Creek Valley Watershed with portions of the Town also located in the Ten-Mile Creek and Roeliff-Jensen Kill Watershed, in the north central portion of Dutchess County, New York (Figure I-1). The geologic history of the Wappinger Creek Valley and the Stanford area is very complicated. Since the Precambrian, over 570 million years ago, there have been three orogenic (mountain building) events and several periods of glaciation affecting the Stanford area (McLelland and Fisher, 1975). These events have caused deposition of sediments, folding, faulting, metamorphism and extensive erosion to occur. The result is a complex layering of differing bedrock units overlain by a relatively thin veneer of glacially deposited sand and gravel. Water obtained from the surficial glacial sediments may be the easiest to obtain, but it is also the easiest to contaminate. Water availability and well yield in the bedrock units is variable because it is controlled by factors such as fractures, faulting, and solution openings, which are not uniformly distributed (Table I-1).

TABLE I-1
AQUIFER TYPES AND CHARACTERISTICS
TOWN OF STANFORD AND DUTCHESS COUNTY, N.Y.

Aquifer Type	Geologic Name	Material	Unit Thickness	Aquifer Yield	Description
Unconsolidated	Glacial Drift	Sand & Gavel, some clay lenses	0-100 feet	2-1,400 gpm	Glacially deposited sand and gravel. Very little saturated thickness, only a significant aquifer locally in valleys where deposits are thickest.
Bedrock	Normanskill FM	Shale and slate with some chert. Also contains layers of firmly cemented dark gray sandstone.	100-3,000 feet	Average of approx. 16 gpm	Comprised of three different units, Indian River Shale, Mount Merino Shale and Austin Glen Graywacke. Graywacke is lighter in color than some of the shale and may produce greater yeilds than the shale.
Bedrock	Wappinger Creek GP.	Carbonates, ranging from pure calcite to pure dolomite	up to 2,800 ft.	Average of approx. 22 gpm	Composed of several different units including the Copake limestone and the Briarcliff dolostone. Some metamorphism may be present toward the southeast. Solution channels and voids are common. Water is typically hard.
Bedrock	Precambrian Granite	Granite and granitic gneiss	greater than 5,000 ft.	Average of approx. 7 gpm	Composed of hard crystalline rock burried beneath the rock of the Wappinger Creek group and the Normanskill Formation. Not usually seen outcropping at land surface

The descriptions contained in the above table represent not only the units located within the Town of Stanford, but also within Dutchess County.

Sources

Horsley Witten Hegemann, Inc., October 1992
Dunn Geoscience Corporation, 1985,
Dutchess County, 1985
Fisher, D. W., and Warthin, A. S., 1976

Geology

The oldest rocks in the Stanford area are Precambrian (over 570 million years old) crystalline granite and gneiss. Above the crystalline bedrock is a series of originally flat lying layers of shale, sandstone and carbonate rocks which formed in a shallow sea during the early part of the Paleozoic Era. First, the Wappinger Creek carbonates, then the Normanskill Formation shales were deposited (Fisher and Warthin, 1976).

Subsequently, a series of orogenic (mountain building) events occurred in the Stanford area. The sediments were uplifted, folded and faulted to form mountains. After the uplifting had finished, erosion became the dominant process and the mountains were worn down. Then the next orogenic event occurred and the whole process of mountain building and erosion was repeated. These processes caused a complex array of marine sediments including carbonates, sandstones and shales to be formed and then folded and faulted. In the third period of mountain building, sediments which had been deposited many miles further to the east were pushed westward over some of the folded and faulted complex of sediments in Dutchess County (McLelland and Fisher, 1975).

The geologic structure which now exists in the Stanford area is comprised of buried Precambrian crystalline bedrock overlain by carbonate units of the Wappinger Creek group including the Briarcliff Dolostone and the Copake Formation. Above the Wappinger Creek carbonates lie the shale, slate and graywacke (graywacke is a type of sandstone) of the Normanskill formation. A thin layer of glacially deposited sand and gravel overlies bedrock and partly fills most of the valleys in the Town of Stanford (Fisher and Warthin, 1976).

The Wappinger Creek group consist of six different carbonate rock units (Fisher and Warthin, 1976). Not all of the units exist in all locations. In the area of Wappinger Creek, the Copake limestone and the Briarcliff Dolostone are present (HWH, 1992). These carbonate rocks range in chemical composition from almost pure calcite ($CaCO_3$) to almost pure dolomite ($MgCO_3$) (Dunn, 1985). The group varies in thickness from approximately 1,000 feet to the south, to approximately 2,800 feet in the vicinity of Stissing Mountain.

The predominant unit of the Normanskill formation which is present in the Stanford area is the Austin Glen Graywacke and Shale. This unit represents an ancient continental shelf deposit which had originally been deposited approximately 60 miles to the east (Dunn, 1985). The sediments where carried westward during a period of rapid uplifting, re-depositing the material where it exists today. The unit consists of thin-bedded, dark gray sandstone interbedded with bluish dark gray shale (Fisher and Warthin, 1976).

Glacial sands and gravels were deposited in the area during the Pleistocene Epoch, approximately 10,000 to 20,000 years ago (Dunn, 1985). During that time, huge ice sheets, moving in a southerly direction, covered all of Dutchess County. During glaciation, the glacial ice and the rock fragments imbedded in it eroded and scoured the bedrock surface removing soil and deepening the north south trending valley of Wappinger Creek. Then, because the temperature began to rise, the ice sheets began to retreat to the north. As this retreat began and melting of the ice occurred, rock fragments, ranging in size from clay to boulders which had been picked up by the glacier in its southerly migration, were deposited over much of the bedrock which had been covered by ice. As the temperature increased, the glacier began to retreat faster and meltwaters from the glaciers deposited large quantities of sand and gravel in the valley areas. The depth of unconsolidated sand and gravel in the Stanford area varies from 0 feet, where bedrock is exposed at the surface, to approximately 100 feet in some of the valley areas (Town of Stanford, 1997; Dutchess County, 1985; Dunn, 1985).

Hydrology

Based on the geology described above, there are four different aquifer types in the Town of Stanford, unconsolidated sands and gravels, carbonates of the Wappinger group, graywacke/shales of the Normanskill Formation and granite. The four types of aquifers found in the Stanford area are quite different from each other, but the ground water in them is probably interconnected via a complex network of pores, fractures, faults and solution channels. Precipitation infiltrates down through land surface in the upland area to the underlying shales and carbonates. Water within these formations then travels both vertically and horizontally via fractures and solution structures hydraulically down gradient. When the water reaches the lower valley areas, it moves laterally and upward via the fractures and channels into the sand and gravel aquifer.

Under the abnormal stress of pumping, the flow directions of ground water may be reversed. While ground water naturally seeps from sand and gravel and bedrock as seepage or as springs into a stream, pumping can lower the water table next to a stream thereby inducing stream water to flow into the ground and then the well. Most of the high yield public supply wells in New York and New England cause this reversal of the natural ground water circulation pattern. Indeed, most of them are highly dependent upon it to sustain a large dependable water supply.

Each aquifer has its own characteristics including water yield, availability and water quality. Table I-1 is a summary of these characteristics for each of the aquifers units.

Sand and Gravel

The glacial aquifer should be considered a limited aquifer due to its limited water saturated thickness (0 to 50 ft.). In areas of Dutchess County where the aquifer is thicker and saturated, a yield of between 2 to 1,400 gpm can be achieved by individual wells with an average yield of 136 gpm, which would make the aquifer acceptable for domestic, commercial and light industrial use (Dutchess County, 1985; Simmons, et. al., 1961). If areas can be found where this aquifer is sufficiently thick and close to a perennial stream, it may be capable of sustaining a small public supply. Previous investigations have shown that the volume of water-saturated sand and gravel in Stanford is small. Therefore, yields from the aquifer would be limited by that volume or, more importantly, by the potential recharge of the aquifer either from direct infiltration of precipitation or from induced infiltration from a surface water body. Induced infiltration from surface waters may be related to increase risk of water quality contamination from potential contaminants carried within those surface waters.

Natural water quality in the sand and gravel can vary. In general, the water would be considered soft to moderately hard with little or a moderate amount of dissolved solids present. Because a significant fraction of the glacial sand and gravel is derived from carbonate rock, the sand and gravel would be expected to contain water with some hardness (Frimpter, 1972).

Carbonates

Ground water flow in the carbonates of the Wappinger group is controlled primarily by fractures and solution channeling which develops as circulating ground water dissolves the carbonates and widens existing features. These features are common in carbonate rock and can lead to the formation of sink holes where carbonates are the dominant aquifer unit and where it lies near the surface. The highest well yield of 100 gpm was reported to be from the carbonate rocks and 15 wells reported yields averaging 20.7 gpm. Based on reported yields in the carbonates in Dutchess County (Simmons, et. al., 1961), the carbonate rocks of the Wappinger group may yield enough water for a small public water supply, if a zone of sufficient fracturing and solution enlargement can be found near a perennial stream. Wells in this aquifer may have very high initial yields that might not be sustainable for long periods of time, because the aquifer's storage is relatively small. Proximity to a stream or other large volume of water would be required in order to replenish the water withdrawn from the aquifer.

The solution of the carbonate minerals, calcite and dolomite, causes relatively high concentrations of dissolved solids, as well as calcium and magnesium, to be present in the water which makes it "hard". Hardness can cause several problems including calcium buildup in pipes and water heaters and other plumbing which comes in contact with the water. This buildup is due to the dissolved carbonate minerals precipitating out of solution (Frimpter, 1972).

Shale and Graywacke

Due to the compact nature of the shale and graywacke units, water is obtained via fractures in the material rather than intergranular pore space. Because shale is usually a soft crumbly rock, fractures in it tend to be small and close up with time. Consequently, wells in shale generally yield less water than wells in other rocks (Fisher and Warthin, 1976). Based on the data provided by the town, most of the wells in town are set in the shale aquifer and have varying yields from as little as 0.25 gallons per minute (gpm) to upwards of 100 gpm. The Town-wide average yield for wells screened in all aquifers is 11.45 gpm (Table I-2 and Table I-3). Since most of the wells in town are screened in the shale-graywacke aquifer, this yield is consistent with what is expected for the graywacke and shale aquifer (Table I-1). The higher yields reported for Town wells are most likely associated with the carbonate and graywacke units which are more solid than the shales and tend to maintain any fractures or faults in them.

Owing to the above conditions, the striking of usable quantities of water tends to be a somewhat "hit or miss" situation. In general, the deeper you drill into a rock, the fewer fractures exist and the lower the chances of increasing yield may be. The wells in the graywacke and shale are at an average depth of 317 feet below land surface (BLS) and appear to have sufficient yields for domestic use, but do not produce enough water for municipal supplies (Table I-3).

The water quality within the shale units varies, but tends to contain less dissolved solid than the carbonates, but more than the glacial deposits. This causes the water from these units to be moderately hard, but not as hard as that derived from the carbonate aquifer. In addition, the water may contain traces of H_2S, hydrogen sulfide gas with the characteristic odor of rotten eggs.

Granite

Granite underlies all of Stanford, but nearly everywhere it is covered by the carbonates, shales and sandstones of the Wappinger Group and Normanskill Formation. Only on Stissing Mountain at the northern border of the Town does the granite outcrop at land surface. The granite is a hard rock which yields water only from fractures. Well yields from granitic type rocks in other areas of southeastern New York are commonly sufficient only to sustain individual home supplies. Only two of the wells in Table I-2 are reported to yield water from granite. The granite aquifer is a very minor source of water for Stanford's residents. Water from this aquifer is expected to range from soft to moderately hard.

TABLE I-2
SUMMARY OF WELL LOGS

Log #	Geologic Material	Unit Thickness (feet)	Well Depth (feet)	Static Water (feet)	Yield (gpm)	Quad Name	Ground Elev. (feet)	At Depth (feet)
920	Hudson River Fm *		78	6		Pine Plains	820	
921	Hudson River Fm *		117	1		Pine Plains	1080	
922	Hudson River Fm *		93	13	2	Millbrook	330	86
925	Hudson River Fm *		200	10		Millbrook	970	
926	Stockbridge Limeston		138	22		Millbrook	340	
970	Hudson River Fm *		151	7		Amenia	890	
1800	Grey Shale	232	240	23	5	Rock City	650	240
1828	Shale	78	80		6	Millbrook	550	80
1829	Sand and Gravel	50	50	20		Millbrook	305	
1830	Shale	237	257	24	10	Pine Plains	625	257
1886	Shale	472	505	40		Pine Plains	738	
1887	Grey Slate	137	140	20	10	Rock City	530	140
1888	Shale	211	231	20	5	Pine Plains	585	231
1889	Shale	187	207	35	25	Pine Plains	425	207
1890	Shale	279	282	15	3	Pine Plains	593	282
1965	Shale	122	132	25	24	Pine Plains		132
2394	Shale	352	432	40	4	Rock City	770	432
2395	Grey Slate	257	260	21	3	Salt Point	500	260
2396	Shale	245	245	30	11.5	Rock City	670	245
2397	Shale	210	245	20	5	Millbrook	310	245
2398	Slate	245	271	70	6	Millbrook	700	271
2399	Shale	356	360	45	3	Millbrook	600	360
2400			170	40	8	Salt Point	560	170
2401	Black Slate	197	200	17	6	Rock City	600	200
2402	Black Slate	204	210	17	7	Rock City	640	210
2403	Shale	198	200		5	Millbrook	890	200
2404	Shale	579	609	50	0.5	Pine Plains	1010	609
2405	Grey Shale	194	200	28	5	Millbrook	480	200
2406	Grey Slate	189	195	17	3	Millbrook	580	195
2407	Shale	230	240		25	Pine Plains	500	240
2408			405	20	26	Rock City	740	405
2409	Shale	145	160		8	Pine Plains	550	160

TABLE I-2
SUMMARY OF WELL LOGS

Log #	Geologic Material	Unit Thickness (feet)	Well Depth (feet)	Static Water (feet)	Yield (gpm)	Quad Name	Ground Elev. (feet)	At Depth (feet)
2410	Shale & Quartz	218	225	10	8	Rock City	590	225
2411	Shale	137	145	20	100	Millbrook	430	145
2412	Shale	319	321	60	0.75	Millbrook	700	320
2413	Clay & Gravel	240	240	30	15	Pine Plains	850	240
2414	Shale	292	532	90	1.5	Pine Plains	810	532
2500	Shale	181	182	40	25	Pine Plains	530	182
2501	Shale	191	200	20	12	Millbrook	780	200
2502	Shale	267	307	60	5	Millbrook	710	307
2503			300	92	0.75	Millbrook	710	300
2504			300	84	3	Millbrook	710	300
2505			315	116	0.75	Millbrook	670	315
2506	Black Shale	443	455	40	0.75	Millbrook	610	455
2507	Shale	350	350	5	3	Millbrook	750	350
2508	Shale	291	307	5	3	Millbrook	480	307
2509	Shale	224	227	5	10	Pine Plains	370	227
2510	Shale	82	132	10	5	Pine Plains	640	132
2511	Shale	116	127	15	10	Millbrook	340	127
2512	Shale		385	70	100	Pine Plains	680	385
2513	Shale	282	307	15	4	Millbrook	355	307
4606			200	7	15	Pine Plains	700	200
4607	Granite	535	605	29	5.3	Millbrook	700	605
4608	Black & Grey Slate	252	260	4	5.5	Pine Plains	845	260
4609	Shale	203	207	20	12	Pine Plain	450	207
4610	Shale (some quartz)	542	543	30	2	Millbrook	570	565
4611	Shale/Quartz	185	205	80	12	Pine Plains	800	205
4612	Sand/gravel/shale	50	105	20	20	Pine Plains	800	105
4613			203		6	Rock City	680	203
4614	Limestone	373	385	20	25	Pine Plains	370	385
4615	Black Slate	314	340	3	4	Pine Plains	550	340
4616	Shale	360	365		0.375	Pine Plains -well 1	750	365
4616	Shale	440	445		0.5	Pine Plains - well 2	750	445
4617	Shale	367	407	15	4	Millbrook	600	407

TABLE I-2
SUMMARY OF WELL LOGS

Log #	Geologic Material	Unit Thickness (feet)	Well Depth (feet)	Static Water (feet)	Yield (gpm)	Quad Name	Ground Elev. (feet)	At Depth (feet)
4618		147	203	4	5	Millbrook	680	203
4619	Shale	420	425	60	4	Pine Plains	780	425
4620	Limestone (weathered)	60	230	70	8	Pine Plains	505	230
4621	Shale	485	505	40	12	Pine Plains	800	505
4622	Slate (Black)	202	220	17	12	Pine Plains	450	220
4623	Blue Stone	142	160		8	Pine Plains	660	160
4624	Shale	185	205	20	7	Millbrook	450	205
4625	Hard Shale	39	55	23	6	Salt Point	320	55
4626	Limestone	252	260	17	6.5	Pine Plains	455	260
4627	Granite	62	72	25	10	Pine Plains	570	72
4628	Shale	395	400	20	4	Pine Plains	750	400
4629			340	17	1	Millbrook	560	340
4630	Shale	342	345		4	Millbrook	550	345
4631	Shale	403	405		2	Millbrook	560	405
4632	Shale	402	405		1	Millbrook	570	405
4633	Black Slate	107	135	27	10	Millbrook	275	135
4634	Black & Gray Slate	326	340	17	2	Rock City	760	340
4635	Shale	161	170	30	24	Salt Point	480	170
4636	Gray Slate	270	340	68	6	Salt Point	480	340
4637	Black Slate/Boulders	214	340	30	15	Salt Point	480	340
4638	Black Slate	293	300	17	3.5	Pine Plains	580	300
4639	Shale	135	135	30	20	Millbrook	435	135
4640	Limestone	20	160	40	30	Pine Plains	460	160
4641	Black Slate	339	400	40	0.5	Millbrook	740	400
4642	Shale	136	136	20	20	Millbrook	560	136
4643	Shale	38	50	18	7	Salt Point	320	50
4644	Limestone	302	307	20	6	Rock City	530	307
4645	Black Slate	378	380	16	30	Pine Plains	600	380
4646	Shale/quartz	500	525	6	0.75	Rock City	520	525
4647	Shale	560	580	27	1	Rock City	520	580
4648	Black Slate	354	360	40	0.5	Pine Plains	870	360
4649	Black Slate	280	340	17	8	Salt Point	600	340

TABLE I-2
SUMMARY OF WELL LOGS

Log #	Geologic Material	Unit Thickness (feet)	Well Depth (feet)	Static Water (feet)	Yield (gpm)	Quad Name	Ground Elev. (feet)	At Depth (feet)
4650	Black Slate	397	400	21	5	Pine Plains	540	400
4651	Limestone	142	150	45	20	Millerton	700	150
4652	Shale	457	460	6	1	Pine Plains	550	460
4653	Limestone	306	307	40	5	Pine Plains	500	307
4654	Shale	163	180	20	15	Millbrook	355	180
5244	Shale	329	340	20	10	Pine Plains	790	340
5245	Shale	579	609	50	0.5	Pine Plains	850	609
5246	Limestone	298	300	3	3.5	Pine Plains	420	300
5247	Shale	299	307	45	50	Pine Plains	875	307
5248	Shale	181	234	30	9	Pine Plains	670	234
5249	Soft Shale	437	440	10	6	Pine Plains	480	440
5250	Black Slate	239	240	17	20	Rock City	600	240
5335	Gray & Black Slate	128	140	16	15	Millbrook	340	140
5336	Soft Shale	425	440	30	15	Millbrook	620	440
5337	Limestone	276	282	12	8	Pine Plains	420	282
5338	Shale	230	240		30	Salt Point	385	240
5339	Shale	165	245	40	60	Salt Point	570	245
5366	Shale/Quartz	283	425	85	12	Millbrook	670	425
5381	Shale	125	127	10	30	Pine Plains	530	127
5382	Shale/Quartz	113	121	12	20	Pine Plains	850	121
5408	Shale	618	658	15	0.75	Salt Point	520	658
5414	Shale	224	227	5	10	Pine Plains	370	227
5416	Shale	602	602		0.5	Pine Plains	870	602
5528			95	18	5	Pine Plains	690	95
5589	Black Slate in Quartz	194	200	10	40	Amenia	840	200
5590	Shale	322	602	95	5	Rock City	520	602
5591	Shale	275	285	20	8	Pine Plains	790	285
6341	Shale	426	435	10	1.5	Rock City	525	435
6342	Slate (Black)	396.5	400	26	3	Rock City	750	400
6343	Slate	298	300	17	5	Rock City	700	300
6344	Bedrock	198	303	75	1.5	Rock City	780	303
6345	Black Slate/Quartz	399	400	17	6.5	Rock City	650	400

TABLE I-2
SUMMARY OF WELL LOGS

Log #	Geologic Material	Unit Thickness (feet)	Well Depth (feet)	Static Water (feet)	Yield (gpm)	Quad Name	Ground Elev. (feet)	At Depth (feet)
6346	Black Slate/Quartz	448	460	20	1	Rock City		460
6347	Shale	423	440	32	2	Pine Plains	470	440
6348	Shale	297	557	46	3.5	Pine Plains	490	557
6349	Black Slate/Quartz	339	340	7	6	Pine Plains	450	340
6350	Shale	422	432	10	3.5	Pine Plains	690	432
6351	Shale	360	365		0.375	Pine Plains - well 1	750	365
6351	Shale	440	445		0.5	Pine Plains - well 2	750	445
6352	Limestone	95	105	24	30	Pine Plains	600	145
6353	Black Slate/Quartz	296	300	10	5	Pine Plains	490	300
6354	Shale	285	485	38	12	Pine Plains	435	485
6355	Black Slate/Quartz	322	340	15	5.5	Pine Plains	405	340
6356	Shale	512	532	40	12	Pine Plains	435	532
6357			80	17	7	Pine Plains	435	80
6358	Black Slate/Quartz	194	210	16	30	Pine Plains	410	210
6359	Bluestone	431	440	51	2	Pine Plains	585	440
6360	Bluestone	295	296	51	13.5	Pine Plains	585	296
6361	Black Slate/Quartz	285	340	16	6	Pine Plains	825	340
6362	Black Slate	388	400	40	0.5	Pine Plains	870	400
6363	Shale	515	530	3	5	Pine Plains	785	530
6364	Shale	642	658	4	3	Pine Plains	1145	658
6365	Limestone	98	200	8	25	Pine Plains	820	200
6366	Shale	206	207	20	15.5	Millerton	1040	207
6367	Gray Slate	109	140	19	20	Salt Point	320	140
6368	Black Slate/Quartz	259	320	23	30	Salt Point	475	320
6369	Shale	365	380	40	2	Salt Point	560	380
6370	Black Slate/Quartz	219	260	16	20	Salt Point	560	260
6371	Shale	277	305	40	20	Millbrook	320	305
6372	Hardpan	115	123	50	8	Millbrook	320	123
6373	Solid Rock	100	185	30	15	Millbrook	335	185
6374	Black Slate	329	340	16	4	Millbrook	375	340
6375	Shale	280	300	22	5	Millbrook	355	300
6376	Black Slate/Quartz	338	340	16	7	Millbrook	320	340

TABLE I-2
SUMMARY OF WELL LOGS

Log #	Geologic Material	Unit Thickness (feet)	Well Depth (feet)	Static Water (feet)	Yield (gpm)	Quad Name	Ground Elev. (feet)	At Depth (feet)
6377	Shale	292	307	8	7	Millbrook	440	307
6378	Gray Slate Bluestone	369	400	16	6.25	Millbrook	320	400
6379	Black Slate	198	200	17	4	Millbrook	460	200
6380	Shale	42	50	7	24	Millbrook	330	50
6381	Shale	335	365	12	0.5	Millbrook	345	365
6382	Shale	293	365	12	1	Millbrook	345	365
6383	Shale	421	425		46	Millbrook	820	425
6384	Shale	12	585	80	6	Millbrook Addendum	820	585
6385			556	17	1	Millbrook	560	556
6947	Shale	420	440		0.375	Rock City	635	440
6948	Shale	355	360	80	5	Rock City	735	360
6949			140	37	6	Rock City	700	140
6950			725		3	Rock City	640	725
6951	Shale	334	365	23	10	Rock City	720	365
6952	Shale	500	500	40	3.5	Rock City	730	500
6953	decayed shale/S&G	20	170	25	25	Pine Plains	810	170
6954	Shale	474	482	25	2	Pine Plains	840	482
6955				100	5.5	Pine Plains	690	
6956	Sand/gravel	57	57	24	12	Millbrook	295	57
6957	Shale	316	335	10	3.5	Millbrook	350	335
6958	Shale	341	360	36	24	Millbrook	440	360
6959	Shale	831	834	14	5.25	Millbrook	915	834
6960	Shale	145	155	20	30	Pine Plains	420	155
7151	Black Slate/Quartz	202	220	16	6	Pine Plains	380	220
7152	Shale	343	345	22	6	Pine Plains	730	345
7153	Shale	409	410	10	2	Pine Plains	1145	410
7154	Shale	357	360		1	Pine Plains	550	360
7155	Shale	402	407	50	1.25	Millbrook	920	407
7156	Gray Slate	240	340	30	20	Millbrook	895	340
1	Shale	113	123		100			123
2		443	460	17	1.5			460
3	Shale	485	485	85	6.5			485

TABLE I-2
SUMMARY OF WELL LOGS

Log #	Geologic Material	Unit Thickness (feet)	Well Depth (feet)	Static Water (feet)	Yield (gpm)	Quad Name	Ground Elev. (feet)	At Depth (feet)
4	Shale	253	260	5	5			260
	Shale	370	500	43	1.5			500
6	Slate (Gray)	288	300	17	50			300
7	Limestone	268	287	22	10			287
8	Liver & Black Slate	288	300	12	30			300
9	Shale	149	150	28	4.5			150
10	Limestone	197	207	20	8			207
11	Shale	205	207	10	12			207
12	Shale	353	365	20	1.25			365
13	Shale	132	136	22	20			136
14	Black Slate	324	340	18	3.5			340
15	Limestone	465	505	4	2			505
16	Limestone	463	503	4	100			503
17	Shale	597	607	10	0.25			607
18	Shale	400	405	35	2			405
19	Shale	499	500		2			500
20	Shale	97	105	15	15			105
21			220	28	1			220
22	Gravel	47	47	20	30			47
23	Shale	454	485	50	3			485
24	Shale	233	285	20	1.25			285
25	Slate	437	445	15	5			445
26	Limestone	240	250	25	30			250
27	Grey/Black Slate	239	240	17	10			240
28	Shale	111	127	30	40			127
29	Shale	477	480	1	2			480
30	Shale	104	107	16	6			107
31	Limestone & Granite	368	398	25	5			398
32	Shale	410	550	120	0.5			550
33	Shale	250	250	115	20			230
34	Shale	342	345	110	55			345
35	Shale	259	345	40	5			345

TABLE I-2
SUMMARY OF WELL LOGS

Log #	Geologic Material	Unit Thickness (feet)	Well Depth (feet)	Static Water (feet)	Yield (gpm)	Quad Name	Ground Elev. (feet)	At Depth (feet)
36			280	39	10			280
37	Shale	321	325					
38	Shale	390	405	5	3			405
39	Green/Black Shale	577	605	35	5			405
40	Shale	367	657	71	1			657
41	Shale	643	657	20	0.5			657
42	Shale	745	805	38	3			805
43	Slate	330	340	18	25			340

* Hudson River Fm. - This designation is interpreted to be shale and sasndstone similar to that of the Hudson River Formation and is probably the Normanskill Formation as mapped by Fisher, 1961.

Geologic Material - Description given by driller of well, not necessarily a qualified geologist

Unit Thickness - Total thickness of unit which was drilled through. This was determined by driller based on material removed from boring.

Well Depth - Total depth of the well

Static Water - The amout (feet) of water existing in the well under non-pumping conditions

Yield - Well Yields were determined at the time the well was installed and may not be representative of current conditions. Over time wells may silt up or get clogged due to mineralization and the yield can decrease.

At Depth - This is the depth at which the well was screened and the Yield was determined

WELL EVALUATION

H&W received well logs for 231 wells located within the Town of Stanford. In some instances the well logs were very complete and contained information regarding location of the well, depth drilled, elevation, static water level, yield, and geologic material encountered. However, not all of the logs contained all of this information. Table I-2 is a summary of well log data evaluated by H&W and Table I-3 is a summary of the relevant statistics obtained from the logs.

In addition to the well logs obtained from the Town, H&W also reviewed other federal and state sources of hydrogeologic data for Dutchess County and the Town of Stanford. The most complete report examined was the 1961 USGS report "Ground-Water Resources of Dutchess County, New York" by E. T. Simmons et. al. More recent work has been done in Dutchess County, but not within the Town of Stanford.

The Simmons study (1961) lists 22 wells in the Town of Stanford. Of these, only one is in the unconsolidated aquifer and the remaining 21 are in either the shale or carbonate bedrock aquifers. Most of these 21 other wells were already listed in the data provided to H&W by the Town. If the data from Simmons report were used, some of the wells would be double counted and the final numbers in this report would be inaccurate. Finally, the Simmons study (1961) lists the wells in two tables. One table is of selected boring logs and the other list data similar to that which is listed in Table I-2 of this report. None of the wells listed in the boring log section of the Simmons study are located in the Town of Stanford. In addition, the information provided in the second data table from Simmons, et. al. is not always complete and differs from the information which is included in Table I-2 of this report. For these reasons, none of the wells listed in the Simmons report were repeated in Table I-2 of this Task I report.

Of the 231 logs reviewed, 212 wells were set in bedrock and only 4 of the wells were screened in the sand and gravel aquifer (Table 3). Data for the remaining 15 logs was incomplete and did not contain information on type of geologic material encountered. However, all 15 of the logs indicate that the wells were set at a depth greater than 100 feet and in most cases greater than 200 feet, so based on the average depth where sand and gravel would be encountered, these wells are most likely set in bedrock. It should be noted, before proceeding any further, that the data contained in the well logs was, in most cases, a description provided by the well driller and not a qualified geologist. Because of this, the data reported may better reflect drilling characteristics of the rock rather than the aquifer classifications used in this report.

TABLE I-3
SUMMARY OF WELL LOG STATISTICS

Total Number of Well Logs:	**231**	
Number of Wells in Bedrock:	**212**	
Carbonate rock (Limestone):	18	
Granite:	2	
Sandstone and Shale:	192	
Number of Wells in Unconsolidated Aquifer:	**4**	
Average Well Depth:	**317**	feet below land surface
Maximum Well Depth:	834	feet below land surface
Minimum Well Depth:	47	feet below land surface
Average Well Yield:	**11.45**	Gallons Per Minute
Maximum Well Yield:	100	Gallons Per Minute
Minimum Well Yield:	0.25	Gallons Per Minute

The bedrock wells were in either a carbonate, granite or sandstone and shale aquifer. Sandstone is used here to encompass rock types described as graywacke, and bluestone, while shale is used to encompass rocks described as either shale or slate. Slight variations were observed in the well logs, such as "limestone and granite" or "shale and quartz", but the major bedrock aquifers are either carbonates from the Wappinger Valley Group or sandstones and shales from the Normanskill Formation (Table I-1). Based on the well logs reviewed, 192 of the bedrock wells were in shale, while only 18 were in carbonates and 2 in granite. Data on the remaining 15 was not available (Table I-2 and Table I-3).

Depths to which the wells were drilled vary from a shallow depth of 47 feet to a maximum depth of 834 feet below land surface (BLS). The average depth is 317 feet BLS (Table I-3). Three of the four wells screened in sand and gravel were all screened at a depth of approximately 50 feet BLS which would be expected for the unconsolidated deposits (Table I-3). Logs for the wells in the carbonates varied from approximately 150 feet BLS to just over 500 feet BLS with most of the wells between 200 to 300 feet BLS.

The reported yields varied from a high of 100 gallons per minute (gpm) to a low of 0.25 gallons per minute. The average yield for all the wells was 11.5 gallons per minute (Table I-3). In general, the yields from the sand and gravel wells were in the range of 10 to 30 gpm while the wells in the carbonates varied between 8 to 30 gpm, with one well having a yield of 100 gpm. The average yield of 15 wells in carbonate rock was 20.73 gpm, nearly double the average yield for all wells. Those wells completed in the shale and sandstone had a lower yields than the other two aquifers, but showed a large variation in yield (Table I-3).

SUMMARY

The hydrogeology of the Stanford area is composed of a complex structure of bedrock and sand and gravel aquifers which are probably interconnected via faults, fractures and solution channeling. Based on the data provided, the majority of the wells are in bedrock and of those, most are in the shale and sandstone (graywacke) of the Normanskill Formation.

The average yield for the wells is approximately 11 gpm which is sufficient for domestic use, but not for large scale municipal wells. Encountering a sufficient yield in the bedrock aquifer is a somewhat hit or miss prospect. This is because ground water availability and flow is controlled primarily by fractures and faults in the shale and fractures and solution channeling in the carbonates of the Wappinger Group. When a large fracture or channel is encountered, a larger yield possibly capable of sustaining a public supply may be obtained.

In general, the deeper a well is drilled, the less likely fractures will be encountered. For this reason, most of the well logs which were examined for the bedrock wells were drilled less than 500 feet below land surface with an average depth of 317 feet (Table I-3).

Based on the data provided, the main aquifer for private wells in the Town of Stanford appears to the shale and sandstone bedrock aquifer. Sufficient yields for domestic supplies can be obtained from this aquifer, but may require drilling of 300-400 feet before a great enough yield will be encountered. Based on the data obtained from the Town, there is no obvious pattern to the distribution of the wells. There are too few wells in the unconsolidated aquifer to see any pattern although it is suspected that most will exist in the populated areas located in the lowland, valley areas. The bedrock wells, which draw water from both the carbonate and shale aquifers, are spread throughout the entire Town both in the upland and lowland areas.

II. SELECTION OF GROUNDWATER SAMPLING SITES INITIAL WATER QUALITY TESTING

The purpose of Task II was to evaluate the current water quality within the town's different aquifers and to determine areas of water quality concern. The Task II scope of work included the examination of existing water quality data; the development of a sampling program, including existing residential wells to be sampled and the parameters to be analyzed; and an evaluation of the results from the towns' sampling of residential supply wells.

Included here is a table (Table II-1) of water quality results from selected private supply wells compiled by the town, a discussion of how these results may relate to mapped potential threats to groundwater quality, and recommendations for future study to further protect the town's groundwater resources.

At the onset of Task II, Mr. Gary Lovett, Chairman of the Stanford Groundwater Resources Committee (SGRC), supplied all available water quality data for the town to H&W. These data were used to determine specific sampling and analytical parameters to include in a monitoring program. Existing water quality data consists of sporadic sampling events undertaken in response to specific water-quality concerns. These data usually pertain to specific contaminants. Well construction data and source formation is generally lacking. These data do, however, indicate generally high nitrate levels and several incidents of bacterial contamination throughout the Town Center area dating back to the early 1990s. Two incidents of petroleum hydrocarbon contamination in the vicinity of gasoline service stations were also documented in those data supplied by the SGRC.

H&W developed a monitoring plan based on existing water-quality data and physical characteristics of the wells, which were examined in Task I. The criteria examined to select sampling sites included location of wells within the town and which geologic units the wells intersect Well sampling was conducted by volunteers from late March to early May of 1998, and the water-quality analysis was conducted by the Dutchess County Health Department laboratory. After the sampling was completed, H&W analyzed the data for issues of water quality concern.

Table II-1 Groundwater Quality Data Summary

Number	Well Location	Date Drilled	Well Log #	Depth	Formation	Comments	Coliform	MCL	Chloride	MCL	Nitrate	MCL	Nitrite	MCL
								0		250		10		1
1	Patricia Lane	1985	2397	245	Shale	Chlorinated Upstream	<1		13.0		<0.20		<0.01	
2	Depot Lane	1987	2508	307	Shale		<1		8.0		<0.20		<0.01	
4	Cold Spring Rd	1986	4614	385	Limestone		1		ND		<0.20		<0.01	
5	N. Anson Rd	1986	4624	205	Shale		<1		6.0		<0.20		<0.01	
8	Rt 82	1989	5335	140	Slate	Near Major Rd.	<1		168.0		<0.20		<0.01	
9	Pumpkin La	1989	5408	658	Shale	Horse Farm	<1		9.0		<0.20		<0.01	
10	Bangall-Amenia Rd	1990	5589	200	Quartz	Horse Stable	<1		12.0		5.62		<0.01	
11	Thompson La	1989	5591	285	Shale		<1		13.0		1.45		<0.01	
13	Bangall	1991	6358	210	Slate	Near Major Roads	<1		126.0		0.52		<0.01	
14	Pugsley Hill Rd	1991	6365	200	Slate	Horse Farm	<1		8.0		2.51		<0.01	
15	Bangall-Amenia Rd	1989	7155	407	Shale		<1		5.0		<0.20		<0.01	
16	Stissing Rd	1987	4626	260	Limestone		<1		5.0		<0.20		<0.01	
17	Hunns Lk Rd	1989	4644	307	Limestone		>=1		5.0		0.27		<0.01	
18	Hunns Lk Rd	1989	4651	150	Limestone	Horse Farm	<1		62.0		3.63		<0.01	
20	Hunns Lk Rd	1985	1889	207	Shale	Near Major Rd	6		125.0		<0.20		<0.01	
21	Carpenter Hill Rd	1987	5247	307	Shale		<1		10.0		<0.20		0.03	
22	Ernest Rd	1987	2412	321	Shale		<1		60.0		0.85		<0.01	
25	Creamery Rd	1991	6355	340	Slate	Sulfur Filter Upstream	<1		14.0		<0.20		<0.01	
26	Creamery Rd	1986	4615	340	Slate		<1		6.0		<0.20		0.025	
28	Hicks Lane	1990	5590	602	Shale		<1		5.0		<0.20		<0.01	
29	Duell Rd	1989	5356	425	Shale		<1		6.0		<0.20		<0.01	
30	Layton Rd	1990	6361	340	Slate		<1		20.0		0.3		<0.01	
31	Pugsley Hill Rd	1992	7153	410	Shale		<1		ND		4.37		<0.01	
32	Patricia Lane	1986	6373	185	Rock(!)		<1		9.0		<0.20		<0.01	
34	Route 82	1990	6378	400	Slate, qtz	Near Major Rd.	<1		8.0		0.32		<0.01	
35	Decker Rd	1985	1888	231	Shale		<1		4.0		<0.20		<0.01	

Table II-1. Groundwater Quality Data Summary

Number	Well Location	Date Drilled	Well Log #	Depth	Formation	Comments	Coliform	MCL	Chloride	MCL	Nitrate	MCL	Nitrite	MCL
36	Route 82			23	gravel	Near Major Rd.	<1		7.0		2.4		<0.01	
37	Route 82			<80		Near Major Rd.	<1		64.0		<0.20		<0.01	
38	Creamery Rd			210	shale		<1		48.0		<0.20		<0.01	
39	Route 82			<80		Near Major Rd.	>=2		7.0		1.62		<0.01	
41	Hus Lk Rd Bangall			60?		Near Major Rd.	<1		379.0		1.78		<0.01	
42	Hunns Lk West			<80			<1		16.0		0.98		<0.01	
43	Hunns L. North			<80			>200		6.0		0.72		<0.01	
45	Upton L. South			40?	rock		52		21.0		2.82		<0.01	
46	Upton L. South			75	rock		<1		21.0		3.16		<0.01	
47	Upton L. South			62	rock		<1		42.0		1.35		<0.01	
48	Route 82			50?		Near Major Rd.	<1		7.0		3.24		<0.01	
49	Route 82					Near Major Rd.	<1		19.0		1.12		<0.01	
50	Bangall Amenia Rd			10	gravel	Dug Well	<1		103.0		<0.20		<0.01	
51	Millis Rd			70	Gravel?	Dug Well	<1		10.5		<0.20		<0.01	
52	Hunns Lk Rd	1994		300	shale		<1		96.0		0.85		0.07	
53	Patricia Lane	1985					<1		6.0		<0.20		<0.01	
54	Mill Rd Bangall			190	shale		<1		6.0		<0.20		<0.01	
55	Church Lane			<30	gravel?		<1		28.0		<0.20		<0.01	
56	Bulls Head Rd	1973			shale		<1		8.0		0.56		<0.01	
70	Rt 82			180	shale		<1		20.0		<0.20		<0.01	
71	Decker Rd			90			1		4.0		1.78		<0.01	
72	Mountain Rd						<1		ND		0.98		<0.01	

Town of Stanford well data. Samples taken April-May 1998. Analyzed by Dutchess County Department of Health laboratory.
Depth in feet. Coliform is a count. Chloride, nitrate and nitrite in mg/L (nitrate and nitrite expressed as N). ND = no data
? after depth means it was from well owner's recollection. If depth is marked <80, it indicates that the actual depth was unknown, but it is fed from a surface "jet pump."
Spreadsheet prepared and checked by Gary Lovett, June 1998.
MCL = New York State Maximum Contaminant Level

Sampling Well Locations

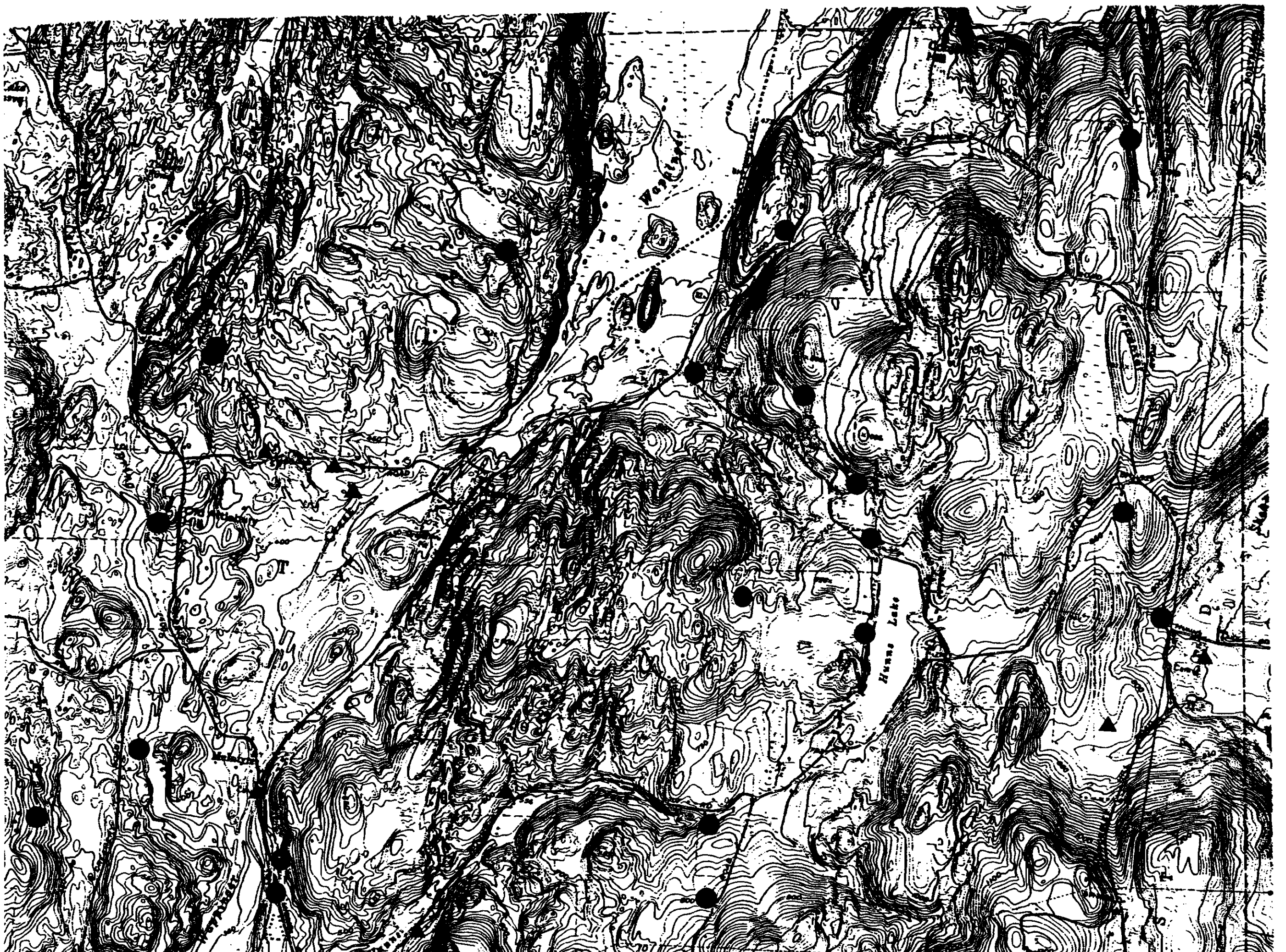
As part of Task II, H&W recommended 75 specific wells and 25 unspecified wells located within the town for groundwater sampling (Figure II-1). From this pool of 100 potential sampling points, it was hoped that the SGRC would be able to obtain permission from well owners to sample approximately 50 of these wells. The number of wells H&W selected from each aquifer was determined based on the proportion of wells existing in each aquifer (H&W, October 1997). Since the number of wells located in the glacial overburden material is unknown, estimates were made. The list of recommended wells included 12 specific wells located in the carbonate aquifer, and 63 specific wells located in the shale/graywacke aquifer. H&W also recommended that 25 unspecified wells be sampled from the glacial drift aquifer for a total of 100 recommended sampling points.

From the 100 candidate sampling points identified by H&W, the town obtained permission from well owners to sample 48 of the wells. Thirty of those wells were screened in the shale/graywacke aquifer, four in the carbonate aquifer, four in the surficial aquifer, and ten in unknown formations. The ten unknown wells are likely screened in the surficial aquifer as those with known depths are all shallow wells. The town's final choice of sampling sites was based on geographic distribution, aquifer type, and the ability to gain access to the well. At the request of the SGRC, no locus map showing sampling locations has been included in this report.

Glacial Drift Aquifer

Data provided to H&W in Task I included only four wells in the town that are known to be set in the unconsolidated glacial drift aquifer. According to Mr. Gary Lovett, however, there are many older wells in town lacking specific construction information. As shallow wells are the easiest to construct, it is likely that many of these older wells also tap the surficial aquifer. Four wells, known to be screened in the surficial aquifer, and ten wells, suspected to be screened in the surficial aquifer, were sampled during the study.

The criteria utilized for well sampling selection included the location of wells relative to areas of critical concern (e.g., roads that are salted during the winter, septic systems, etc.) and the likelihood of obtaining permission from private landowners for access to specific wells. It was also recommended that some wells be chosen in isolated areas that are not of critical concern so that the data obtained from these wells could be used as an evaluation of background aquifer conditions and as a comparison to wells in the areas of critical concern. Although known physical characteristics of the wells are limited, all available


Hunns Lake
Stanfordville
Rudd Pond
Tamarack