APPLICATION OF PALEOGEOMORPHIC MAPPING TECHNIQUE TO THE SUBSURFACE EVALUATION OF THE APPALACHIAN BASIN OF NEW YORK

Three Study Areas in Southcentral and Southeastern New York

Prepared for:

NYS Energy Research and Development Authority
2 Empire State Plaza, STE 1901
Albany, New York 12223-1253

Prepared by:

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

May, 1997

CERTIFICATIONS

I hereby certify that Arthur J. Pyron, P.G., C.P.G., has completed this geological investigation on the captioned subject, and has assembled the appropriate and provided material in a manner which presents the information in a format consistent with his understanding of the industry standard and recommended format for oil and gas investigations. This document is limited to review and interpretation of publicly available documents by Pyron. I attest that this geological investigation has been prepared in accordance with good geological practices. This certification becomes valid upon completion of their respective duties by all parties.

Arthur J. Pyron, PG.
Professional Geologist

Registration Number: P00073PG

State: Pennsylvania

(Original Seal in Blue Ink)
Date: ________________

TABLE OF CONTENTS

APPENDICES

1.0 INTRODUCTION

The basis of this paper is a demonstration of the application of the paleogeomorphic technique) to evaluate and identify stratigraphic traps in the Appalachian Basin. One of the problems cited by "knowledgeable" industry observers is that mature basins, like the Appalachian Basin, have no new exploration targets. While geologists who work mature basins know that this is not true, this logic becomes repeated by investors and the technical press until it becomes a *de facto* reality. In the late 1980's, geologists working in Tioga County, New York discovered a new field (the Stagecoach Field) in an old reservoir (the Oriskany Sand). Given the access to market, established storage and distribution infrastructure, and relative shallowness of reservoirs, the economic benefit to be derived from similar discoveries is obvious.

Pyron Consulting has spent 15 years using a variety of surface and subsurface methods to evaluate the potential of reservoirs worldwide. Past experience in mapping suggests that traditional isopach or structure maps are not precise enough to define subtle reservoirs. In addition, seismic data (whether 2-D or 3-D) has limited effectiveness and, as a generalization, is not significantly refined to reveal subtle stratigraphic trapping. Pyron Consulting has developed a subsurface mapping technique using sequence stratigraphy to identify potential new reservoirs. The premise of this mapping technique is the identification of regional sequence stratigraphy (usually by well log interpretation), and identifying, on a local basis, areas where thinning of the mapped interval occurs. This technique has been successfully used on a variety of lithologies and reservoir types in both domestic and international basins, and has revealed itself to be a sensitive indicator of economic accumulations of hydrocarbon reserves.

Having developed a mapping tool that is sensitive enough to identify stratigraphic trapping, Pyron Consulting then attempts to address a larger question - can subsurface mapping be used in combination with historic production data (or other relatively inexpensive data) to determine whether a given prospect is economically ***and*** technically viable? By this statement, Pyron Consulting suggests the obvious, that the nature of exploration has fundamentally changed since the industry restructuring of the 1980's. Exploration capital has become the most crucial element needed to develop new exploration concepts. Unlike the past history of exploration, limited access to capital precludes its free application in the exploration of questionable or risky prospects, and thus both serendipitous or accidental discoveries are eliminated, as are those discoveries which might be attributed to exploration concepts which vary too far from what the market deems "acceptable" exploration technique.

Over the last 25 years, 3-D seismic methods have gained a predominant position as an exploration tool. The rise of the application of 3-D seismic methods is in part a method of quantifying or minimizing risk by attempting to "see" the reservoir before it is drilled, and is in part a screening method used by exploration staffs to eliminate prospects early on in the evaluation phase. This application minimizes the amount of capital and time required to conduct a "due diligence" evaluation, and allows exploration staffs to stretch limited budgets. Unfortunately, the base of data (it should be remembered that 3-D seismic methods have been used by major multinational companies since the late 1970's) suggests it is best applied to the search for Tertiary reservoirs; 3-D seismic has proven to be less valuable and more expensive than traditional exploration methods in basins with Paleozoic rocks.

It is in this venue that the mapping method presented here must be tested and validated. Given the economics of exploration in a maturing basin like the Appalachian Basin, efficient use of exploration capital prior to drilling is mandatory.

The historic record has shown that the success rate for exploratory wells in the domestic arena has experienced a significant decline, in spite of the greater application of 3-D seismic technology, more rigorous selection criteria for prospects in response to decreased investment capital, and a more conservative decision making process related to an extended period of depressed prices (Figure 1.0). This decline has been attributed to maturation of the basins, but Pyron Consulting believes that it can be attributed to something far more critical to the future of this industry.

In 1986, industry observers cited many economic, legislative, and political reasons for the wholesale collapse of the domestic market. Certainly, all of these factors contributed to the collapse of the domestic industry. Pyron Consulting believes that something more significant occurred simultaneously with these events. We believe that the era of the deliberate search for the structural trap ended in the 1980's for most of North America, and is within a decade or two of ending in the international arena. This is a significant development, because the search for anticlines, on the surface or in the subsurface, as well as the search for structures associated with these anticlines, has been the driving force for exploration for over 70 years. If oil exploration and the resulting acquisition of reserves is to continue, then methods which identify stratigraphic and diagenetic traps must be developed, and more importantly, accepted by industry and investors.

Pyron Consulting developed its paleogeomorphic mapping technique as a tool to identify reservoirs where entrapment is associated with stratigraphic or diagenetic processes. The paleogeomorphic mapping technique can be used as a primary decision maker to select the optimum locations for well placement or lease acquisition, to guide the investment of capital, and to maximize the potential for success. In the event that the operational protocols of a company require the acquisition of seismic support data, then the paleogeomorphic mapping technique can be used to reduce proportionally that part of the exploration budget dedicated to purchasing seismic by limiting the purchase to the area of ultimate drilling.

2.0 THE PALEOGEOMORPHIC MAPPING TECHNIQUE

Early in the history of oil and gas exploration, geologists recognized that stratigraphic as well as structural traps existed. The direct search for stratigraphic trapping was diminished with the advent of tools (notably, reflection and refraction seismic methods) which aided the search for stratigraphic traps in areas of greater interest, like the Gulf Coast area. In the 1950's, after several decades of success in identifying structural traps, Scholten (1959) noted that many hydrocarbon reservoirs existed at topographic highs on the depositional bottom. Since the formation of this type of reservoir is independent of its structural position, it became obvious to him that structural mapping methods alone could not explain this occurrence, and that new mapping techniques are needed.

Scholten, in his 1959 paper, introduced the concept of synchronous highs as a tool to identify stratigraphic or diagenetic trapping. A synchronous high is defined as a topographically expressed feature which formed simultaneously (synchronously) with the deposition of (petroliferous) sediments [Figure 2.0]. The topographic expression may be the result of pre-existing structures, erosional features, stratigraphic geoforms (reefs), or basement features. If the petroliferous sediments were deposited uniformly across the area, including over the synchronous high, and if these sediments were subsequently buried, then the matured hydrocarbon liquids generated by maturation of these sediments would migrate updip to the top of the synchronous high.

Whether discussing clastic or carbonate sediments, porosity and permeability form in sediments deposited on the synchronous high, either by preferential accumulation and sorting of coarser grained sediments, or by the promotion of reef formation or increased dissolution of carbonates on the synchronous high proper. This happy coincidence of porosity, permeability, and hydrocarbon source materials allows the formation of diagenetic and stratigraphic reservoirs, which are preserved whether or not subsequent deposition obscures or enhances the synchronous high paleostructure.

Synchronous high mapping (or paleogeomorphic mapping) involves the identification of a regional mapping interval (especially the localized thinning of the mapping interval) by the study of well logs [see note]. [1] It is that thinning, under the theory of synchronous highs, which is the preferential habitat for the migration and preservation of hydrocarbons. Production is almost always related to thin map intervals which represent a topographic high (change in depositional environment). Therefore, in a paleogeomorphic map, valleys are considered source areas and hills are potential traps. In mapping synchronous highs or paleogeomorphic highs, it is important to realize they are lithostratigraphic units representing continuous deposition in a particular depositional environment and may be time-transgressive.

Assembly of a paleogeomorphic map involves a derivative subsurface mapping method which uses sequence stratigraphy to identify regional mapping intervals which can be extended laterally to incorporate facies changes. Localized thinning of the mapping interval can be demonstrated to be related to economic accumulations of hydrocarbons. The precision of the methodology allows evaluation of new drilling locations by determining those areas with the best potential for hosting economic reserves, and by drilling those locations which could maximize the return on investment.

---

[1] Pyron applied the term paleogeomorphic mapping to the technique because his use of synchronous high tended to cause some clients to infer that synchronous high was equivalent to a structural "closure". We believe that it is important to differentiate structural mapping from lithostratigraphic mapping (i.e., synchronous high mapping), hence the name change.

The paleogeomorphic technique derives its logic from fundamental geological principals established by Steno and Walther (Middleton, 1973). Thinning of the identified sequence can be related to those elements necessary for the formation of a hydrocarbon reservoir:

- Porosity
- Permeability
- High oil/low water content
- Trapping mechanism (most often diagenetic)

Paleogeomorphic mapping is effective because the lithostratigraphic mapping interval unit is directly related to the depositional environment. Because it is lithostratigraphic, depositional boundaries are defined by unconformities, whether they be diastems, hiatuses, or non-conformities. By comparison, isopaching map intervals are often defined by time boundaries based on fossil assemblages. And these boundaries may often be artificial because of inadequate or incomplete paleontologic data.

Porosity, permeability, and hydrocarbons are found in the paleogeomorphic high proper. Scholten (1959) infers that these topographic high areas will have accumulated comparatively less sediments than lower adjacent areas. The key is that the paleogeomorphic high creates conditions which promote the formation of porosity, whether in clastic or carbonate rocks. Scholten describes the process of porosity formation as being the result of either cogenetic or epigenetic events. Epigenetic porosity is the preferential accumulation of coarse sediments on a pre-existing paleogeomorphic high, whether by aeolian or fluvial sorting processes. In most carbonates, cogenetic porosity, or porosity associated with the deposition of the rock type, forms as a result of the physical processes associated with the accumulation of carbonates. These definitions apply to both primary and secondary porosity, including that associated with dolomitization. Dolomitization of a carbonate environment is more pervasive in the paleogeomorphic high, and may create fracture porosity, particularly on the high, due to the greater brittleness of dolomite (Pyron, 1984). Once porosity is created in carbonates within paleogeomorphic highs, it is preserved by the migration of hydrocarbons. Later cementation of surrounding areas adjacent to the high prevent hydrocarbons from remobilizing (Pyron, 1984). Hydrocarbons will remain after migration unless tectonic or erosional changes cause breaching of the reservoir.

Crucial to the process of hydrocarbon migration is the development of pathways by which hydrocarbons can reach the paleogeomorphic highs. Pyron (1984) has previously discussed the formation of migration pathways. While it is preferential to explore the identified synchronous highs (thins), pathways can also be unique exploration targets, especially in situations in which there has been insufficient maturation of source material, or in situations when high initial production is desired.

Migration pathways can maintain the porosity and permeability after the initial hydrocarbon migration flush because cementation within the pores and fractures is halted when hydrocarbons are present. The theory that hydrocarbons move to geologically high areas after their formation (Scholten, 1959) implies these topographic high areas will have accumulated better sorted, preferentially coarser sediments than those sediments deposited in lower adjacent areas. In the topographically lower areas, finer grained sediments, including organic sediments, have a greater chance to accumulate, especially is depositional conditions are representative of lower energy environments.

Traditional methods of mapping anticlinal structures(i.e., looking for a gas-saturated horizon, a broader oil-saturated horizon, and an oil-water contact down-dip) yield a success rate of 10-25% on these structures (i.e., oil producing wells as compared to all wells drilled). In areas in which stratigraphic or diagenetic traps are present, this success rate may be even lower. The search for this trap type is not aided by the application of either structural mapping methods or by the application of seismic techniques. While paleogeomorphic highs are "hills" or high spots in the depositional environment, and while these highs will stand out in the regional paleotopography, when viewed in the context of a complete stratigraphic column, they appear to be very subtle features. To map a given depositional interval, the explorationist must choose the proper lithostratigraphic unit, which represents continuous deposition in a particular depositional environment and may be time-transgressive. In short, the mapping method represents a pragmatic application of sequence stratigraphy to exploration geology.

When paleogeomorphic maps are properly applied, they are locally sensitive subsurface maps which can be used for cumulative production predictions on a per well basis. The sensitivity of the mapping technique allows the use of paleogeomorphic maps as an effective tool for in-field development and lease purchase appraisals. It is also an effective tool for exploration for stratigraphic traps in areas prone to this type of trap because the mapping method is reliant on pre-existing well log data, and as such, can be applied with minimal well control at a minimum cost.

2.1 *Application of the Technique*

As an introduction to the application of the paleogeomorphic methodology to the chosen Appalachian Basin problems, a discussion of some past successful application is appropriate. The two examples presented here are from the Permian Basin of Southeastern New Mexico. Specifically, these examples are from Pennsylvanian age rocks, which were deposited in a transitional marginal marine environment similar in many ways to the pre-Mississippian deposition of the Appalachian Basin.

The Permian Basin of Southeastern New Mexico (Figure 3.0) is a cratonic downwarp of Paleozoic age which hosts deposition ranging from restricted shelf or lagoonal environments (i.e., clastics, evaporites, limestones, and dolomites), to shelf edge reef facies, and finally into restricted marine basin environment (i.e., basinal micrite, sandstone, and gravity displacement products which have been identified as debris flows, turbidites and/or fluid density flows). These sequences have been extensively studied in subsurface and outcrop; still in dispute is the interpretation of many important features such as the nature of the "reef" buildups, the extent of subaerial exposure, and early freshwater diagenesis of the shelf, reef, and slope deposits. Oil and gas in the Permian Basin is produced not only from strata behind the shelf margin, but also from shelf edge, especially reef facies, and deep water deposits.

The Delaware Basin and the Northwestern Shelf (exclusive of the Central Basin Platform) have distinct sequences of deposition, and each sequence is bound by a diastem, hiatus, or other unconformity. Each sequence can be related to regional tectonic re-adjustment. Re-adjustment is directly related to the transgressive-regressive sedimentary history noted by other workers. The paleogeomorphic maps presented here have been extracted from regional studies.

The following examples were chosen because they may provide analogs to the depositional conditions found in the Appalachian Basin of New York. The first discussion involves the Lower Pennsylvanian (Atoka-Morrowan) clastic carbonate assemblage identified as the Atoka Morrow Formations. Where productive, the Morrow Formation is an essentially clean, quartzose sandstone with interstitial porosity and permeability. When traced across the Permian Basin, the Atoka-Morrow sequence transitions from a continental environment, to a marginal marine environment, to a deeper marine basin environment. Atoka-Morrow reservoirs, when located in the optimum paleogeomorphic position, are noted for higher initial flows, quick payout of investment, and effective lifespans of 10-15 years of optimum production.

The second discussion included here involves the Upper Pennsylvanian (Virgilian) patch reefs (bioherms), which are locally identified as either Cisco or Permo-Penn reservoirs. These bioherms formed in a marginal marine environment on localized high spots on the depositional basement. As a genetic type, the carbonate assemblage which includes these localized bioherms may be similar to the Ordovician, Silurian, and Devonian depositional environments of Eastern New York State. When located in optimum paleogeomorphic positions, wells drilled into Virgilian bioherms can yield 200,000 to 450,000 barrels of oil and an equivalent amount of natural gas or condensate. A typical field can yield between 2-3 million barrels of oil from 6-8 wells.

2.1.1 The AM Interval

The Morrow Formation of Southeastern New Mexico is one of the more significant natural gas producing formations in the Delaware Basin. The AM paleogeomorphic mapping interval (Figure 4.0), comprised of the Atoka and Morrow Formations, represents the initial depositional environment in the post-Mississippian Basin. An overview of the tectonic elements in Early Morrowan time would show the Central Basin Platform, the Matador Arch, and the Pedernal Massif surrounding a broad peneplain (Figure 5.0). Along its northern border, the contact between the Matador-Pedernal feature and the Morrowan peneplain has been demonstrated to be a normal fault (Pitt, 1973) with as much as 500 ft. of stratigraphic separation.

By late Early Morrowan times, clastic debris shed from the various positive areas formed alluvial fans which eventually coalesced and formed a broad, featureless alluvial plain. At the same time, a warm water sea transgressed from the south-southeast and formed a marginal marine environment adjacent to the alluvial plain. Eventually, this marginal marine zone prograded north-northwestward into a basinal clastic environment with the stabilization of the of the transgressing sea. The facies represented by the transgressing sea in Southeastern New Mexico have been discussed in detail by L. Mazzullo (1984).

Alluvial channels developed in the alluvial plain, and were filled with medium and coarse grained sand. These channels were similar, both in method of formation and physical appearance, to the arroyo channels which currently cut the area. Instead of implying a genetic classification, the terminology "channel" is used to describe the linear shaped paleogeomorphic thinning mapped in the AM interval in Southeastern New Mexico.

By Late Morrowan time, the initial influx of clastic sediments had decreased, and deposition had changed from fine grained clastics to sandy carbonates. The Upper Morrow and Atoka are represented by massive sandy limestones with discontinuous beds of fine grained sandstone. The most noteworthy of these is a relatively thick (50-75 ft.) layer of fine sandstone found at the top of the AM interval. The top of the sandstone layer represents a diastem or hiatus surface, because the carbonates of the Strawn Formation suggest a different depositional environment than those in the Upper Atoka Formation.

Exploration for both Morrowan and Adjoin reservoirs offers the challenge of trying to identify a very subtle stratigraphic trap with limited subsurface control. The use of seismic stratigraphy has proven largely ineffective in the direct location of hydrocarbon bearing channels in these rocks. Over a seven year period, greater than 90% of all Morrow prospects reviewed by Pyron Consulting were seismically oriented; when drilled, over 75% were either dry holes or were uneconomic to complete. Further, reliance on seismic has caused many companies to abandon township-sized lease plays based on the results of one or two dry holes. This decision overlooks the possibility that as many as two or three wells per section may be needed to properly define the channels with AM potential. In addition, other potential reservoirs may exist in the AM interval.

2.1.1.1 Example - Carlsbad Field

The Carlsbad Field is located in T 22 S, R 26,27 E of Eddy County, New Mexico, near the city of Carlsbad (Figure 6.0). The field was discovered in 1968, and was developed during the 1970's and 1980's. Production is located in the Morrow sand pay. As of 1985, the field produced in excess of 0.21 TCF of natural gas from 100 wells, or roughly 2.0 BCF per well. Approximately 45% of all of the wells in the field have produced in excess of this amount. Condensate or light oil is an associated by product of these wells.

The paleogeomorphic map for this field, presented in Figure 7.0, uses the AM interval for subsurface mapping purposes. The linearity and sinuosity that one would expect from alluvial channels is present. Detailed study of the well logs shows an increase in permeability, porosity, and net sand pay for wells located in the thinned areas. Wells located in the thinned areas also show an increase in cumulative production, although it should be remembered that cumulative production is a function of both completion techniques and operating skill, as well as geology.

2.1.2 The CI Interval

During the Late Pennsylvanian (Virgillian), a broad carbonate ramp formed in a marginal marine environment. Deposition consisted of a dark gray to black micritic limestone interrupted by localized biohermal accumulations of a lighter grey to buff fossiliferous "reef" limestone. Tectonically, the major extensional events of the Early and Middle Pennsylvanian had finished. A warm water sea had covered the entire basin, with the exception of the Matador-Pedernal positive areas and the Central Basin Platform. Neither of the positive areas contributed sediment to the depositional system. Deposition in the Virgilian interval occurred in broad carbonate platform, which had localized buildups of bioherms, and a restricted depositional trough, which had interbedded micritic limestones and very fine grained sandstones.

While local workers refer to the carbonate buildups as patch reefs, Cys and Mazzullo (1986) note that they are more properly classified as phylloidal algal bioherms. They developed on selected depositional or erosional highs having favorable conditions. Many local geologists suggest that the presence of the Middle Paleozoic Tatum Basin restricted the lateral distribution of these bioherms. Regional geological mapping by the Pyron Consulting suggests that the Tatum Basin did not exist by CI time; it had been neutralized by Early Pennsylvanian deposition.

The mapping interval used by Pyron Consulting to model Virgilian bioherms is identified as the CI interval (Figure 8.0). The CI interval encompasses those rocks identified by workers in Southeastern New Mexico as Permo-Penn, and includes pay zones known as the Bough Zones and the Cisco. There is considerable debate as to whether these rocks can properly be defined as belonging to the Wolfcampian (Lower Permian) or the Virgilian (Upper Pennsylvanian) systems. Paleontological evidence from cores and cuttings noted by Cys and Mazullo, 1985, suggests that the zone is transitional. Using the CI interval avoids this issue because that map interval represents a lithostratigraphic depositional sequence, and, as such, cuts across time boundaries but not unconformities. The CI interval relates more to deposition than to time intervals.

The CI interval represents a discrete depositional sequence that is bound by very subtle unconformities, probably diastems, on both its upper and lower contacts; Figure 8.0 shows a representative type section of this interval. The lower contact represents the transition from Canyon (Missourian) to Cisco (Virgilian) rocks. The Upper Canyon is typically a limy sandstone with a carbonate cement; the contact between the Canyon and Cisco is both distinctive in sharpness and persistent laterally across the basin. The contact between the Canyon and the Cisco is a diastem or hiatus, with each formation representing a unique depositional environment.

The upper contact of the CI interval has an even more subtle nature; on electric logs and sample logs, there is a persistent marker lying above the Bough A zone (Cys and Mazzullo, 1986, p.281, Figure 17-3). This marker is identified as a shale; in some areas, it is red shale, in others, it is dark gray to black shale. This marker represents a transition from the CI depositional sequence to the overlying Wolfcampian interval.

2.1.2.1 Example - Morton Field

The Morton Field (Figure 9.0) is located in T 14,15 S, R 34,35 E of Lea County, New Mexico; it was discovered in 1967, and has produced in excess of 2.5 MMBO. An excellent technical article on the Morton Field was done by Cys and Mazzullo (1985). The Morton Field produces from a fractured buff to white chalky limestone which is found at an average depth of 10,500 ft. Reservoir parameters included fractured to vuggy porosity of 10%, permeability of 42 md, and an average calculated water saturation of 26%. The formation yields 42-43 degree gravity API sour oil. Significantly, it is reported that in the discovery well there was no reported cut, fluorescence, or staining of the pay zone. The well was still completed, presumably on good log response.

The Morton Field map is based on the previously identified CI interval. The paleogeomorphic map shows several small thinned areas which may be related to bioherm development. Most productive wells in the field are located in or adjacent to these closures. The size of the thinned areas in both the Morton and Tulk Field examples is less than 80 acres. With exploration logic and proration units often limiting drilling to one well per section, production can often be overlooked, even with reliable structure maps and seismic.

3.0 STATISTICAL BASIS OF THE TECHNIQUE

When a new technology is introduced to the marketplace, there is a period of time required to validate it by independent observers or users. If the technology is associated with manufacturing, or data processing, it is easier to validate the effectiveness of the technology by measuring a relative increase in productivity, or a relative reduction in the cost of operation, that application of the technology creates. It is more difficult to measure the effect that the application of a conceptual technology has on its marketplace.

An approach at gauging the effect that a conceptual technology has, and which is scientifically rigorous, is to apply the technology to demonstration area, then following the demonstration area's historic development. By plotting the success of drilling versus the position of wells relative to a mapped paleogeomorphic feature, one can develop a statistical basis to review the technique.

Pyron (1996) provided a statistical discussion of the application of paleogeomorphic mapping to a relatively new field area in the Permian Basin of New Mexico. The Shipp Field is located in Lea County, New Mexico, and produces from a Strawn (Middle Pennsylvanian) carbonate at a depth of 10,500 feet. In 1984, Pyron Consulting recommended a block of acreage for acquisition based on his regional paleogeographic mapping. While his client was not successful in acquiring the lease block, subsequent exploratory and developmental drilling revealed the Shipp Field.

In 1995, Pyron Consulting reviewed the development history of the Shipp Field and remapped it using the new well data and the same paleogeomorphic interval. In the eleven years following the 1984 mapping project, a total of 36 wells were drilled in the recommended block. Of these wells, 22 were drilled within the paleogeomorphic high, 10 wells were located outside the paleogeomorphic high and were plugged and abandoned, and 4 wells were temporarily abandoned. The wells which were located within the paleogeomorphic high averaged 308,326 barrels of oil and 600,492 MCF of natural gas per well. Those wells which were located outside of the paleogeomorphic high averaged 26,781 barrels of oil and 40,865 MCF of natural gas per well. This demonstrates a significant difference in the location of wells which demonstrates the power of paleogeomorphic technique.

The valuation study of the field is even more diagnostic. Using a standard price of $15.00 per barrel of oil and $1.65 per mcf of natural gas, which were the historic prices for the commodities during the eleven year study period, the valuation of the hydrocarbons for a typical well within the paleogeomorphic high was $ 5.62 million. The valuation of the hydrocarbons for wells located outside of the paleogeomorphic high was $ 469,000.00. Presuming a cost of drilling and operation of $950,000 per well, then the calculation of return on investment (ROI) for wells inside of the paleogeomorphic high was 4.92:1, while wells located outside of the palegeomorphic high did not return their initial investment.

If the Shipp Field is viewed as a unit, then the 22 productive wells located within the high have a calculated value of $123.55 million, using the standards established above. The cost to drill and operate these wells was $20.9 million. The ROI for the wells located within the paleogeomorphic high was 5:91:1.

Similar studies have been completed by Pyron Consulting for application of the paleogeomorphic technique to demonstration areas in the Eagle Basin of Colorado, the Bighorn Basin of Wyoming, the Salinas and San Joaquin Basin of California, and the Black Warrior Basin of Alabama, and identified similar economic results. Empirical evaluation of the paleogeomorphic technique consistently demonstrates that it preferentially locates wells in optimum positions which optimize recovery and maximize profitability.

4.0 EXPLORATION PROBLEM #1 - MODELING AN EXISTING FIELD

The Appalachian Basin is a Paleozoic basin of approximately 100 million acres which extends over ten states (Figure 10.0). Historically, exploration in the basin is said to have begun in 1859 with the Drake well in Titusville, PA., and many oil and gas historians cite this well as the beginning of the North American Oil and Gas industry. The Appalachian Basin hosts well over 500,000 oil and gas wells, which have an average depth of 3,700 feet. Production, primarily natural gas, comes from Pennsylvanian, Mississippian, and Devonian Formations. Additional development occurs in Silurian, Ordovician, and Cambrian age rocks; these older Paleozoic formations generally form the basis for new exploration in the basin.

The regional structure of the basin has been affected by the thrusting which formed the Appalachian Mountain range, known informally as the Eastern Overthrust. This thrust faulting is important because it creates zones of fractured porosity and localized structural traps. Secondary porosity formation is essential to the economics of production, especially in the eastern portion of the basin, because naturally occurring interstitial porosity is rare, especially in clean silicilastic sediments, like the Oriskany Sand.

Source rocks for hydrocarbon generation are broken up into two sequences. The younger sequence includes marine shales of Middle Devonian to Early Mississippian age. The older sequence consists of marine shales and nodular limestones Middle to Late Ordovician age. In addition, there are interbedded limestones, coal beds, and siltstones which might provide regional sources of hydrocarbon for individual reservoirs

4.1 *Geology of the Tioga County Study Areas*

Two of the problems modelled in this investigation are based in Tioga County, New York. By way of introduction, a discussion of the stratigraphy of the region will provide a framework for evaluation of the paleogeomorphic model created.

Tioga County was chosen because it is located at the transition of the Devonian Catskill Delta from marginal marine to deep marine depositional environments. The deeper Devonian basin lay to its south and east. Deposition in the proto-basin transitioned from carbonates in early Devonian time through clean sandstones in the middle Devonian though dark organic shales in the Middle through Upper Devonian as the Catskill Delta prograded into the basin proper.

4.1.1. Regional Stratigraphy of the Area

4.1.1.1 Devonian Formations

Upper, Middle and Lower Devonian rocks of southcentral New York constitute one of the more complete Middle Paleozoic stratigraphic sections in North America. Drilling and logging of oil and gas wells in search of the economic resources (oil , natural gas) associated with the unique depositional environment found in this section has created a database which has allowed more detailed analysis and documentation of subsurface conditions in the respective sequences of rocks. In this discussion, Pyron Consulting opts for the more familiar terminology used by exploration geologists in identifying formation tops on geophysical well logs. This terminology may not be as precise or as rigorous as the many detailed investigations on the three dimensional geodynamics of deposition, that have been conducted by more academic geologists, but serves the purpose of identifying regional and local transitions, hydrocarbon prone structures, and areas with potential for testing.

In our discussion of the Devonian, Pyron Consulting recognizes three general groupings of rocks: the Genesee Group, the Hamilton Group, and the Helderberg-Onondaga Group. The Genesee Group consists of a thick sequence of organically derived shales. In many studies, the Genesee is considered one of the more significant tongues of deposition which comprise the Catskill Delta. Locally eroded, the sequence is not completely present in Tioga County. At the base of this sequence lies the Tully Limestone. Based on the analysis by Heckel (1966), the Tully is a significant formation in that deposited on and represents a significant unconformity between Genesee and Hamilton sequences. In addition, the Tully also represents a significant lateral facies change from a clastic equivalent further east, to a carbonate over much of the Appalachian Basin province.

The Hamilton Group is considered by many observers to be the precursor of the Catskill Delta. It is composed on a thick sequence of black and gray organic shales which apparently represent a cyclical depositional cycle, as well as a perceived upward coarsening of sediments within a given cycle (Landing and Brett, 1991). Within this sequence of rock, two formations, the Cherry Valley Limestone and the Marcellus Shale have been identified as easily recognized markers within the Hamilton Group, and have been used for structural isopach mapping.

The last Devonian interval of significance in this investigation is the Helderberg Onondaga grouping. This interval includes a basal carbonate member (the Helderberg Group), a middle arenaceous sandstone member (the Oriskany Sandstone) and upper carbonate member (the Onondaga Limestone Group). These rocks were deposited in a near shore marginal marine transition zone. They are of importance in this study because the Helderberg and the Oriskany form significant reservoirs in the Appalachian Basin. As a result, there is a great deal of subsurface data on these interval, especially as a result of exploratory drilling.

4.1.1.2 Pre-Devonian Rocks

The Devonian rocks of Tioga County unconformably overlie Silurian evaporites of the Salina Group. A Silurian Age "salt basin" formed to the south of Tioga County, and allowed deposition of gypsum, anhydrite and halite. Rickard (1969) noted the similarity and uniformity of deposition of the evaporitic sequence in both the Appalachian and Michigan Basins, with the exception that the barrier reefs found in the Michigan Basin are not found rimming the Appalachian Basin.

Both Cambrian and Ordovician rocks are believed to underlie the Silurian in the study area. When initially conceived, this project was to include modeling of Silurian and older rocks. However, since the base of data available to Pyron Consulting included only a few wells which penetrated the upper 100 feet of the Silurian, further evaluation or modeling of Pre-Devonian rocks could not be completed.

4.1.2 Structural Geology

In the context of this report, structural geology is meant to include those features which affected the deposition or post depositional history of Devonian and older rocks. There are numerous mapped anticlines and synclines in the study area. Many of these feature are the result of Appalachian orogeny, and may have had minimal effect on the entrapment of hydrocarbons.

More importantly, through the investigation of the Stagecoach field, Pyron Consulting became aware of localized and regionalized faulting which apparently was contemporaneous with Middle and Upper Devonian Deposition. The cause of this faulting is not well known, but is presumed to be related to either deep basement readjustment, or adjustment associated with the post-Acadian orogeny.

4.2 *The Stagecoach Field of Tioga County, New York*

The Stagecoach Field is located in southeastern Tioga County, New York. It was discovered in 1987 with the drilling of the Belden and Blake (Quaker State) #1 Fyock well. The field was confirmed with the drilling of the Belden and Blake (Quaker State) #1 Racht well. Operation of the productive wells in the field, and additional developmental drilling, was transferred to Belden and Blake Corporation in the early 1990's.

Currently, there are 12 productive wells and 15 dry holes in the Stagecoach Field area. As on early 1996, cumulative production from the field was 7.88 billion cubic feet of natural gas, with close to half of that production coming from two wells, the Belden and Blake W. Widell # 1 (2, 295.36 MMCF) and the Belden and Blake E. Campbell # 1 (1,792.65 MMCF). The enclosed well index (Table 1.0) and well location map (Figure 11.0) provides detailed information on the wells located in the Stagecoach Field. In addition, Appendix B provides well reports for each well.

Production in the Stagecoach field is listed by the state agency as being from the upper Helderberg Formation. Discussion with the field operators suggests that they believe that production is associated with a significant fracture which intersects the Oriskany Sandstone. Of even greater interest is that these wells are producing dry natural gas, with very little associated water. Based on review of NYDEC files, it appears as though many of these wells are producing through natural flow, with no completion or induced fracturing treatments. A type log for the field, the W. Widell #1 (Figure 12.0), shows very clearly the pronounced fracture at the top of the Helderberg section.

4.2.1 Subsurface Evaluation of the Stagecoach Field

When the mapping project was initiated, Pyron Consulting spent time assembling data for the study areas. This included accessing basemaps and well history data at the Division of Mines and Mineral Resources, New York Department of Environmental Conservation offices in Albany and Avon, New York. As part of the operational procedure, Pyron Consulting established a file for each well identified in Tioga County. In this file were placed the following documents, if available:

- NYDEC completion form
- A well log recording porosity parameters
- A well log recording resistivity parameters
- A Petroleum Information completion card
- A sample description
- Cumulative and initial production data
- Anecdotal information on the well

In addition to this information, Pyron Consulting accessed copies of NYDEC's GIS base maps for Tioga County. These maps allowed a relatively precise location well bores in the study area. This map was in turn scanned into Pyron Consulting's computer workstation to create a digital product for subsurface mapping.

Using the assembled data, Pyron Consulting began assembling subsurface maps on select intervals based on well log interpretation, and interpolation. First, traditional structure maps were assembled by subtracting the top of the mapped interval from the ground level elevation of the well bore to get the respective subsurface datum. Structure maps were assembled for the following datum:

- Top of the Devonian (Figure 13.0)
- Top of the Tully Limestone (Figure 14.0)
- Top of the Cherry Valley Limestone (Figure 15.0)
- Top of the Onondoga Limestone (Figure 16.0)
- Top of the Oriskany Sandstone (Figure 17.0)
- Top of the Helderberg Limestone (Figure 18.0)

Upon completion of the structural mapping, a second series of maps based upon the isopachous thickness of select intervals. An isopach map is prepared by subtracting the depth to the top of the selected interval from the depth to the bottom of the selected interval. The following isopach maps were prepared for this investigation:

- Tully Limestone Thickness (Figure 19.0)
- Cherry Valley Thickness (Figure 20.0)
- Onondoga Limestone Thickness (Figure 21.0)
- Oriskany Sandstone Thickness (Figure 22.0)

Finally, a paleogeomorphic or synchronous high map was constructed for the field area (Figure 23.0). The upper interval selected was the top of the Cherry Valley Limestone, which many workers believe represents an unconformity surface. The base of the interval is the top of the Silurian. In those wells in which the Silurian was not encountered, interpolation of the projected top of the Silurian was completed by correlation between wells. This interval is referred to as the First Derivative Interval, and it represents the type of intervals that would be mapped under the paleogeomorphic mapping method.

4.2.3 Analysis of the Subsurface Data

The subsurface mapping exercise in the Stagecoach Field provides an interesting evaluation of the subsurface conditions in the field area. To evaluate these maps, the following evaluation parameters were established:

1. The datum points for a particular interval represent possible conditions in the subsurface.
2. The interpolated maps provide a reasonable interpretation of subsurface conditions and relate well to the production history of the wells.
3. When all data for the area is integrated, the synergized history can be represented by the cumulative, per well production.
4. Based on the derived mapping, suggestions can be made which will either highlight new development opportunities, or will provide a logic for the development of an exploration model that can be used elsewhere in the basin.

Using these evaluation parameters, several interesting interpretations can be made based upon the subsurface data.

- Without exception, the structural maps created on various datum were neither sensitive nor reliable enough to relate to cumulative production. As a result, these maps were not reliable indicators of production. The structure map based upon the Top of Devonian datum was interesting because it apparently shows the location of fault blocks under the field boundaries. Given this interpretation (which has not been verified either by seismic investigations or evaluation of published structure maps), it is easy to understand why faulted reservoirs are so significant to production in this field.

- The isopach maps which were prepared are slightly more reliable indicators of production, but still not sensitive enough to equate to cumulative production histories. Of greater interest are the isopach maps showing thickness of the Oriskany Sandstone, and the thickness map of the Tully Limestone. In the former, the interpreted thickness of the Oriskany sand increases to greater than 90 feet along the center of the field. (It is important to recognize that sand thickness is not an indicator alone of reservoir quality; the presence of fractures is also very important). The Tully Limestone isopach map shows thinning of this interval over the top of the field.

- The paleogeomorphic map based on the First Derivative Interval is the most sensitive map interval produced during the subsurface mapping program. This map identifies interval thinning typical of a paleogeomorphic high. Thinning of the mapped interval is synonymous with hydrocarbon accumulation and production.

Based upon integration of the subsurface mapping, production data, and other subsurface information, it is apparent that several of the subsurface maps which were created can be directly applied to hydrocarbon occurrences in the Stagecoach Field. Using the criteria established above, it appears that the First Derivative Interval , a paleogeomorphic map, is an indicator of for the location of economic amounts of hydrocarbons. Those wells which are proximate to the 600 foot thickness interval on this map show the best production, most probably because fractures intersected by the well bore tap the prime reservoir, which lies within the 600 foot interval.

As verification of this analysis, the production history of select wells in the field provides a good basis for appraising the validity of application. The Belden and Blake (Quaker State) #1 Widell well (cumulative production - 2.295 BCF) has a First Derivative Interval thickness of 644 feet, while the Belden and Blake (Quaker State) #1 Campbell well (cumulative production - 1.793 BCF) has a First Derivative Interval thickness of 645 feet. By comparison, the Belden and Blake (Quaker State) #1 Fyock (cumulative production - 8.9 MMCF) has a First Derivative Interval thickness of 718 feet. This corroborates the assumption that wells located closer to the paleogeomorphic thin (i.e., thinning of the interval) with well established fractures will host more economic production than similarly fractured wells located in thicker paleogeomorphic intervals.

A second interval which may be an indicator of production at depth is the Tully Limestone thickness. There appears to be a correlation between thinning of the Tully interval and production in the Stagecoach Field, with significant production being associated with the 75 foot thickness interval. Figure 24.0 shows the relationship between production and the isopach interval.

Thinning of the Tully Limestone may be related to the presence of a paleo-structure under the surface of deposition. In other areas, Pyron Consulting has noted that chemically precipitated sedimentary rocks (i.e., limestone, dolomites, anhydrites, and even bedded salts) have often formed a marker bed overlying structures which have hosted hydrocarbon accumulations. If a paleo-structure was formed simultaneously with deposition of a limestone, then the limestone would be thinner over the structure. Presuming that there was no post limestone deposition erosion, then the thinning of the limestone bed is diagnostic of the underlying paleo-structure, whether or not that structure exists now.

In the Stagecoach Field example, thinning of the Tully Limestone can be correlated with thickening of the underlying Oriskany Sandstone. Genetically, this thickening of the Oriskany Sandstone looks like a "channel" deposit. In this usage, channel is used not to imply a fluvially generated geological formation, but is used to represent a linear clastic deposit whose origin may vary from deltaic deposit to strand deposit to marginal marine deposits. An interpretation of the breadth of the "channel is provided in Figure 25.0.

Based upon this mapping, it appears that several infill positions still remain to be developed in the Stagecoach Field. More importantly, the model developed here could be used on a regional basis to develop additional exploration targets in the county.

5.0 EXPLORATION PROBLEM #2 - MODELING A REGION WITH POTENTIAL

The second exploration problem studied here involves application of the paleogeomorphic technique on a regional basis. Specifically, it involves applying the model developed for the Stagecoach Field to determine whether other untested features can be identified in the exploration fairway. If there are features identified using either the First Derivative Interval or the Tully Limestone isopach, then a case can be made that these features are analogs to the mapped Stagecoach Filed, and that they hold the potential for hosting economic reserves, in addition to being viable exploration targets.

5.1. *Regional Geology, Tioga County, New York*

5.1.1 Stratigraphy and Structure

The stratigraphy of Tioga County is similar to that identified in the Stagecoach Field discussion (above). On a regional basis, Devonian strata begin to thin to the north, and thicken to the south and southwest. In addition, there is a pronounced facies change from a marine to marginal marine (delta) to continental from the west to the east.

For the purposes of this investigation, Pyron Consulting uses the well log signatures of formation names. These are derived from the many academic, detailed sedimentological and biostratigraphic studies previously completed, and provide a basis for regional evaluation of distribution of formations.

Key formations on the regional evaluation of Tioga County include the Tully Limestone, the Onondaga Formation, the Oriskany Sandstone and the Helderberg Group. The base of data used in this investigation is limited to well logs which as a generalization do not completely penetrate the Helderberg Formation. Given this limited data, key structural, isopachous, and paleogeomorphic maps have been prepared for the second study area.

Regional studies completed by Rickard (1969,1973,1989) were very useful in providing a sense of the regional relationship of the various formations. They also provided information on regional faulting, especially in the Tioga County area. Several pairs of normal faults form a series of downdrop structures across central and extreme northern Tioga County. These faults are apparently pre-Devonian in age, and seem to have effected the amount of deposition in the respective downdrop block.

5.1.2. Well History

In Tioga County, outside of the wells located in on trend with the Stagecoach Field, there are a total of eleven identified exploratory wells (Figure 26.0). Information for two of these wells, the Sawyer well, which was drilled in 1888, and the Dwight D. Decker well, which was drilled in 1931, could not be found in any of the data repositories checked. Information for an additional two wells, the Tioga Utilities C. Miller #1 (drilled in 1931), and the New York Natural Gas W.E. Stevens #1 (drilled in 1947), was only partially incomplete. The following wells had complete information (i.e., well logs completion cards and associated information) and formed the basis for this evaluation:

- Shell Oil Company Francis Robinson Unit #1 and the Klasner #1 (both drilled in 1973)
- Arlington Exploration Glenn O Tiffany #1 (drilled in 1982)
- Susquehanna Natural Gas K. Pompelly #1 (drilled in 1930)
- Quaker State Oil Company Robinson #1 (drilled in 1986)
- Fault Line Oil Van Riper Unit #1 and the Spencer et. al. Unit #1 (drilled in 1990)

Pertinent information on these wells is provided in Table 2.0. A well location map is provided as Figure 27.0 and well top information is provided in Appendix C.

5.2 Subsurface Evaluation

As discussed above, Pyron Consulting assembled data and base maps for the identified wells. Using the assembled data, Pyron Consulting began assembling subsurface maps on select intervals based on well log interpretation, and interpolation. First, traditional structure maps were assembled by subtracting the top of the mapped interval from the ground level elevation of the well bore to get the respective subsurface datum. Structure maps were assembled for the following datum:

- Top of the Tully Limestone (Figure 27.0)
- Top of the Cherry Valley Limestone (Figure 28.0)
- Top of the Onondoga Limestone (Figure 29.0)
- Top of the Oriskany Sandstone (Figure 30.0)
- Top of the Helderberg Limestone (Figure 31.0)

Upon completion of the structural mapping, a second series of maps based upon the isopachous thickness of select intervals. An isopach map is prepared by subtracting the depth to the top of the selected interval from the depth to the bottom of the selected interval. The following isopach maps were prepared for this investigation:

- Tully Limestone Thickness (Figure 32.0)
- Cherry Valley Thickness (Figure 33.0)
- Onondoga Limestone Thickness (Figure 33.0)
- Oriskany Sandstone Thickness (Figure 34.0)

Finally, a paleogeomorphic or synchronous high map was constructed for the field area (Figure 35.0). The upper interval selected was the top of the Cherry Valley Limestone, which many workers believe represents an unconformity surface. The base of the interval is the top of the Silurian. In those wells in which the Silurian was not encountered, interpolation of the projected top of the Silurian was completed by correlation between wells. This interval is referred to as the First Derivative Interval, and it represents the type of intervals that would be mapped under the paleogeomorphic mapping method.

5.3 Analysis of the Subsurface Data

The subsurface mapping Tioga County provides some subsurface clues to the location of additional exploratory targets. To evaluate these maps, the following evaluation parameters were established:

1. The datum points for a particular interval represent possible conditions in the subsurface.
2. The interpolated maps provide a reasonable interpretation of subsurface conditions and relate well to the production history of the wells.
3. When all data for the area is integrated, the synergized history can suggest new exploration targets. The derived mapping provides the logic for the development of an exploration model that can be used elsewhere in the basin.

Using these evaluation parameters, several interesting interpretations can be made based upon the subsurface data.

- Without exception, the structural maps created on various datum suggest that structures formed within the individual downdrop blocks. These individual structure (which might be referred to as closures) seen to trend north-south, although this may be a result of the distribution of data points, or a bias in the method of contouring. A significant structure (designated Target A) is located in the downdrop block immediately north and west of the Stagecoach Field. A second smaller structure (Target B) is located in the northwestern quadrant of Tioga County. Given this interpretation (which has not been verified either by seismic investigation) it is possible that these features might constitute viable exploratory targets.

- The isopach maps which were prepared also suggest the presence of potential exploration targets in the downdrop block north and west of the stagecoach field. The isopach maps showing thickness of the Oriskany Sandstone, and the thickness map of the Tully Limestone. In the former, the interpreted thickness of the Oriskany sand increases to 110 feet in the area estimated to be the ultimate trap for Target A. In Target B, the Oriskany Sandstone has an estimated thickness of 20 feet. (It is important to recognize that sand thickness alone is not an indicator alone of reservoir quality; the presence of fractures is also very important). The Tully Limestone isopach map shows significant thinning over both Target A and Target B, and this may be more suggestive of the location of the ultimate trap.

- The paleogeomorphic map based on the First Derivative Interval, the most sensitive map interval associated with the Stagecoach Field, identifies Target A as having significant interval thinning typical of a paleogeomorphic high. The ultimate trap identified in this interval seems to fall in the southern half of the downdrop block. Interpretation of the offsetting well, the Susquehanna Natural Gas Pompelly and Harris #1, would allow projection of the top of the Oriskany sand at a depth of 4,000 feet. The mapping for Target B is not as successful, as there is only one datapoint in which Pyron Consulting feels confident. However, the sum of data for this target is enhanced by a reported show of natural gas in the Oriskany Sand in the NYS Natural Gas W.E. Stevens well. This well offsets what should be the paleogeomorphic high. Using the Stagecoach Field experience as a model, thinning of the mapped interval is an effective indicator hydrocarbon accumulation and production.

Based upon integration of the subsurface mapping, production data, and other subsurface information, it is apparent that several of the subsurface maps which were created can be directly applied to hydrocarbon exploration in Tioga County. Using the criteria established above, it appears that the First Derivative Interval, a paleogeomorphic map, is an indicator of where economic amounts of hydrocarbons may be located. By analog to the Stagecoach Field, those wells which fall within a mapped thinning of the paleogeomorphic interval have a better than average change of holding hydrocarbons.

6.0 EXPLORATION PROBLEM #3 - MODELING AN AREA FOR GAS STORAGE POTENTIAL

The third exploration problem for this project was evaluation of the geology of an area that was close to the Iroquois Pipeline for its potential for natural gas storage. The area chosen for this evaluation included those portions of Sullivan and Ulster Counties, New York, which are north and west of the thrust fault that essentially delineates the Appalachian Mountain thrust. Upon collection of subsurface data for the study area, it became apparent that the subsurface control in the area was sparse (i.e., four data points) and limited to the Devonian section. These constraints certainly limited the evaluation of the lower Paleozoic section. However, the data that have been collected can provide a preliminary evaluation of the Devonian section for storage potential.

6.1 *Geology of the Sullivan and Ulster County Study Area*

The Sullivan Ulster County study area (Figure 36.0) is unique in that hosts a complete section of Devonian rocks which are associated with the Upper and Middle Devonian Catskill Delta. Deposition in the study area was associated with the Appalachian Basin, a depositional trough which formed to the west of the Appalachian Mountains. Based upon structural maps based on the Precambrian datum, as much as 20,000 feet of sediments were deposited in this trough. The northwestern edge of this basin is located in the study area.

A second geologic feature is the thrust fault which defines the edge of the Appalachians. Known locally as the Port Jarvis trough, the trend of the fault extends from the southeastern corner of Sullivan County across southern and eastern Ulster County. To the south and east of this trend, Ordovican and Silurian rocks are exposed. Several oil and gas test wells in this area reveal a significant stratigraphic section. It is inferred that these Silurian and Ordovician rocks are also found at great depth in the study area.

6.1.1 Structural Geology

Soren (1961) notes that most of Sullivan County lies on the eastern arm of a broad northeast trending syncline, which may be the surface expression of the previously mentioned Appalachian Basin depositional trough. A series of folds are superimposed on this regional structure, but these folds are difficult to trace for any great extent.

Faulting associated with the formation of the Appalachian Basin is no doubt present in the study area, but these faults are often obscured by Quaternary sediments. There is no documented evidence of surface expression of faulting in the study area. There is evidence of jointing in exposed outcrops of the Paleozoic rocks.

In the literature published and reviewed by the Pyron Consulting, there is no mention of either significant surface structures, or faulting in the study area other than the broad regional features discussed above. Aerial photogrammetry or remote sensing analysis of the study area might reveal such geological features, but neither of these types of studies were available to the Pyron Consulting.

6.1.2 Stratigraphy

The stratigraphy of the study area in Sullivan and Ulster Counties is similar to other areas of the Appalachian Basin. On a regional basis, Devonian strata thicken to the south and southwest. In addition, there is a pronounced facies change from a marine to marginal marine (delta) to continental as one moves to the east.

Key formations on the regional evaluation of Sullivan and Ulster Counties include the Tully Limestone and its lateral continental transition, the Gilboa Formation, the Onondaga Formation, the Oriskany Sandstone and the Helderberg Group. In addition, from the Tully equivalent upward is a complete Upper Devonian section, which is part of the Catskill Delta Complex. This includes a complete section of the Genesee and Catskill Groups which consist of interbedded shales and sandstones. The base of data used in this investigation is limited to well logs, which in the study area completely penetrate the Helderberg Formation. Given this data, key structural, isopachous, and paleogeomorphic maps have been prepared.

Of interest is the relationship and lithologic composition of the Helderberg, the Oriskany, and the Onondaga Group equivalents. These formations are productive elsewhere in the Appalachian Basin, but have only been lightly tested in the study area. Of interest for this study is whether these formations, given their proximity to the thrust faulting of the Appalachian Mountains, have developed sufficient secondary porosity to be considered for storage of natural gas.

6.1.3. Well History

In the Sullivan and Ulster County study area, there are a total of four identified exploratory wells (Figure 37.0). The following wells had complete information (i.e., well logs, completion cards, and associated information) and formed the basis for this evaluation:

- Gulf Oil Corporation F.E. O'Donnell #1 (drilled in 1977)
- Texas Eastern Transmission Shandalee Hunting Club #1 (drilled in 1971)
- Dome Oil and Gas #1 A. Herdman (drilled in 1955)
- Mid-Hudson Dome Oil Company #1 G. Armstrong (drilled in 1957)

These wells are located to the north and west of the thrust faulting which defines the surface expression of the Appalachian Mountains. In addition, three shallow water wells are identified by the NYS Department of Environmental Conservation Oil and Gas Division. These wells were drilled to a depth less than 1500 feet, and were not considered significant for this study.

Further, five wells were drilled to the south and east of the fault zone. While not discussed here, these wells are important for individuals wishing to evaluate the Pre Silurian depositional history of the area.

Pertinent information on the wells located in the study area, and included in this evaluation, is provided in Table 3.0 . Well data records are provided as Appendix D.

6.2 Subsurface Evaluation

As part of this evaluation, Pyron Consulting assembled data and base maps for the study area. Using the assembled data, Pyron Consulting began assembling subsurface maps on select intervals based on well log interpretation, and interpolation. First, traditional structure maps were assembled by subtracting the top of the mapped interval from the ground level elevation of the well bore to get the respective subsurface datum. Structure maps were assembled for the following datum:

- Top of the Gilboa Formation (Tully clastic equivalent) (Figure 38.0)
- Top of the Cherry Valley Limestone (Figure 39.0)
- Top of the Onondoga Limestone (Figure 40.0)
- Top of the Oriskany Sandstone (Figure 41.0)
- Top of the Helderberg Limestone (Figure 42.0)
- Top of the Silurian (undifferntiated) (Figure 43.0)

Upon completion of the structural mapping, a second series of maps based upon the isopachous thickness of select intervals. An isopach map is prepared by subtracting the depth to the top of the selected interval from the depth to the bottom of the selected interval. The following isopach maps were prepared for this investigation:

- Gilboa Formation (Tully clastic equivalent) Thickness (Figure 44.0)
- Cherry Valley Thickness (Figure 45.0)
- Onondoga Limestone Thickness (Figure 46.0)
- Oriskany Sandstone Thickness (Figure 47.0)
- Helderberg Thickness (Figure 48.0)

Finally, a paleogeomorphic or synchronous high map was constructed using the previously defined First Derivative Interval (Figure 49.0). The upper interval selected was the top of the Cherry Valley Limestone, which many workers believe represents an unconformity surface. The base of the interval is the top of the Silurian.

6.3 Analysis of the Subsurface Evaluation

The subsurface mapping in the study provides some subsurface clues to possibilities for storage potential. To evaluate these maps, the following evaluation parameters were established:

1. The datum points for a particular interval represent possible conditions in the subsurface.
2. The interpolated maps provide a reasonable interpretation of subsurface conditions and relate well to the production history of the wells.
3. When all data for the area is integrated, the synergized history can suggest formations which might be amenable for natural gas storage capacity.

Using these evaluation parameters, several interesting interpretations can be made based upon the subsurface data.

- Without exception, the structural maps created on various datum suggest that a broad syncline associated with the aforementioned Appalachian trough cuts diagonally from southwest to northeast across the study area. As a result, the potential for thickening of certain Devonian intervals increases.

- The isopach maps which were prepared also suggest the presence of a syncline across the study area. Horizons which appear to have an increased depositional thickness include the Cherry Valley Limestone, the Onondaga Formation, the Oriskany Sandstone, and the Helderberg Limestone. All of these horizons may have potential for development of storage capacity. Curiously, the Gilboa Formation seems to thin across the suggested syncline. This may be a result of the depositional history or the position of the formation relative to the Catskill Delta.

- The paleogeomorphic map based on the First Derivative Interval identifies significant interval thinning typical of a paleogeomorphic high which is imposed over the axis of the previously identified syncline. Given the nature of paleogeomorphic thining, this feature may suggest that either an oil or natural gas trap exists in this area, or that interstitial and/or fracture porosity and permeability could be found in the Middle and Lower Devonian rocks of the study area.

Based upon integration of the subsurface mapping, production data, and other subsurface information, it is possible that the area associated with a mapped syncline, which transects the central portion of the study area, might be a target for development of a natural gas storage facility. Certainly, given the economics of such a facility, and the proximity to the Iroquois Pipeline, this concept should be given further evaluation.

7.0 CONCLUSIONS

The purpose of this investigation was the demonstration of the effectiveness of the paleogeomorphic mapping technique in locating subtle stratigraphic traps in Appalachian Basin province of New York State. The sensitivity of the technique directly relates to the subsurface conditions which define a hydrocarbon trap (e.g., porosity, permeability, seals, and source material), and this in turn relates to how the mapping interval is chosen, and what the sequence stratigraphy (i.e., depositional environment) for the interval is. The success rate associated with this mapping method promotes the more effective use of exploration capital. This allows the cost of exploration to be significantly reduced and more effective, and this is extremely important in the economic reality in which the domestic oil industry operates.

In addition to modelling the Stagecoach Field, one of the more significant recent discoveries in the Appalachian Basin, the technique identified two additional Devonian exploratory targets in the Tioga County area. It also provided a unique evaluation of a second non-productive area in Sullivan and Ulster Counties, New York. Based on this latter evaluation, an area with potential for either natural gas storage or hydrocarbon exploration has been identified.

Of perhaps greater importance than the physical results of this investigation is that it was completed on a limited budget, with easily accessible, low cost data. If this study were done in an industry exploration setting, the next step would be the directed acquisition of geophysical data, including seismic. By first applying the paleogeomorphic method, the cost of geophysical data would be reduced because its acquisition would be directed towards areas with the best potential. Not only would the data acquisition be more pertinent, but its acquisition would be cost effective. In the new world of exploration, the value of a tool of this type is obvious.

8.0 REFERENCES

Brett, Carlton E., 1986, Dynamic Stratigraphy and Depositional Environments of the Hamilton Group (Middle Devonian) in New York State, Part I, New York State Museum, Bulletin #457

Brett, Carlton E., and Landing, Ed, 1991, Dynamic Stratigraphy and Depositional Environments of the Hamilton Group (Middle Devonian) in New York State, Part 2, New York State Museum, Bulletin #469

Choquette, P.W., and L.C. Pray, 1970, Geological nomenclature and classification of porosity in sedimentary carbonates: American Association of Petroleum Geologists Bulletin, vol. 54, p. 207-250.

Cys, J.M. and Mazzullo, S.J.,1985, Depositional and Diagenetic History of a Lower Permian (Wolfcamp) Phylloid-Agal Reservoir, Hueco Formation, Morton Field, Southeastern New Mexico, in Carbonate Petroleum Reservoirs, Perry O. Roehl and Philip W. Choquette, editors pp.279-288

DeWitt, Wallace, Jr. and Colton, George W., 1959, Revised Correlations of Lower Upper Devonian Rocks in Western and Central New York, AAPG, Vol. 43,no. 12, pp 2810-2828

Dunham, R.J., 1969, Early vadose silt in Townsend mound (reef),New Mexico: Society of Economic Paleontologists and Mineralogists Special Publication 14, p. 139-181.

Finn, Fenton H., 1949, Geology and Occurrence of Natural Gas in the Oriskany Sandstone in Pennsylvania and New York, AAPG, Vol. 33, No. 3, pp 305-335

Frey, M. Gordon, 1973, Influence of Salina Salt on Structure in the New York-Pennsylvania Part of the Appalachian Plateau, AAPG, Vol. 57, no.6, pp 1027-1037

Friedman, G.M., and J.E. Sanders, 1978, Principles of Sedimentology: John Wiley & Sons Publishers, 792 p.

Friedman, G.F., Jackson, D.R., and Worden, C.O., 1986, Reservoir Rocks of the Northwestern Shelf and the Delaware Basin of Southeastern New Mexico, Notebook of the Short Course, SWS-AAPG 1986 Ruidoso New Mexico Meeting, Roswell Geological Society, A.J. Pyron, J.W. Peterson, and R.T. King, editors

Gaddess, Jack, 1931, Deep Sand Development in Tioga County, PA, AAPG, Vol. 15, no. 8, pp 925-939

Garrett, S.G., 1931, Oriskany Gas Fields of Pennsylvania and New York, AAPG, Vol. 15, no. 7, pp 837-839

Gehman, H.M., Jr., 1962, Organic matter in limestones: Geochimica et Cosmochimica Acta, v. 26, p. 885-894.

Grabau, Amadeus W., 1917, Stratigraphic Relationships pf the Tully Limestone and the Genessee Shale in Eastern New York, Bull. Of the GSA, Vol. 28, No.12, pp 945-958

Gray, J.H., 1984, Successful Exploration on a Small Budget, First International Conference on Shallow Oil and Gas Resources, UNITAR, pp 125-129.

Hartnagel, C.A. and Russell, W.L., 1925, The Oil Fields of New York State, AAPG, Vol. 9, no. 4, pp 798-803

Heck, E. T., 1948, New York Subsurface Geology, AAPG, Vol. 32, no. 8, pp 1449-1456

Heckel, Philip H., 1966, Stratigraphy, Petrography, and Depositional Environment of the Tully Limestone (Devonian) in New York State and Adjacent Region, Disertation, Rice University, Houston, TX 448 pp.

Hedberg, H.D., 1964, Geological aspects of the origin of petroleum: American Association of Petroleum Geologists Bulletin, v. 48, no. 11, p. 1775-1803.

Hills, J.M., 1972, Late Paleozoic sedimentation in West Texas,Permian Basin: American Association of Petroleum Geologists Bulletin, v. 56, no. 12, p. 2303-2322.

Hills, J.M., 1979, Delaware Basin sedimentation, tectonism and hydrocarbon generation: in Neil M. Sullivan, ed.,Guadalupian Delaware Mountain Group of West Texas and Southeast New Mexico: Society of Economic Paleontologists and Mineralogists Guidebook, Publication 79-18, 226 p.

Horak,Ralph L.,1985, Tectonic and Hydrocarbon Maturation History in the Permian Basin, OGJ, May 27,1987, pp. 124-129

Irwin, M.L., 1965, General theory of epeiric clear water sedimentation: American Association of Petroleum Geologists Bulletin, v. 49, p. 445-459.

Jones, T.S., and H.M. Smith, 1965, Relations of oil composition and stratigraphy in the Permian Basin of West Texas and New Mexico: American Association of Petroleum Geologists Memoir 4, p. 101-224.

Land, Lynton S., 1982, Dolomitization: Education Course Note Series No. 24; prepared for 1982 American Association of Petroleum Geologists Fall Education Conference, Denver, Colorado.

Mazzullo, Lewis, 1983, Reservoir and clay mineral trends in the Morrow Formation, Southeastern New Mexico, West Texas Geological Society, Vol 23, No.1, pp. 4-9

Meissner, F.F., 1972, Cyclic sedimentation in Middle Permian strata of the Permian Basin, West Texas and New Mexico,in J.G. Elam and S. Chuber, eds., Cyclic sedimentation in the Permian Basin: West Texas Geological Society, p. 203-232.

Middleton, G.V., 1973, Johannes Walther's Law of the Correlation of Facies, GSA Bull., Vol. 84, No. 3, pp. 979-988

Newell, N.D.,Rigby, J.K., Fischer, A.G., Whiteman, A.J., and Hickox,J.E.,and Bradley, J.S., 1953, The Permian Reef Complex of the Guadalupe Mountains, Texas and New Mexico, W.H. Freeman, 287 pp.

Oliver, William A., Jr., 1956, Stratigraphy of the Onandoga Limestone in Eastern New York, Bulle. GSA, Vol. 67, pp. 1441-1474

Perroden, A., 1983, Dynamics of Oil and Gas Accumulation, Bull. de Cent. de Recherche Expl. Prod.,Elf Aquitaine, Memoir 5, 368 p.

Pitt, W.D., 1973, Hydrocarbon Potential of Pre-Pennsylvanian Rocks in Roosevelt County, New Mexico, NMBMMR Circular 130, 7 p.

Pratt,W.E.,1952, Toward a Philosophy of Oil Finding, AAPG, Vol.36, No.12, pp. 2231-2236

Pyron, A.J., 1984, Synchronous High Mapping Aids in Locating Reserves, World Oil, Vol.198, No.4, pp.85-94

" " " " ,1986, Paleogeomorphic Mapping: Aid to Identifying Stratigraphic Traps in the Delaware Basin and the Northwestern Shelf of New Mexico, paper presented to the 1986 SWS-AAPG meeting, Ruidoso, New Mexico

" " " " , 1988, Lowering the Cost of Exploration for Independents: How Remotely Sensed Data Aids in the Search for Oil and Gas, ERIM, International Conference, Houston, Texas, May 15,1988

" " " " , 1991, New Exploration Technologies for Identification of New Guadalupian Production in the Northwestern Shelf Area of the Permian Basin, S.E.NM, Permian Basin Section, SEPM, Field Trip Guidebook, AAPG National Meeting, Dallas, Texas, pp 133-141

" " " " , 1992, An Alternate View of Selected Permian and Pennsylvanian Reservoir Rocks of the Delaware Basin and the Northwestern Shelf of New Mexico: Where Will the Future Reservoirs Be Found? Unpublished manuscript

" " " ", 1995, Remote Sensing Evaluation of the Hydrocarbon Potential of the S.E. New Mexico Study Area, Study for confidential client's NASA Investigation, May, 1995

" " " ", 1995, Sequence Stratigraphy Based Mapping Technique for the Leonardian Bone Springs Pay, WTGS 1995 Fall Field Trip, Fall, 1995

" " " ", 1996, Integrated Exploration Technology (IET) as a Cost Saving Tool for Energy Companies: The Shipp Field, New Mexico Example, A talk presented to the SIPES 1996 Naytional Convention, Dallas, TX

Pyron, A.J., Peterson, J.A. and King, R.T., 1986, Reservoir Rocks of the Northwestern Shelf and Delaware Basin, Southeastern New Mexico, Editor in Chief, SWS-AAPG Meeting, Ruidoso, New Mexico

Ramondetta, P.J., and R.G. Todd, 1969, Permian cyclic strata, Northern Midland and Delaware Basins, West Texas and Southeastern New Mexico: American Association of Petroleum Geologists Bulletin, v. 53, p. 2223-2251.

Rickard, Lawrence V., 1969, Stratigraphy of the Upper Silurian Salina Group, New York, Pennsylvania, Ohio, and Ontario, New York State Museum and Science Service, Map and Chart Series #12, 57 pp plus 14 plates

Rickard, Lawrence V., 1973, Stratigraphy and Structure of the Subsurface Cambrian and Ordovician Carbonates of New York, New York State Museum and Science Service, Map and Chart Series #18, 26 pp plus 19 plates

Rickard, Lawrence V., 1989, Stratigraphy of the Subsurface Lower and Middle Devonian of New York Carbonates of New York, Pennsylvania, Ohio, and Ontario, New York State Museum and Science Service, Map and Chart Series #39, 59 pp plus 40 plates

Ross, C.A., 1986, Paleozoic Evolution of the Southern Margin of the Permian Basin, G.S.A.Bull, Vol.97, no. 5, pp 536-554

Scholten, Robert, 1959, Synchronous Highs- Preferential Habitat for Oil ?, AAPG Bull. Vol.43, No.8, pp.1793-1833

Shumaker, R.C., 1974, Influence of Salina Salt on Structure in New York-Pennsylvania, Discussion, AAPG, Vol. 58, no. 3, 543-544

Soren, Julian, 1961 The Ground-Water Resources of Sullivan County, New York, New York State Water Resources Commission and U.S.Geological Survey, Bulletin GW-46, 66p,2 plates

Torrey, Paul D., 1931, Natural Gas from the Oriskany Formation in Central New York and Northern Pennsylvania, AAPG, Vol 15, no. 6, pp 671-689

Walper, Jack L.,1977, Paleozoic Tectonics of the Southern Margin of North America, GCAGS,Transactions, Vol. 27, pp. 230-241

Weeks, L.G., 1952, Factors of sedimentary basin analysis that control oil occurrence: AAPG Bulletin, v. 36,no. 11, pl 2071-2124.

Willard, Bradford and Stevenson, Robert E, 1950, Northeastern Pennsylvania and Central New York Petroleum Probabilities, AAPG, Vol.34, no. 12, 2269-2283

Wilson, J.L., 1975, Carbonate facies in geologic history: New York, Springer-Verlag, 471 p.

Wright, Nancy A, 1973, Subsurface Tully Limestone, New York and Northern Pennsylvania, New York State Museum and Science Service, Map and Chart Series #14, 15 pp plus 4 plates

Appendix A - TABLES, FIGURES

Figure 1.0 - Well List, Stagecoach Field, Tioga County, NY

County Designator	Designator Number	Well Name	Operator Name	Latitude	Longitude	Field	TD	Status	1996 Cumulative Production MMCF
107	21420	Jones # 01	Belden & Blake Corporation	42°.05'06"	76°.10' 00"	STAGECOACH	4634	SI	653.54
107	21300	Widell # 01	Belden & Blake Corporation	42°.05'	76°.10' 00"	STAGECOACH	4720	AC	2295.36
107	21451	Pierce # 01	Belden & Blake Corporation	42°.05'	76°.07' 30"	STAGECOACH	4823	AC	4.68
107	21424	Campbell # 01	Belden & Blake Corporation	42°.05'	76°.12' 30"	STAGECOACH	5031	SI	1792.65
107	21421	Brenchley # 01	Belden & Blake Corporation	42°.02'30"	76°.15' 00"	STAGECOACH	5203	SI	232.69
107	20644	Barnhart # 1	Belden & Blake Corporation	42°.02'30"	76°.15' 00"	STAGECOACH	5232	AC	949.03
107	21294	I. Mead # 01	Belden & Blake Corporation	42°.02'30"	76°.15' 00"	STAGECOACH	5268	AC	23.06
107	21394	Larcher # 01	Belden & Blake Corporation	42°.02'30"	76°.17' 30"	STAGECOACH	5293	AC	319.19
107	21264	Owen # 01	Belden & Blake Corporation	42°.02'30"	76°.15' 00"	STAGECOACH	5375	AC	622.44
107	20531	Racht # 1	Belden & Blake Corporation	42°.02'30"	76°.12' 30"	STAGECOACH	5410	AC	433.48
107	21272	Cook # 01	Belden & Blake Corporation	42°.02'30"	76°.17' 30"	STAGECOACH	5455	AC	549.11
107	20427	Fyock # 1	Belden & Blake Corporation	42°.02'30"	76°.12' 30"	STAGECOACH	5534	AC	8.9
107	21461	Frank Waite #1	Quaker State Corporation	42°.05'00"	76°.10' 00"	STAGECOACH			
107	21462	Pierce # 02	Quaker State Corporation	42°.05'00"	76°.07' 30"	STAGECOACH	4585	PA	
107	21452	Bell # 01	Quaker State Corporation	42°.05'00"	76°.10' 00"	STAGECOACH	4813	PA	
107	21376	Smith # 01	Quaker State Corporation	42°.02'30"	76°.20' 00"	STAGECOACH	4888	PA	
107	20661	Dodge # 1	Quaker State Corporation	42°.02'30"	76°.10' 00"	STAGECOACH	5121	PA	
107	20532	Torbert #1	Quaker State Corporation	42°.05'00"	76°.12' 30"	STAGECOACH	5154	PA	
107	20645	T. Mead # 1	Quaker State Corporation	42°.02'30"	76°.10' 00"	STAGECOACH	5225	PA	
107	21265	Owen # 02	Quaker State Corporation	42°.02'30"	76°.15' 00"	STAGECOACH	5295	PA	
107	21497	I. Meade# 02	Quaker State Corporation	42°.02'30"	76°.15' 00"	STAGECOACH	5338	PA	
107	20534	Hakes # 1	Quaker State Corporation	42°.02'30"	76°.12' 30"	STAGECOACH	5484	PA	
107	21375	Kittle # 1	Quaker State Corporation	42°.02'30"	76°.17' 30"	STAGECOACH	5597	PA	
107	5958	Traue #1	Quaker State Corporation	42°.05'	76°.10' 00"	STAGECOACH			
107	21373	H. Visscher	Quaker State Corporation	42°.02'30"	76°.20' 00"	STAGECOACH			
107	6634	L.LaDue #1	Quaker State Corporation	42°.02'30"	76°.17' 30"	STAGECOACH			
107	21547	Faber #1	Quaker State Corporation	42°.02'30"	76°.15' 00"	STAGECOACH	5435	PA	
107	801	Kemp C #1	Broome-Tioga Corp.	42°.04.'39"	76.16888	DRY WILDCAT	UN	1020	
107	2363	Hiram Terbush #1	Hiram Terbush 1	42°.04'73.9"	76.16924	DRY WILDCAT	UN	0	
						Cumulative Production in MMCF			7,884.13

Table 2.0 Well List for Tioga County, NY Exclusive of the Stagecoach Field Area

County Code	Designator Number	Well Name	Operator	Latitude	Longitude	Type	Status	TD
107	21502	FRANZENBURG UNIT # 1	ARDENT RESOURCES; INC.	42°.07'23.3"	76°.07'30"	DW	PA	0
107	17788	TIFFANY 1	ARLINGTON EXPLORATION	42°.07'30"	76°.05'	GW	HU	4453
107	21378	SPENCER 1	FAULT LINE OIL CORP	42.°15'	76°.25'	DH	PA	3246
107	21349	VAN RIPER 1	FAULT LINE OIL CORP	42.°12'30"	76°.30'	DH	PA	3293
107	1147	DECKER	NONE SPECIFIED	42°.05'	76°.01'	DW	UN	0
107	1059	SAWYER	NONE SPECIFIED	42°.22'05.7"	76°.41'	DW	UN	1350
107	799	SHOEMAKER	NONE SPECIFIED	0	0			
107	257	STEVENS W E 1	NYS NATURAL GAS CORP.	42°15'	76°.25'	DW	UN	3150
107	20425	ROBINSON 1	QUAKER STATE CORP.	42°.07'30"	76°.10'	DW	PA	5236
107	9557	KLOSSNER M R 1	SHELL OIL COMPANY	42°.10'	76°.20"	DW	PA	5140
107	9848	ROBINSON FRANCIS 1	SHELL OIL COMPANY	42°.05'	76°.25'	DW	PA	5220
107	800	POMPELLY & HARRIS 1	SUSQUEHANNA NAT. GAS	42°05'	76°15'	DW	UN	4130
107	2356	MILLER C 1	TIOGA UTILITIES			DW	UN	4360

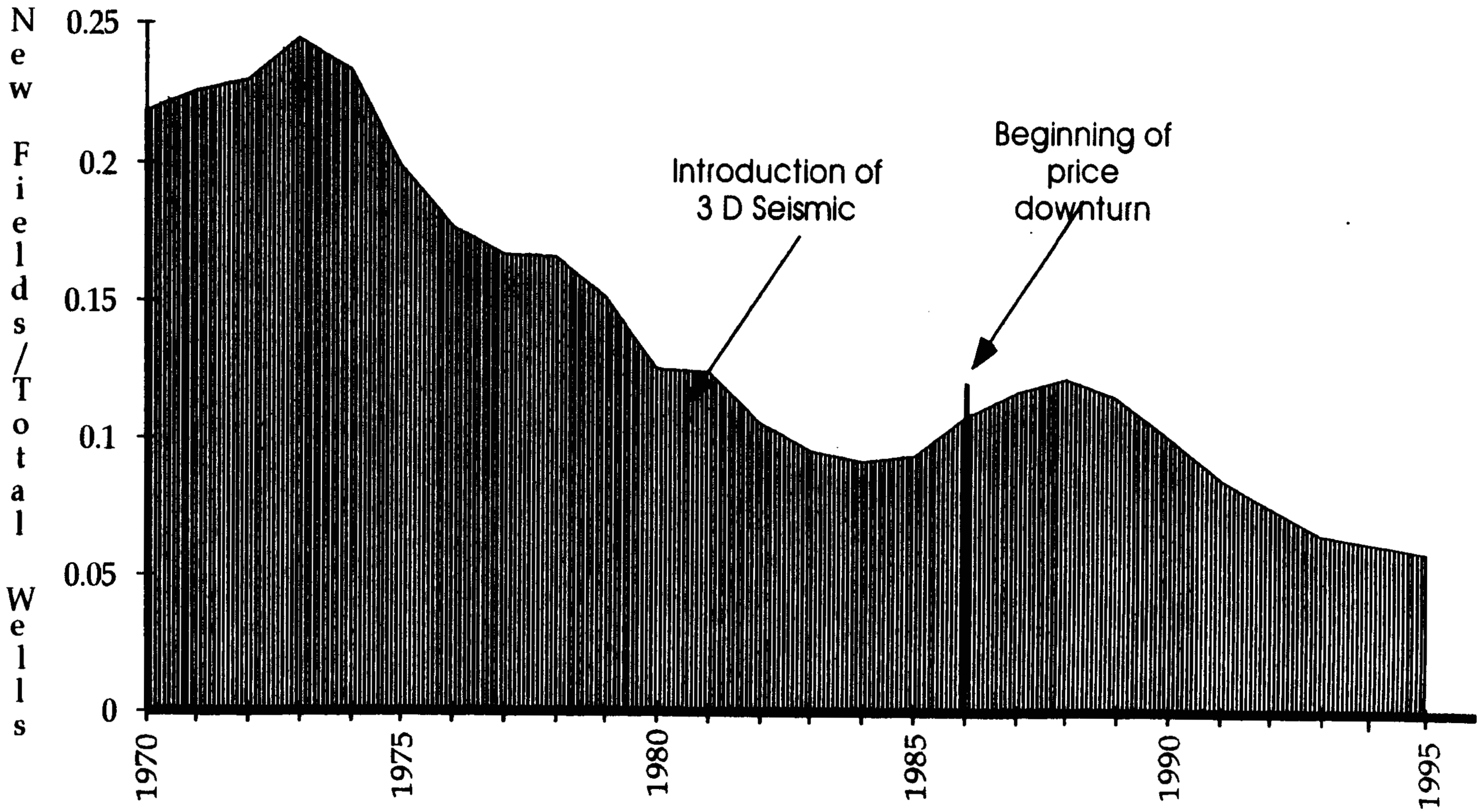
TABLE 3.0 - Well List for Sullivan and Ulster Counties

County Code	Designator Number	Well Name	Operator	Latitude	Longitude	Type	Status	TD
Wells In Study Area								
SULLIVAN CO.								
105	12,861	F.E.O'Donnell	Gulf Oil Corporation	41°45'74"	74°40'	DW	P&A	8275
105	8,578	Shandalee Hunting Club 1	Texas Eastern Transmission Co.	41°55'74"	74°50"	DW	P&A	9995
ULSTER CO.								
111	2,656	Water Well 1	NONE SPECIFIED	42.°11'02	74.°35'42	DW	P&A	0
111	2,657	Water Well 2	NONE SPECIFIED	42.°09'93	74.°34'35	DW	P&A	0
111	2,658	Water Well 3	NONE SPECIFIED	42.°10'06	74.°34'74	DW	P&A	0
111	3,199	A Herdman 1	Dome Oil & Gas	42° 05'	74° 25"	DW	P&A	6400
111	3,245	Armstrong George U 1	Mid Hudson Natural Gas	42° 05'	74° 30'	DW	P&A	3809
Wells Outside of Study Area								
SULLIVAN CO.								
105	2,359	*	Standard Oil Co.	00.°00'00	00.°00'00			
ULSTER CO.								
111	15,725	ARCO 1 Susi 1	ARCO Metals Co-American Brass	41.°66'24	74.°12'71	DW	P&A	7030
111	5,783	Village of Ellenville 1	Brooklyn Union Company	41.°70'03	74.°34'58	DW	P&A	10184
111	4,202	Schaller F 1	Gas & Oil Land Leasing Corp.	42.°11'30	74.°02'93	DW	P&A	2808
111	4,666	Fee Canoe Hill 1	Gas & Oil Land Leasing Corp.	42.°10'00	73.°95'43	DW	P&A	705
111	4,515	Lake Minnewaska Mt House 1	Gulf Oil Corporation	41.°73'80	74.°21'53	DW	P&A	8489

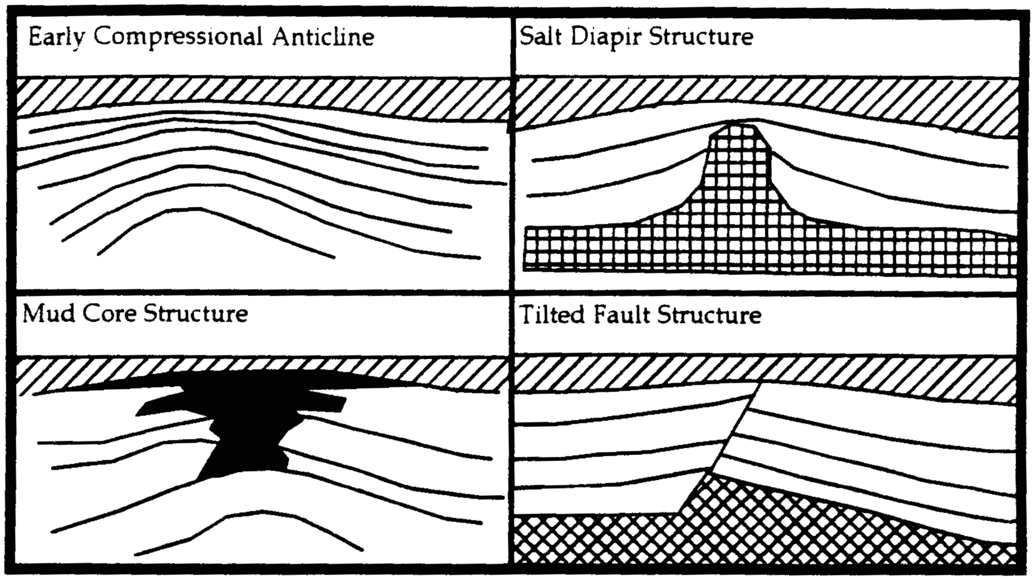
Notes:

* - Data on this well was not discovered in NYDEC files

Figure 1.0 - Exploratory Success for New Field Wells 1970-1995

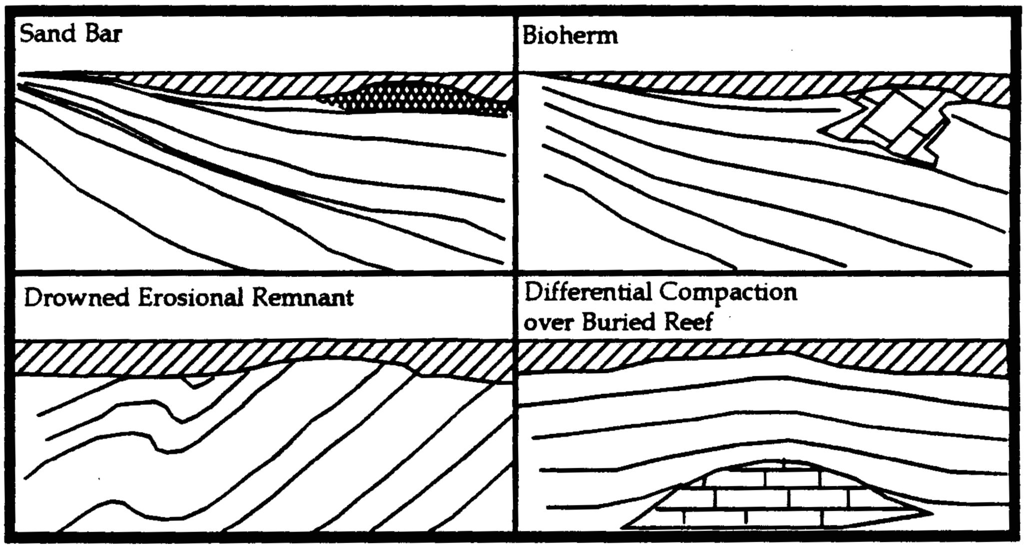


Paleogeomorphic Highs (Synchronous Highs) of Diastrophic Origin



After Scholten 1959

Paleogeomorphic Highs (Synchronous Highs) of
Depositional,Erosional, and Inherited Origin



After Scholten 1959

Figure 2.0
Examples of Paleogeomorphic Highs (Synchronous Highs)

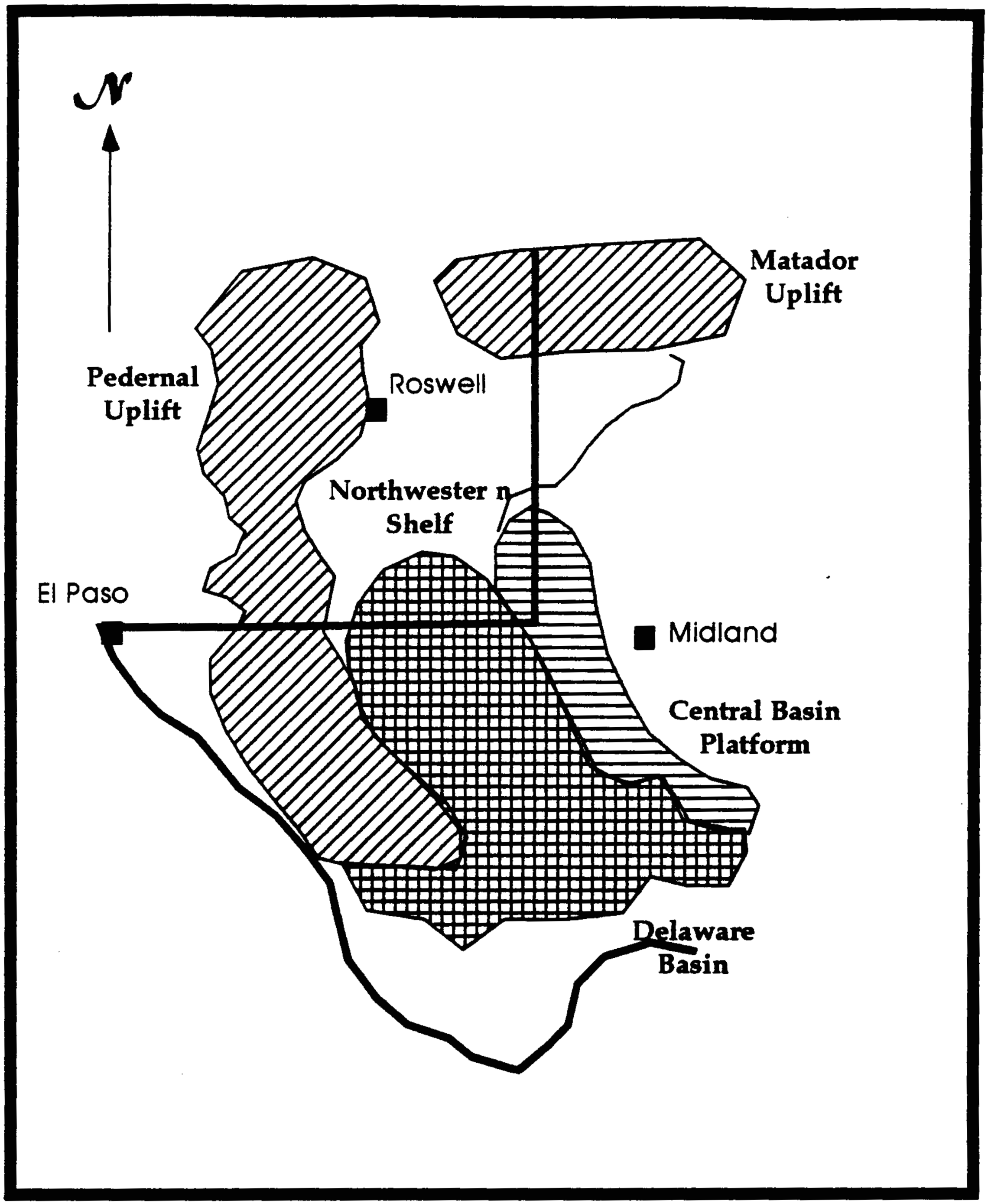


Figure 3.0
Physiographic Elements of the Delaware Basin, New Mexico

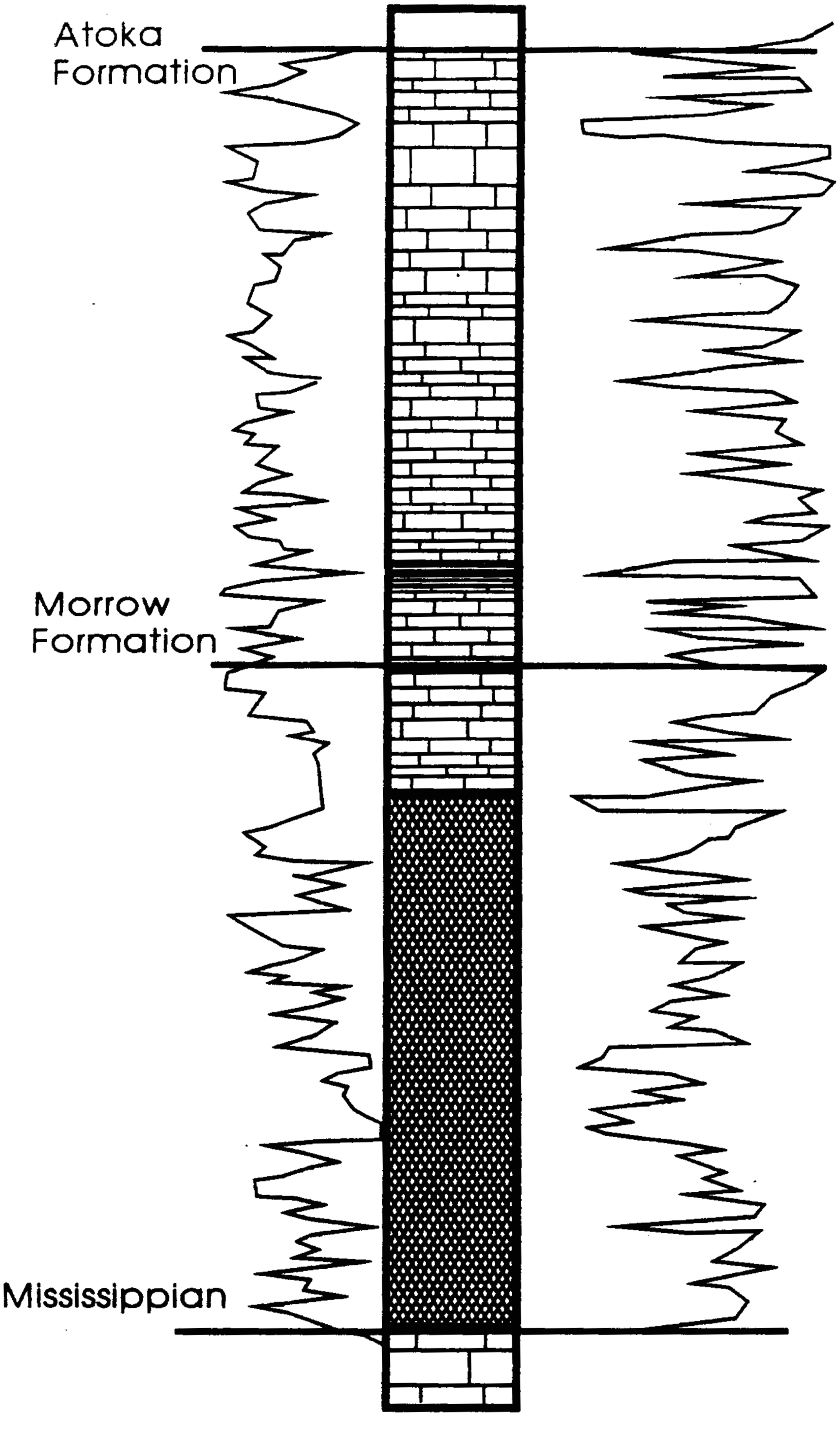


Figure 4.0
AM Paleogeomorphic Mapping Interval
Permian Basin, NM

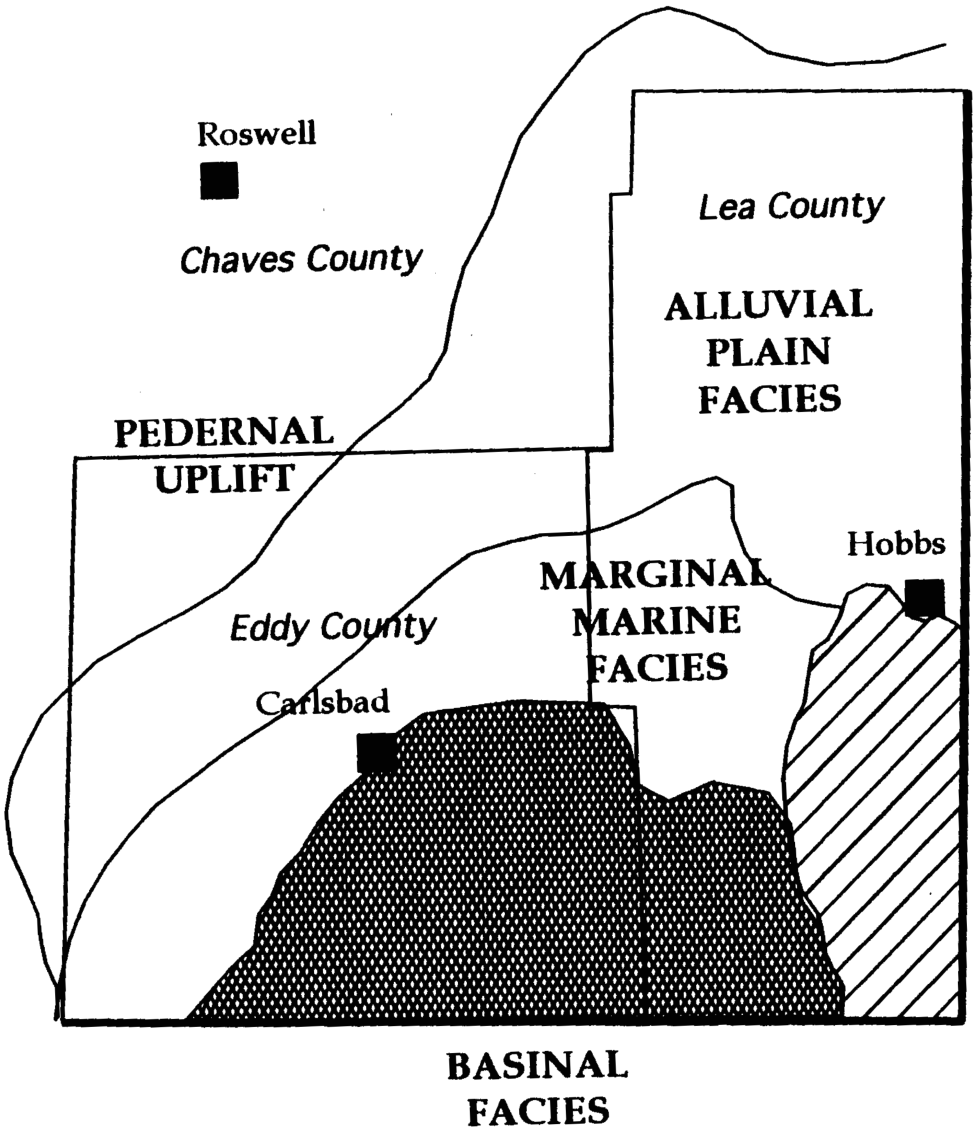


Figure 5.0

Tectonic Elements of the Early Pennsylvanian Permian Basin of Southeastern New Mexico

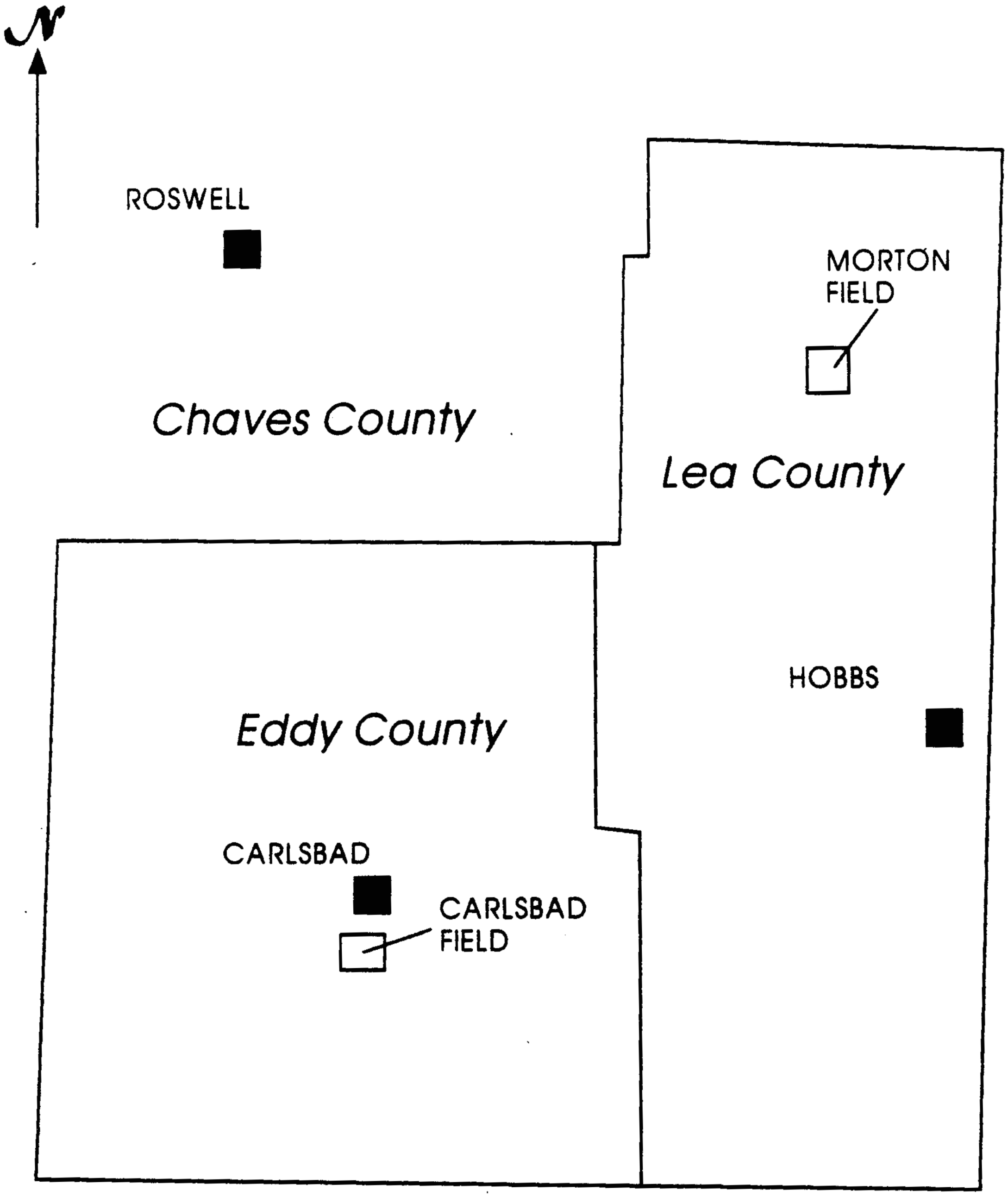
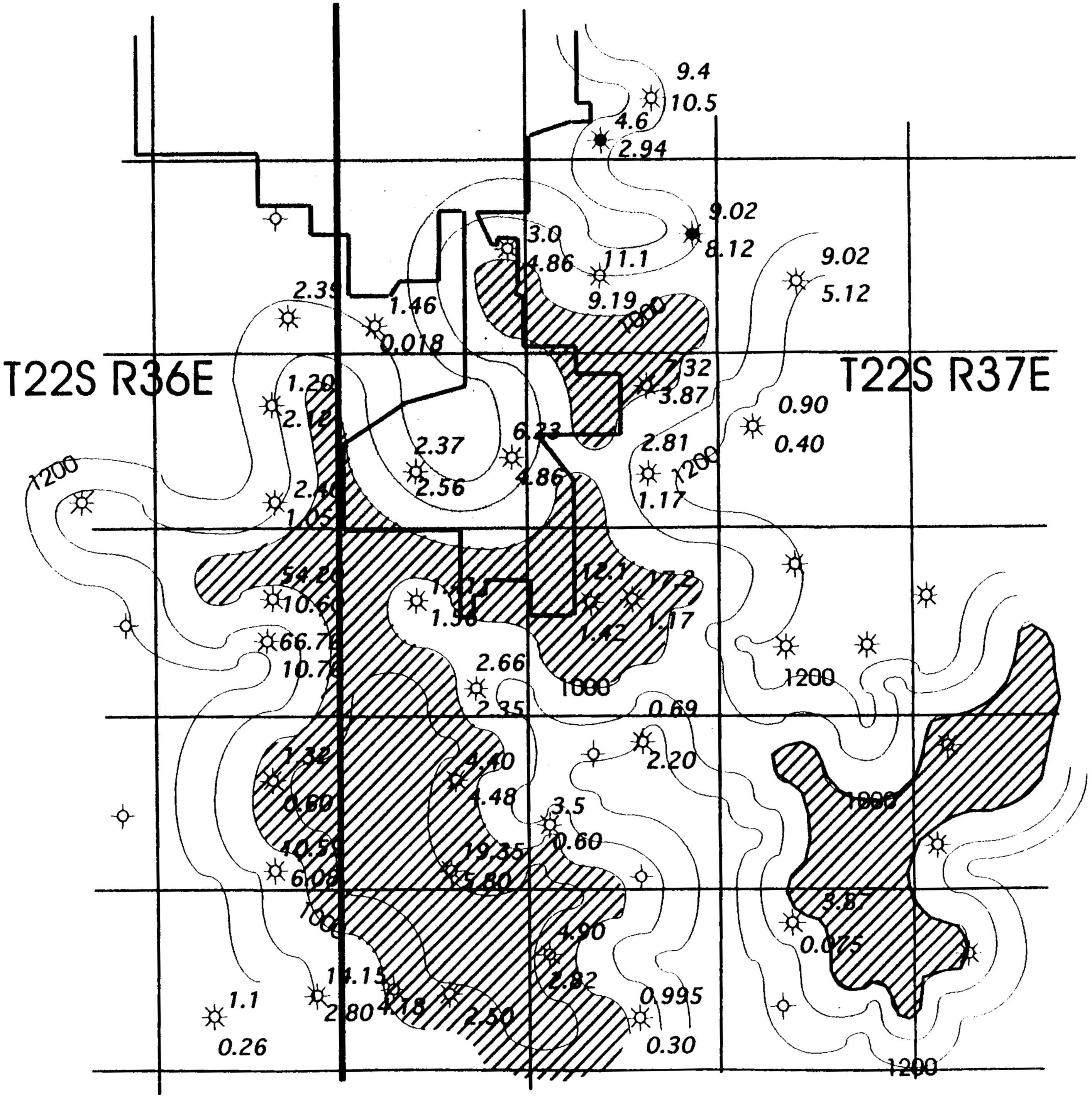


Figure 6.0

Location Map, Carlsbad and Morton Fields



NOTE

On this map, production data from 1989 is reported. The upper figure is initial production in MMCF. The lower figure is cumulative production in BCF.

Figure 7.0
Carlsbad Field
Eddy County, N.M.
Paleogeomorphic Map
Morrow (Pennsylvanian)
Production

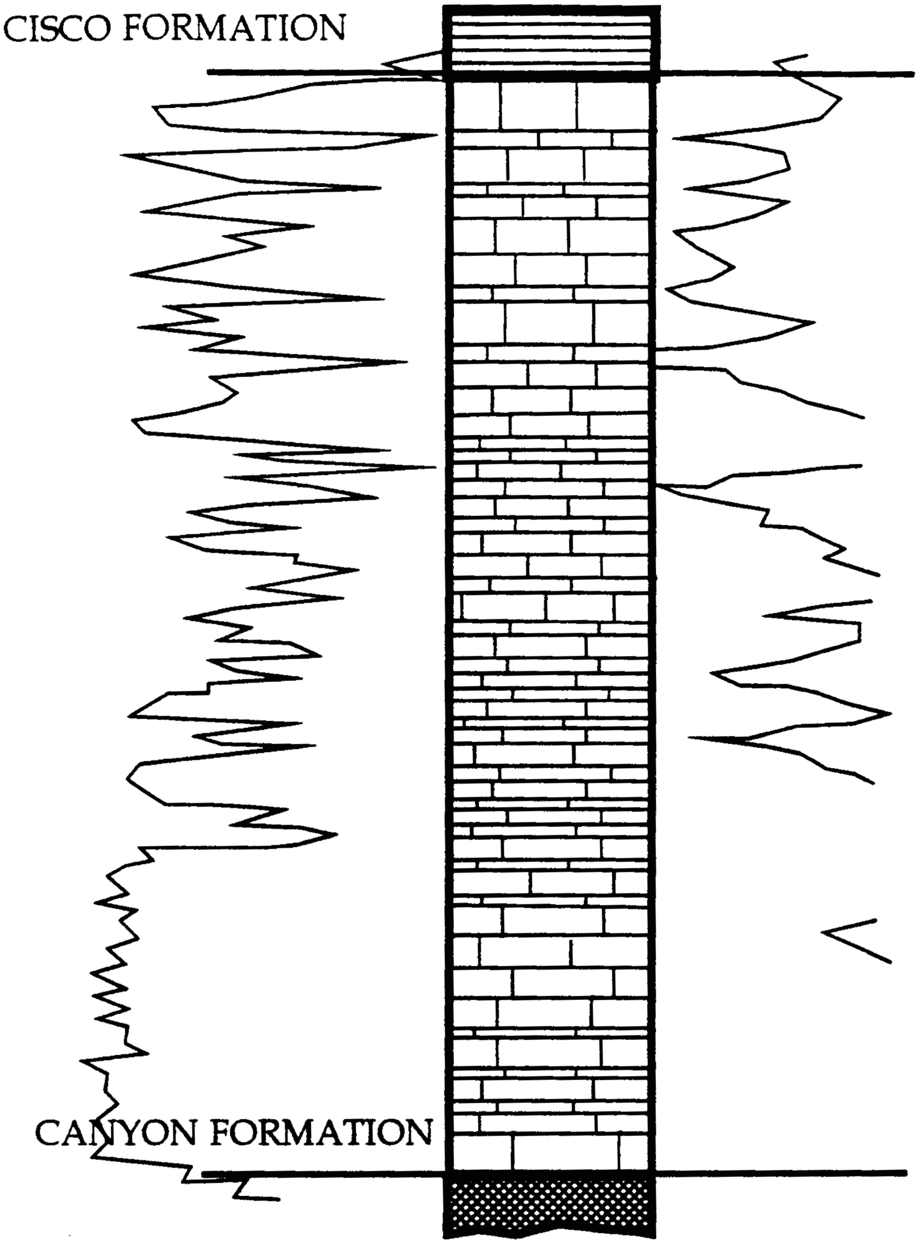


Figure 8.0
CI Geomorphic Interval Used in Paleogeomorphic Mapping
Permian Basin, New Mexico

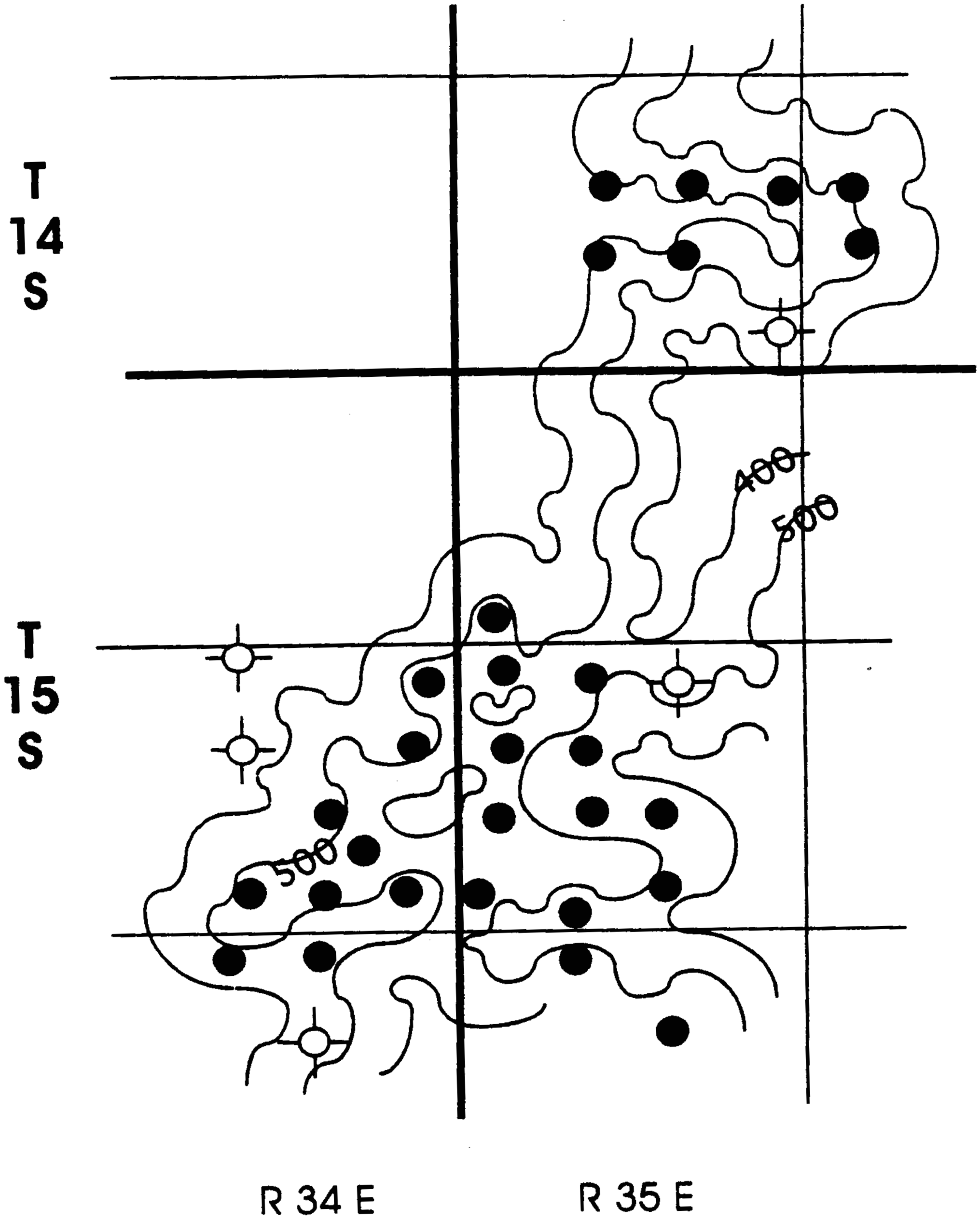


Figure 9.0
Paleogeomorphic Map, Morton Field
Lea County. New Mexico

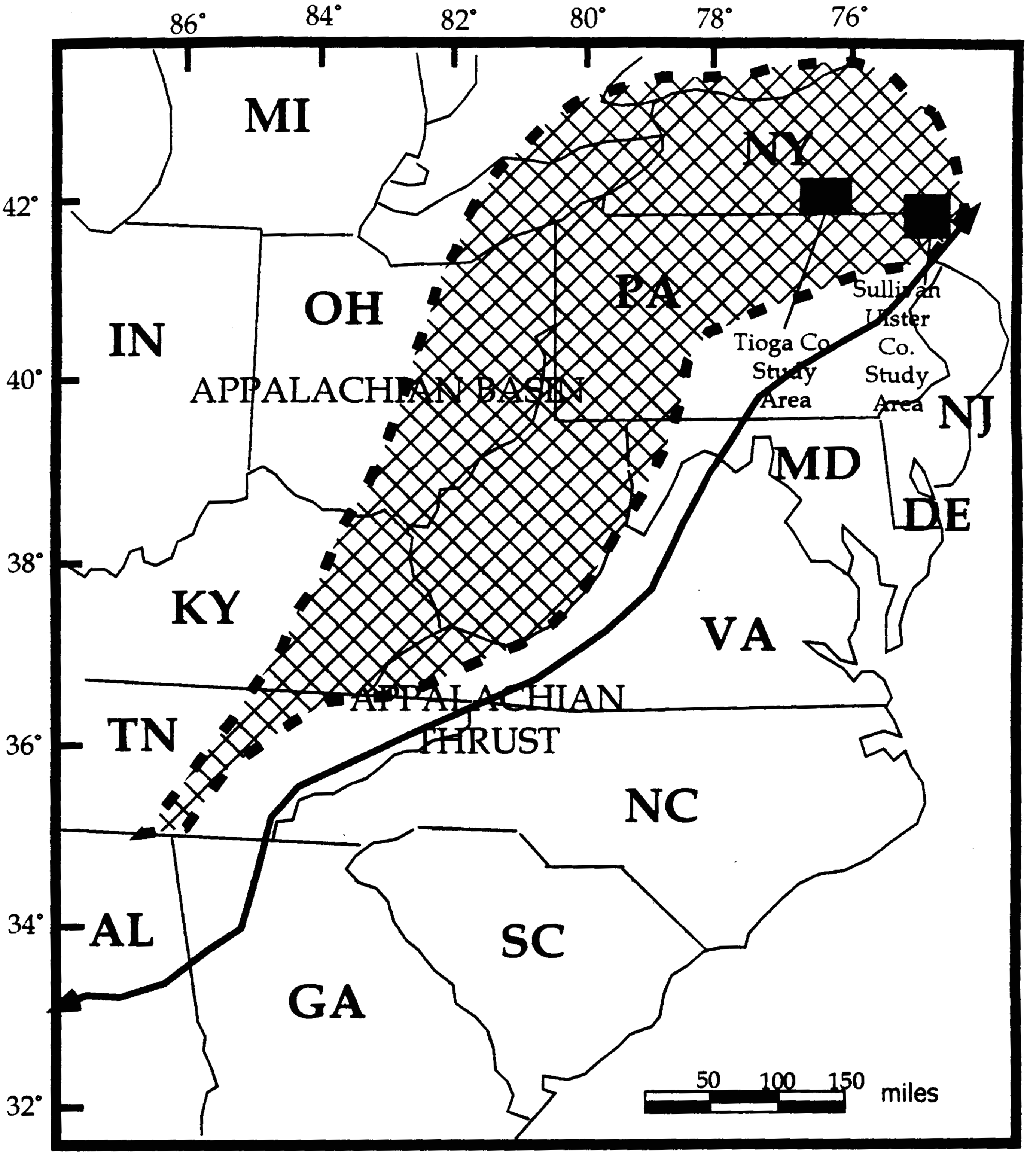


Figure 10.0
Regional Map, Appalachian Basin

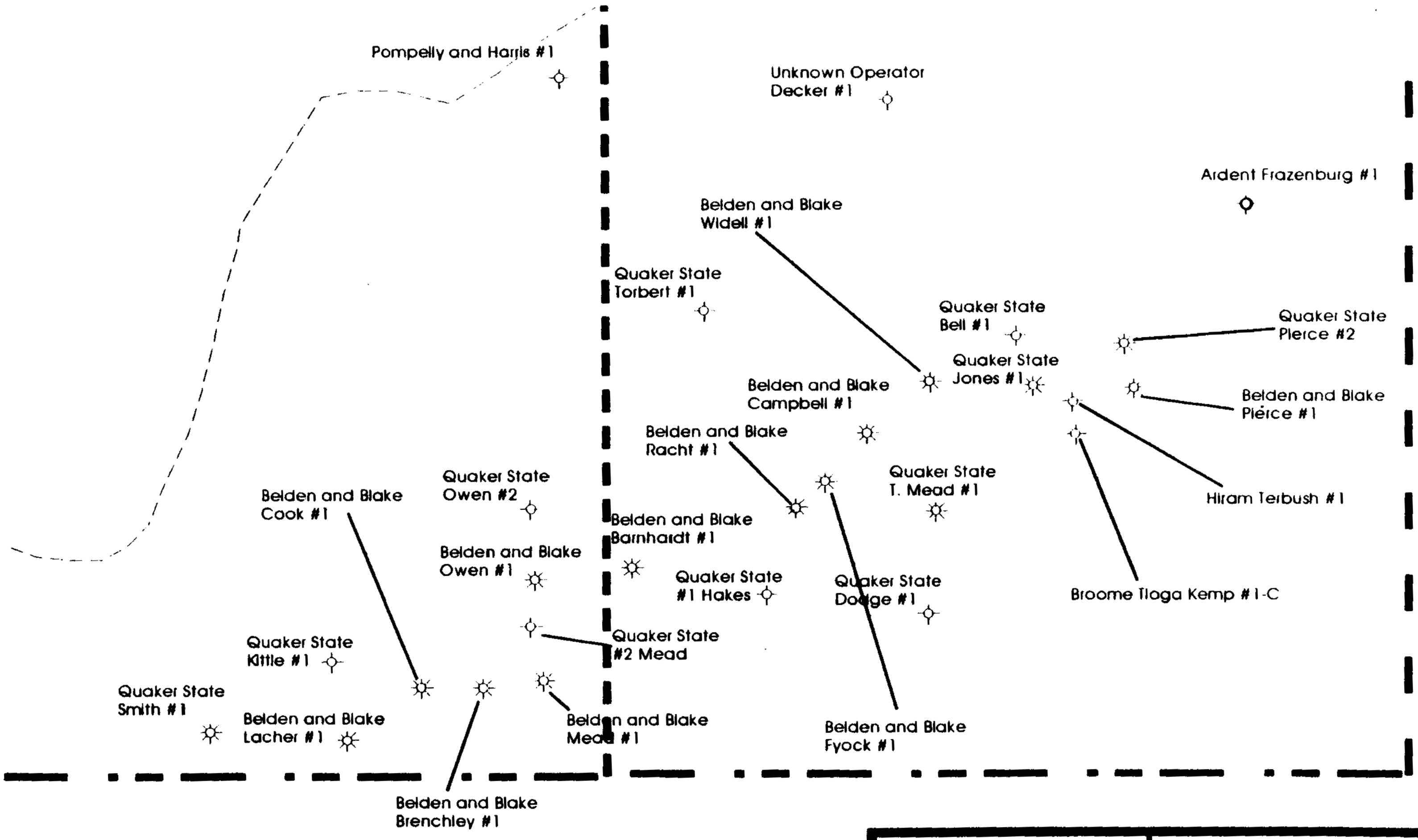


Figure 11.0

Well Location Map
Stagecoach Field
Tioga County, N.Y.

NYSERDA PROJECT
Purchase Order R 2068

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

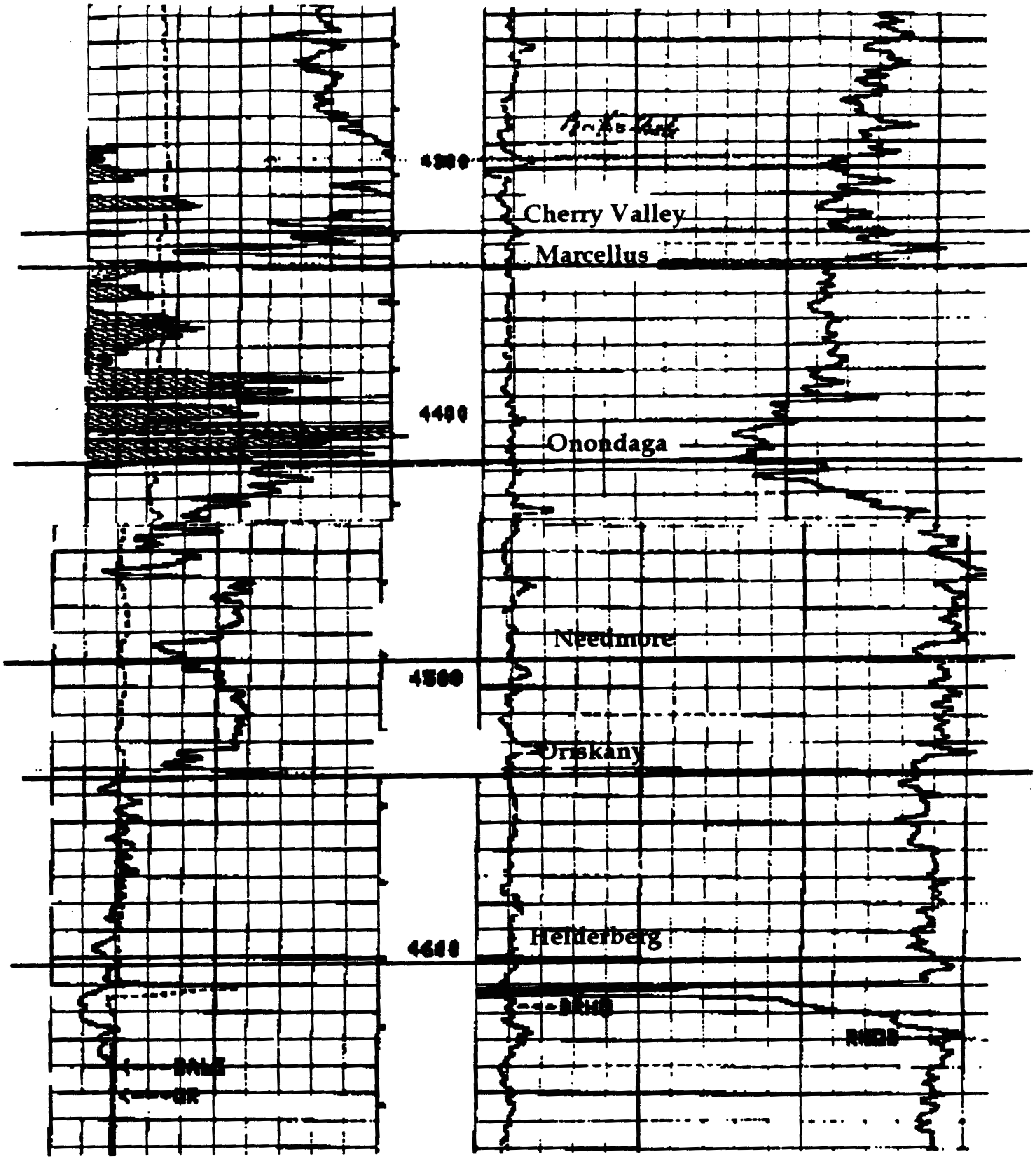


Figure 12.0

Type Log, Stagecoach Field, Tioga County, New York
Belden and Blake #1 W. Widdell

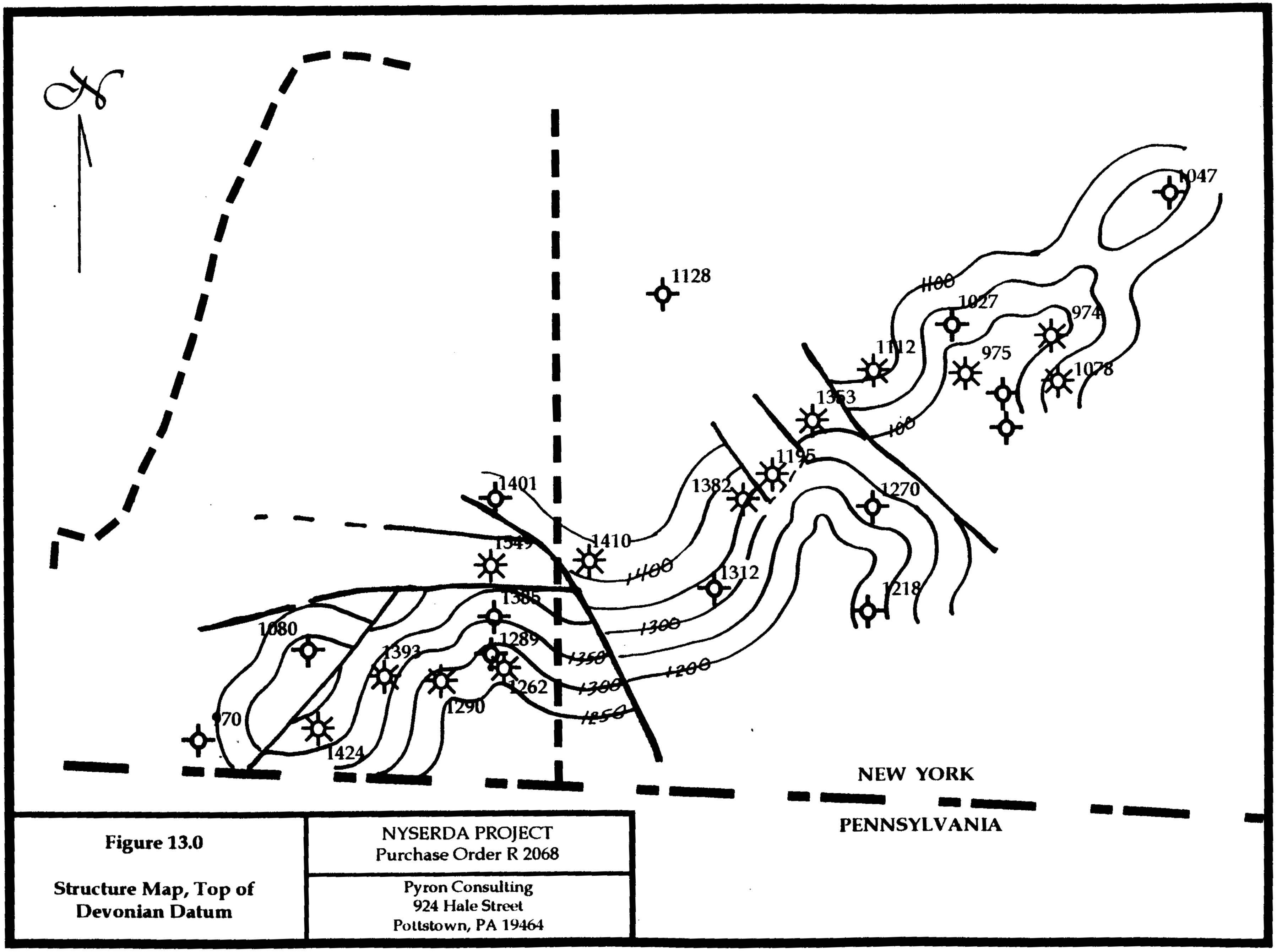


Figure 13.0

Structure Map, Top of Devonian Datum

NYSERDA PROJECT
Purchase Order R 2068

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

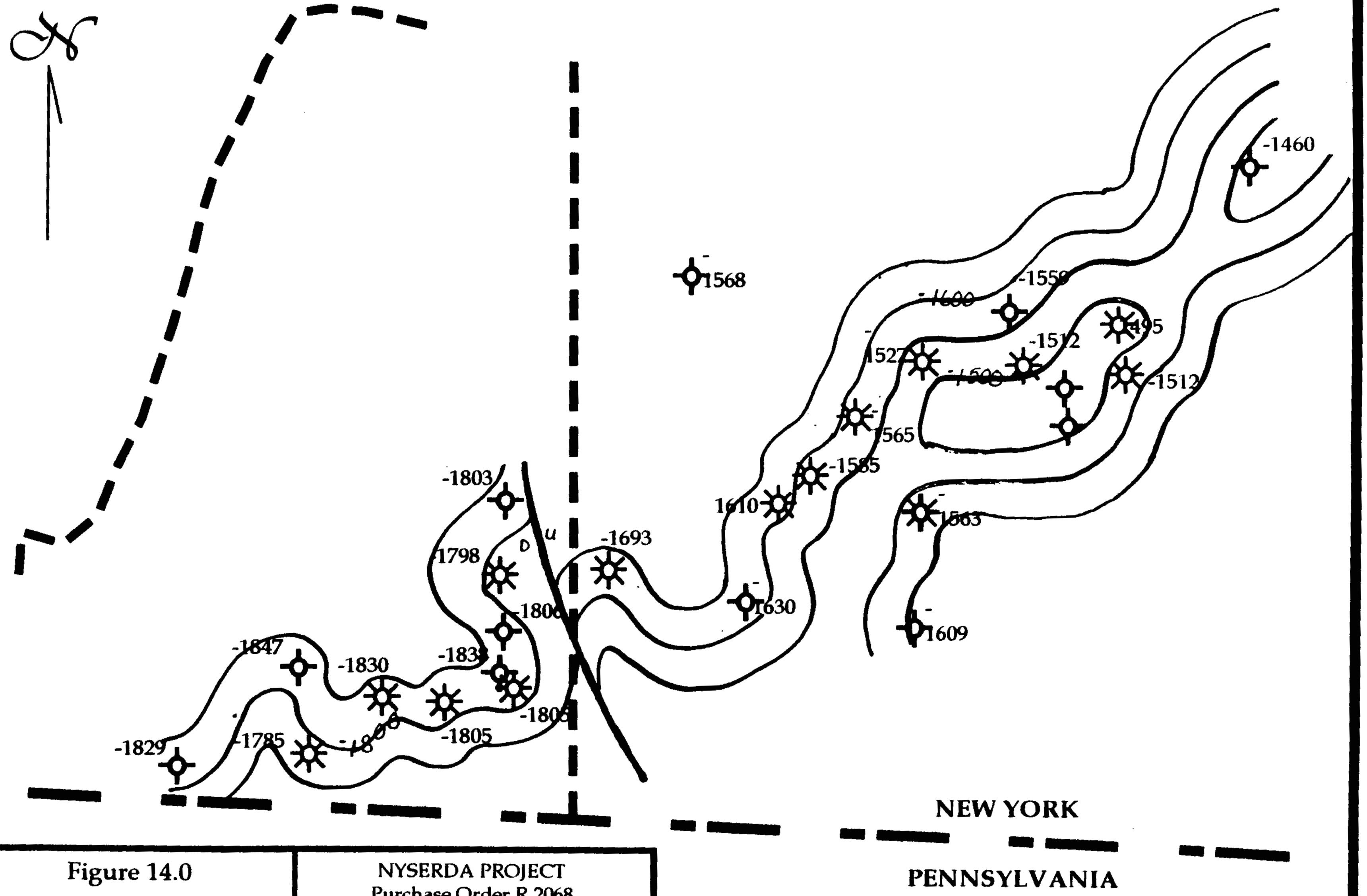


Figure 14.0

Structure Map, Top of Tully Limestone Datum

NYSERDA PROJECT
Purchase Order R 2068

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

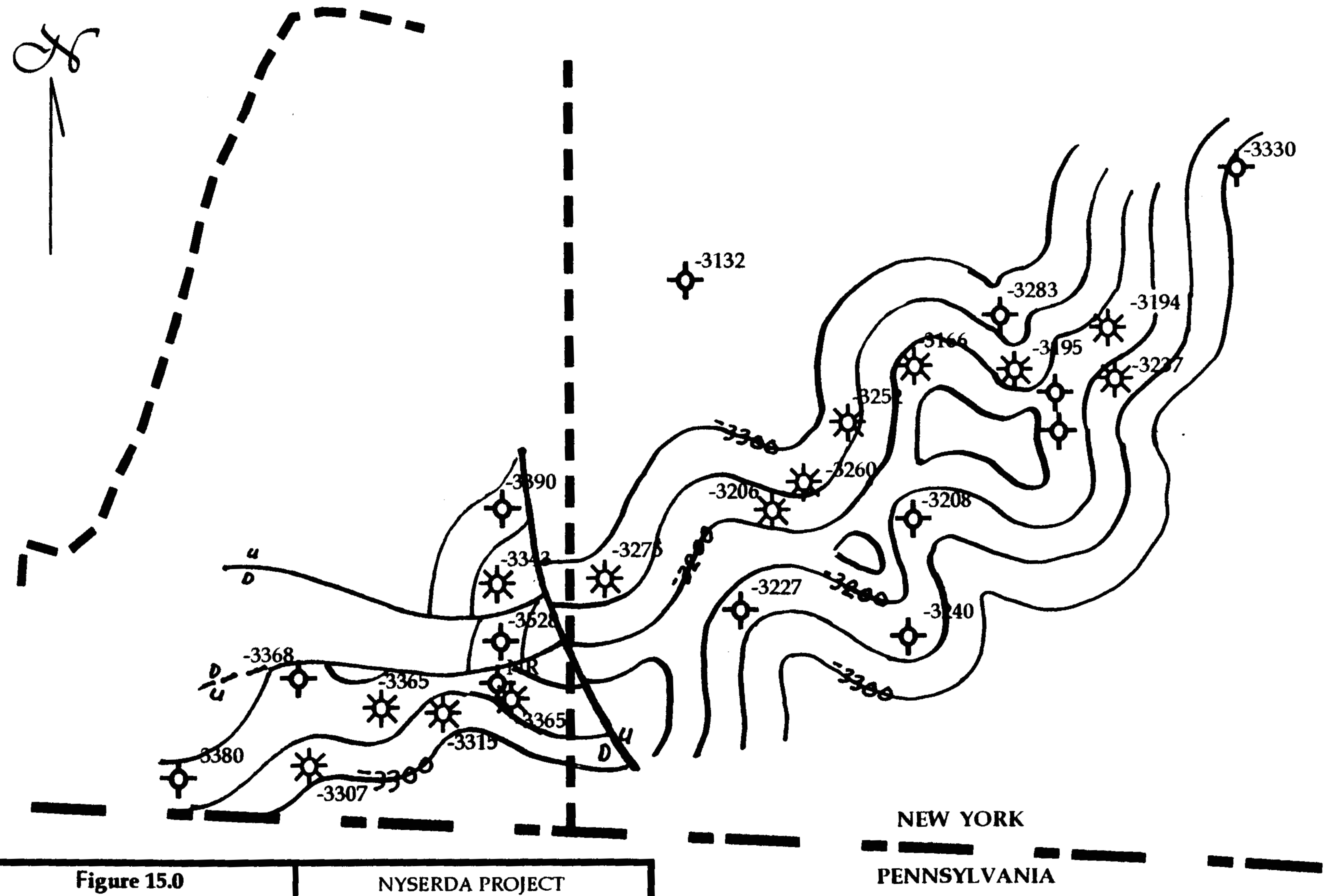


Figure 15.0

Structure Map, Top of Cherry Valley Limestone Datum

NYSERDA PROJECT
Purchase Order R 2068

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

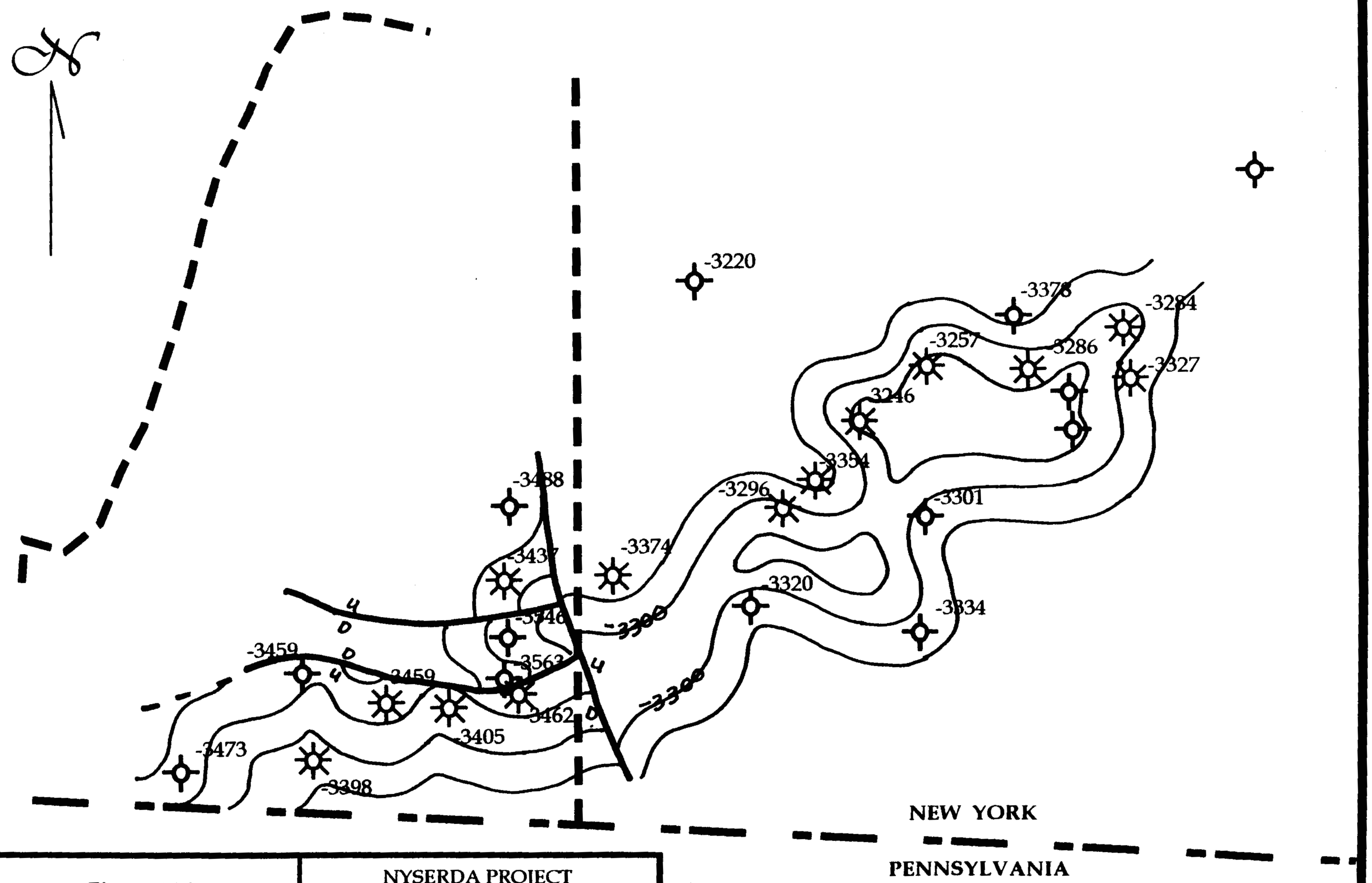


Figure 16.0
Structure Map, Top of
Onondaga Limestone
Datum

NYSERDA PROJECT
Purchase Order R 2068

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

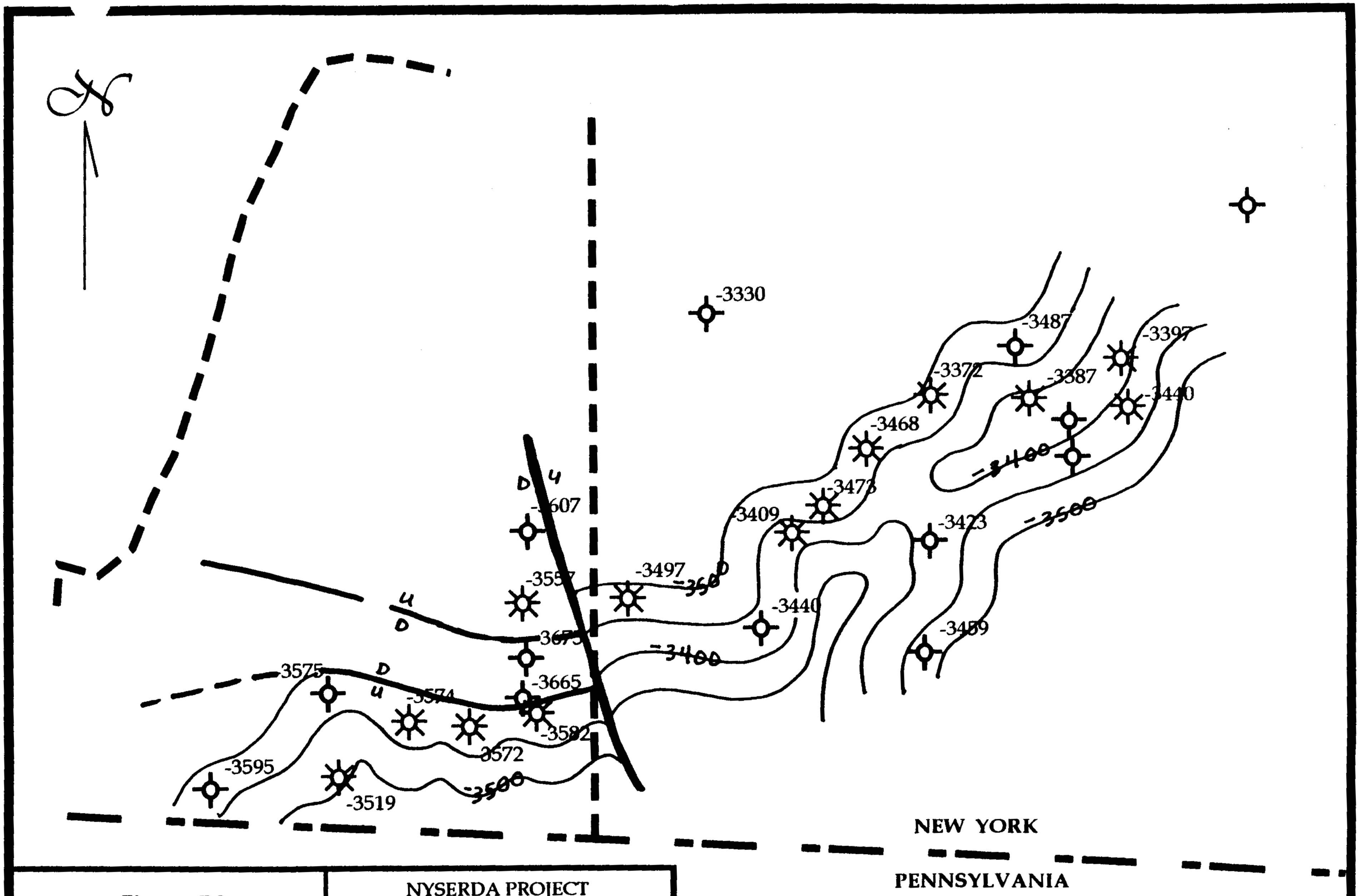


Figure 17.0
Structure Map, Top of Oriskany Sandstone Datum

NYSERDA PROJECT
Purchase Order R 2068

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

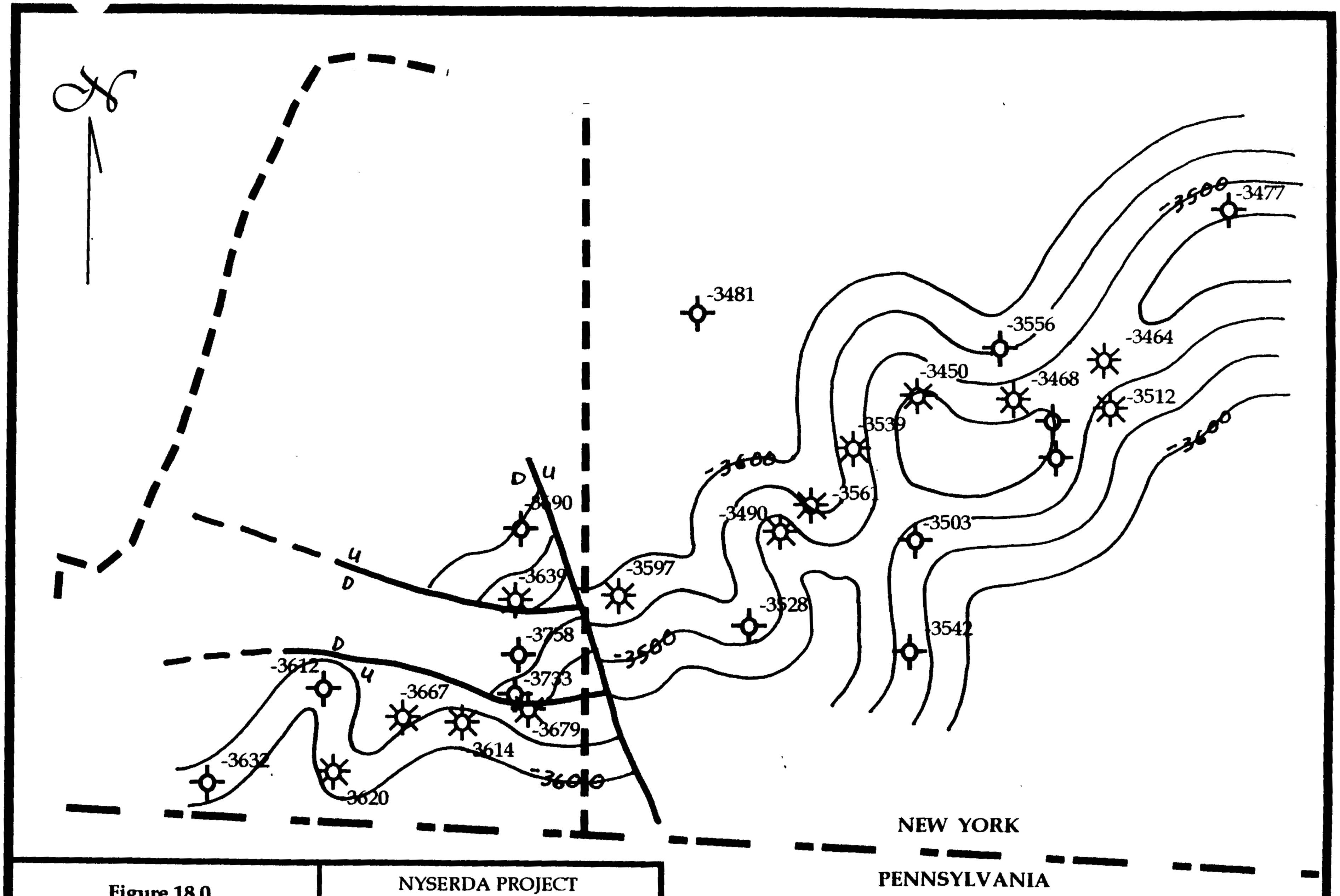


Figure 18.0
Structure Map, Top of Helderburg Limestone Datum

NYSERDA PROJECT
Purchase Order R 2068

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

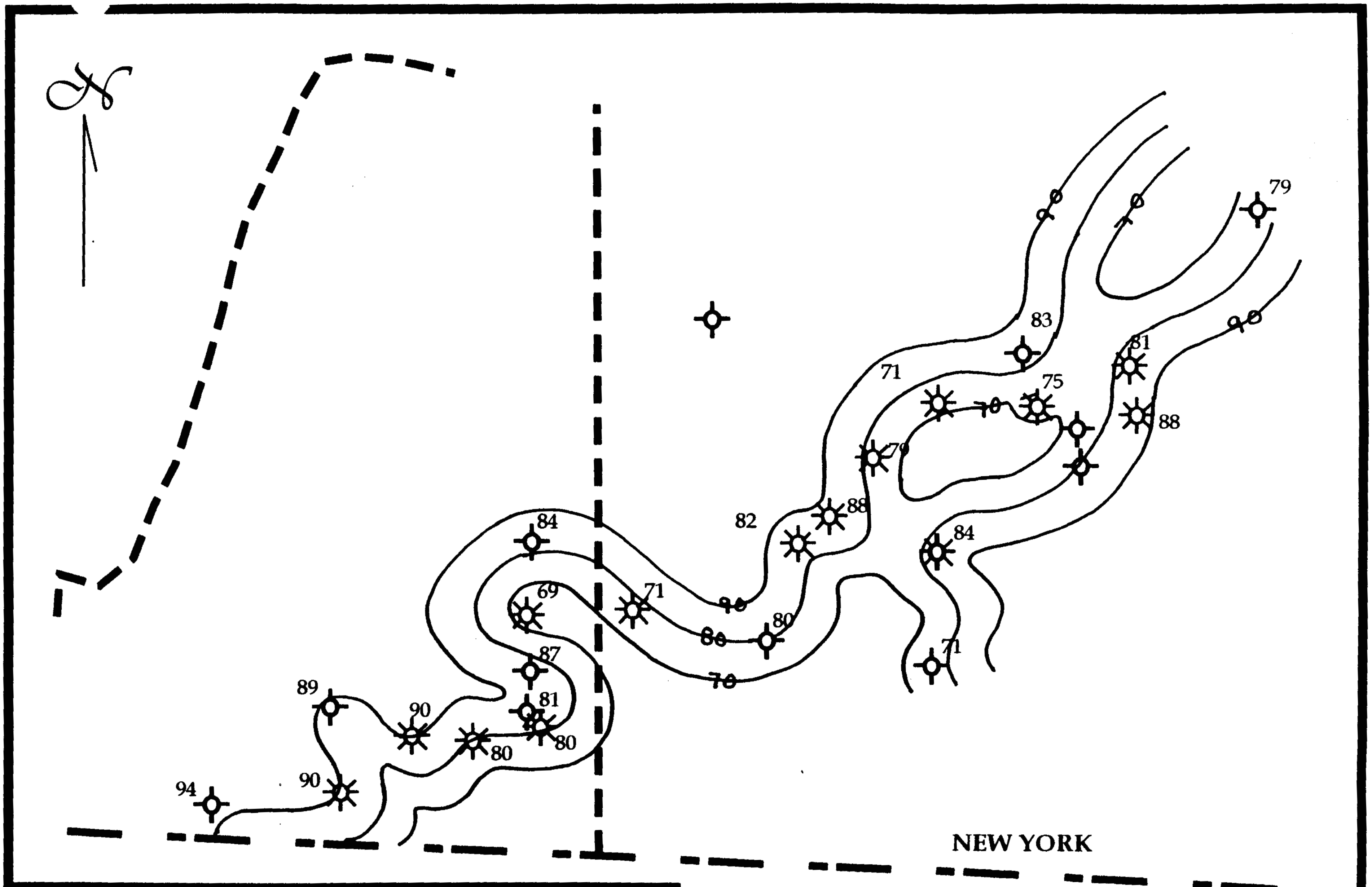


Figure 19.0
Isopach Map, Tully
Limestone Thickness

NYSERDA PROJECT
Purchase Order R 2068

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

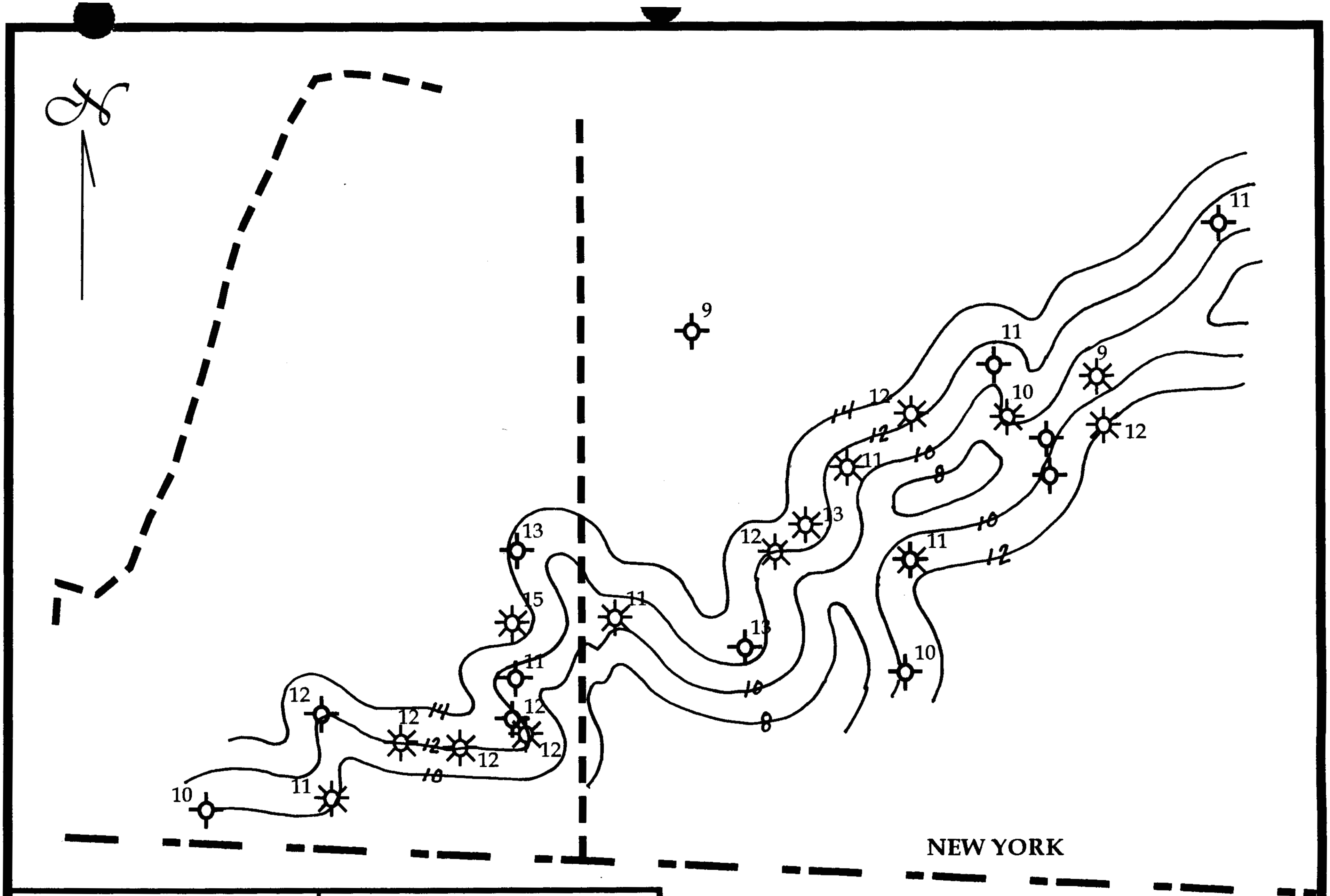


Figure 20.0
Isopach Map,
Cherry Valley
Limestone Thickness

NYSERDA PROJECT
Purchase Order R 2068

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

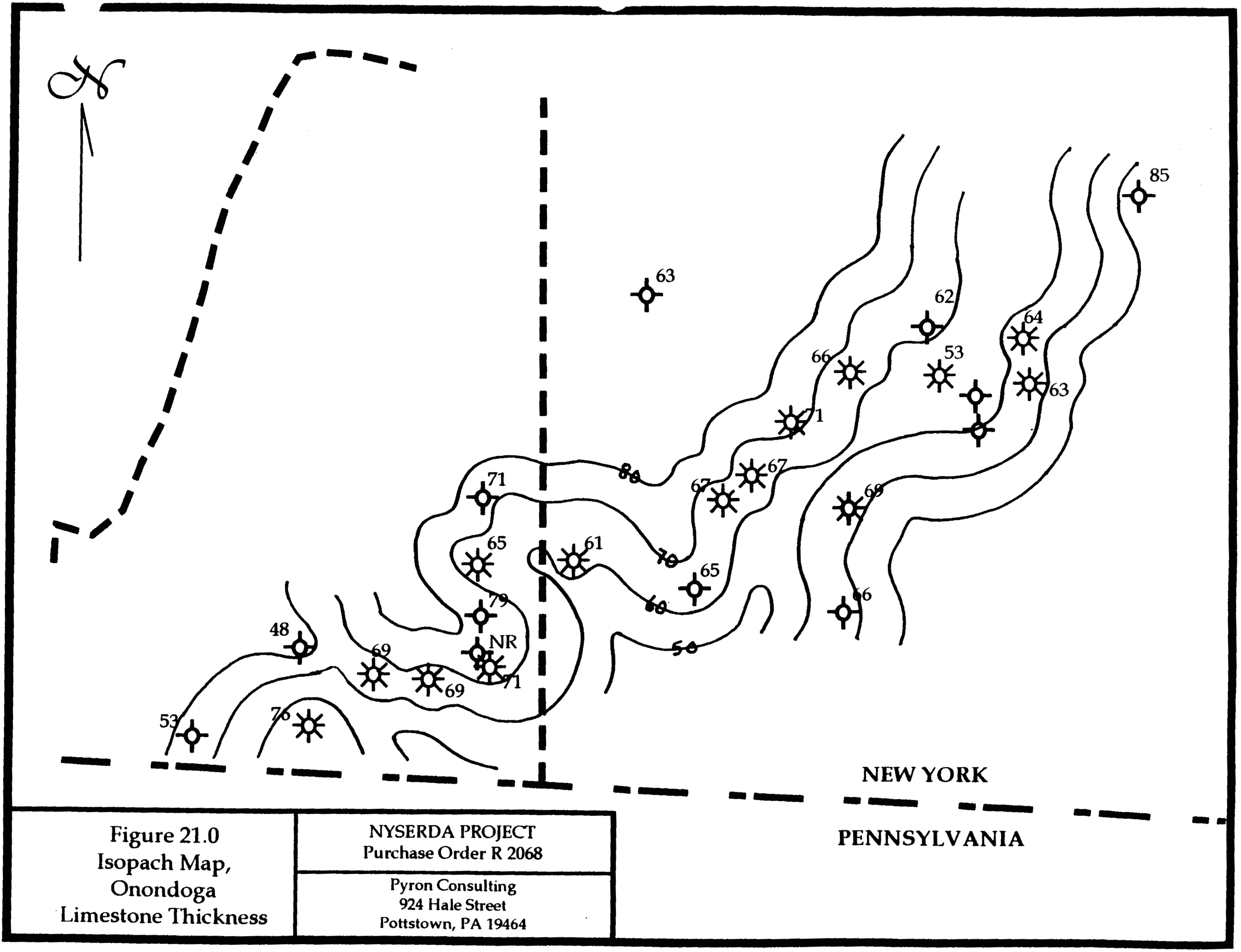


Figure 21.0
Isopach Map,
Onondoga
Limestone Thickness

NYSERDA PROJECT
Purchase Order R 2068

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

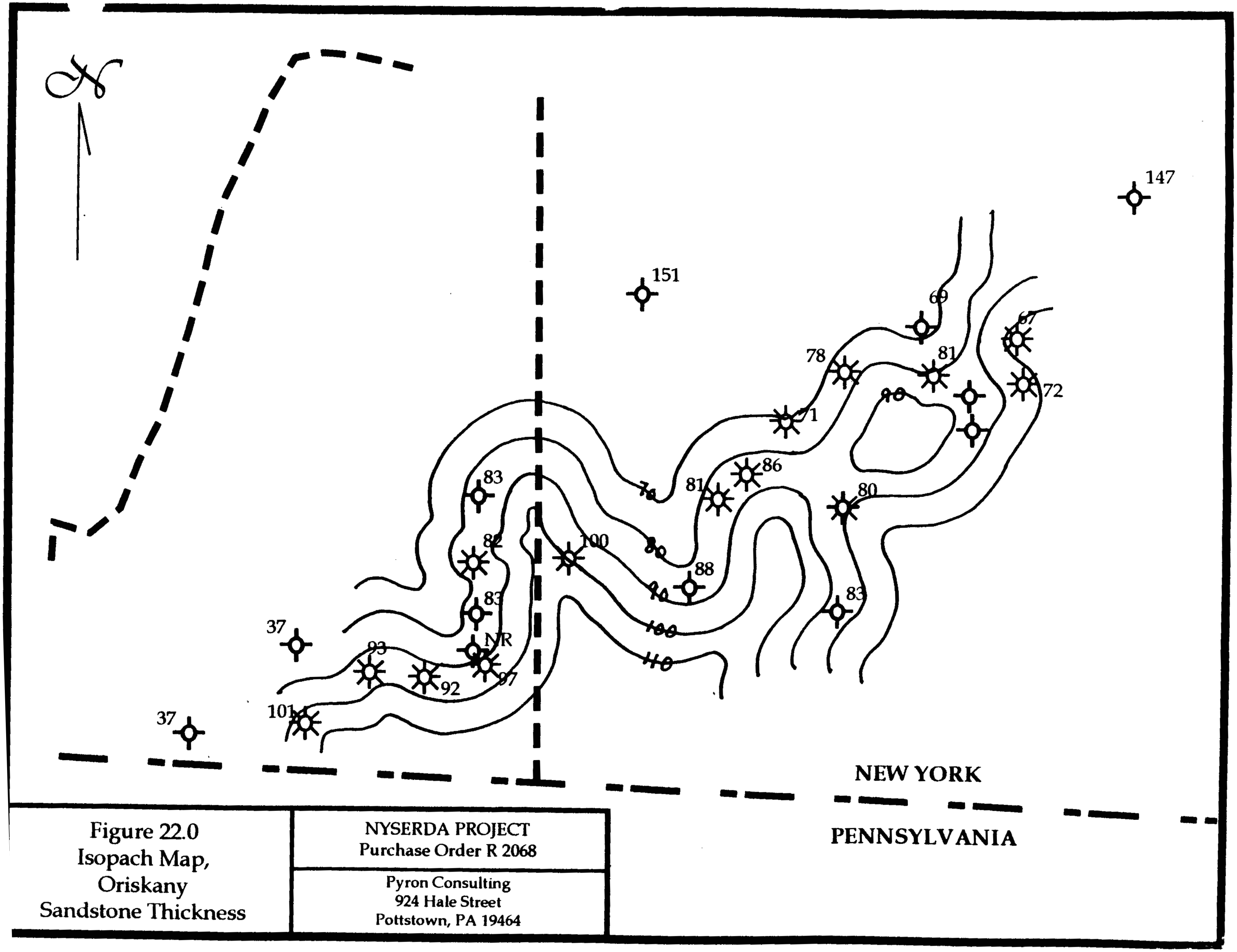


Figure 22.0
Isopach Map,
Oriskany
Sandstone Thickness

NYSERDA PROJECT
Purchase Order R 2068

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

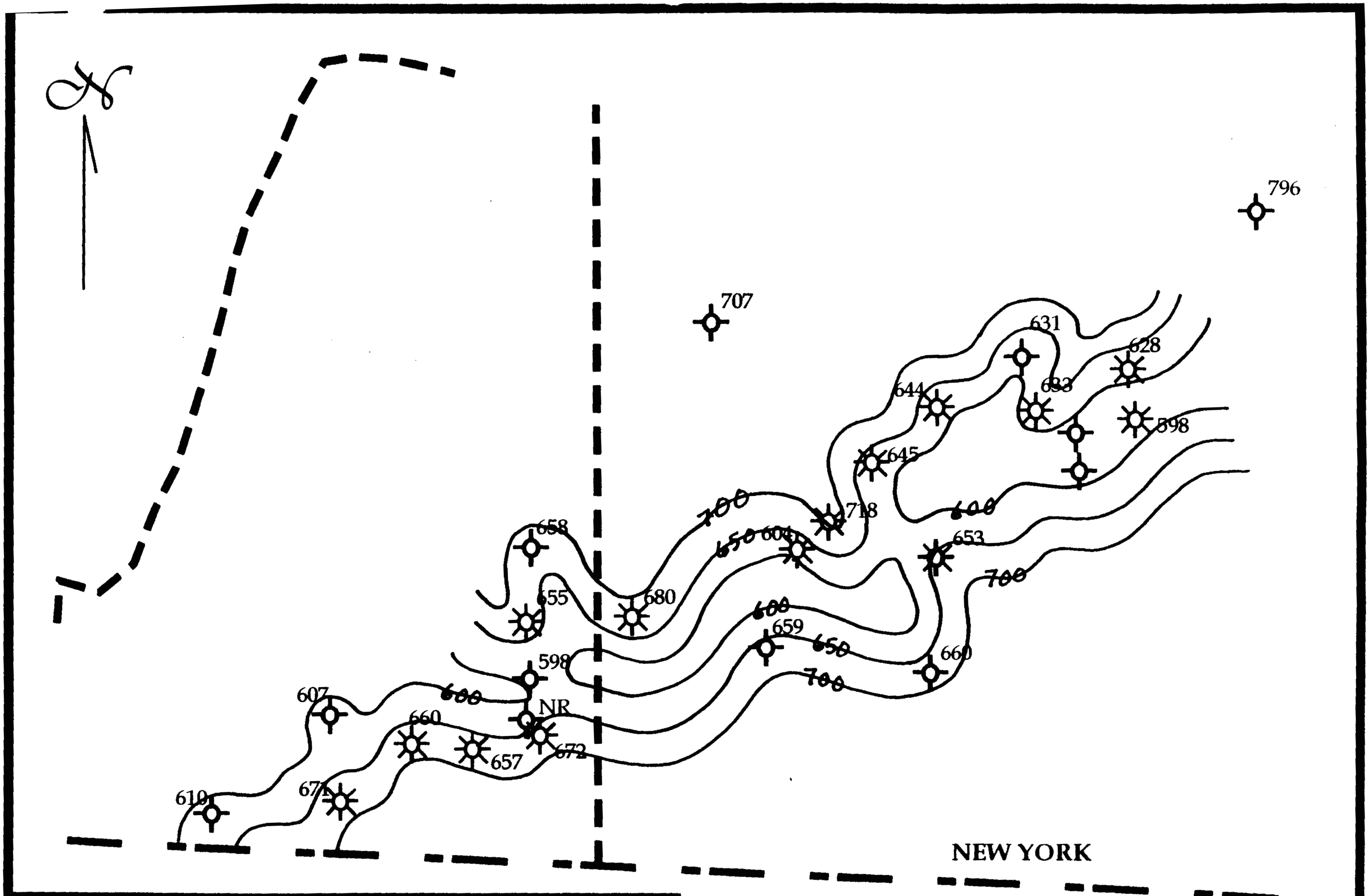


Figure 23.0
Synchronous High Map,
First Derivative Interval

NYSERDA PROJECT
Purchase Order R 2068

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

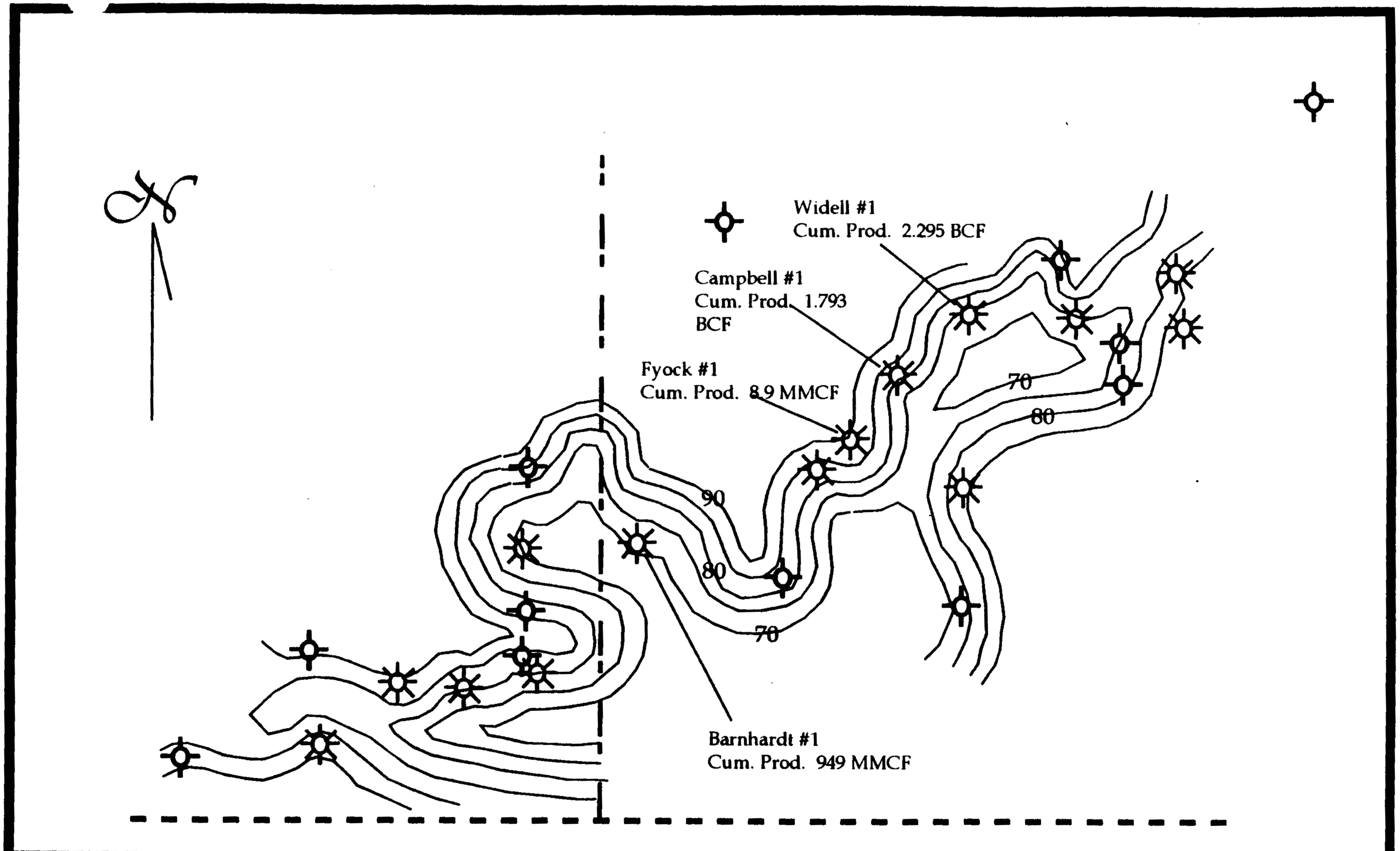


Figure 24.0
Tully Thickness
with Production
Data,
Stagecoach Field
Tioga County, N.Y.

NYSERDA PROJECT
Purchase Order R 2068

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

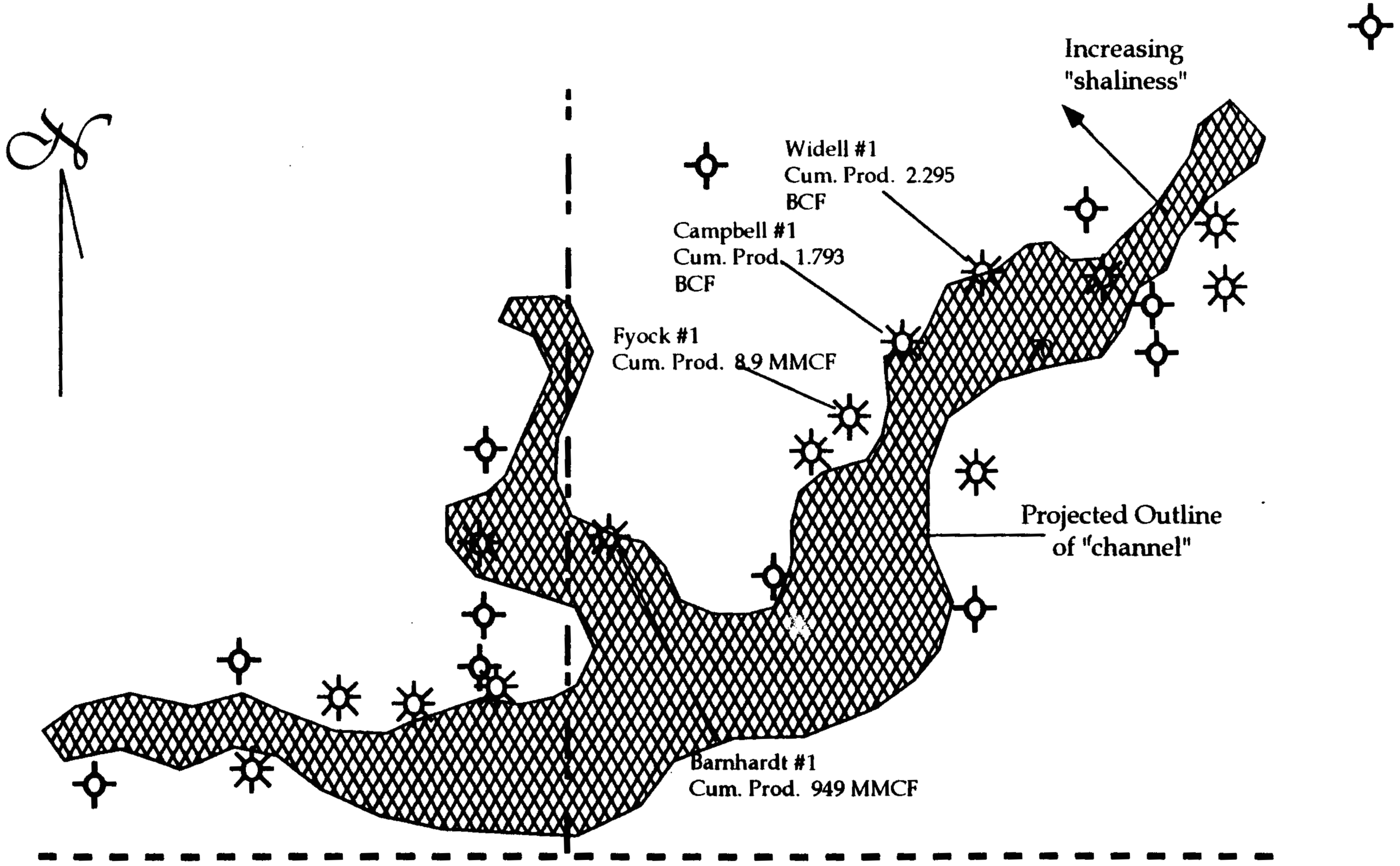


Figure 25.0
Interpretation of
Subsurface
Mapping
Stagecoach Field
Tioga County, N.Y.

NYSERDA PROJECT
Purchase Order R 2068

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

FIGURE 26.0

Well Locations in Tioga County, NY Exclusive of the Stagecoach Field Area

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

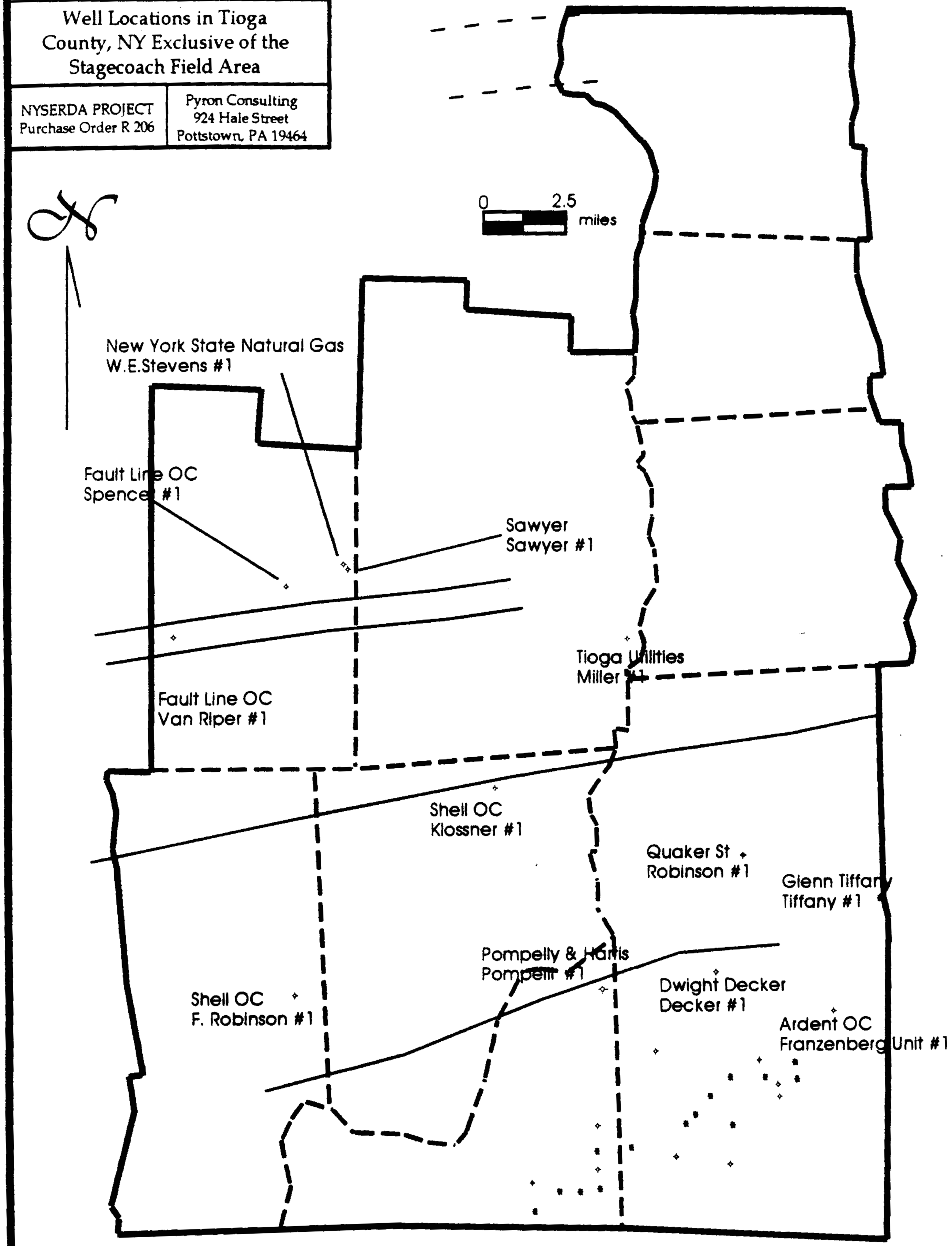


FIGURE 27.0

Structure Map,
Tully Interval
Tioga County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

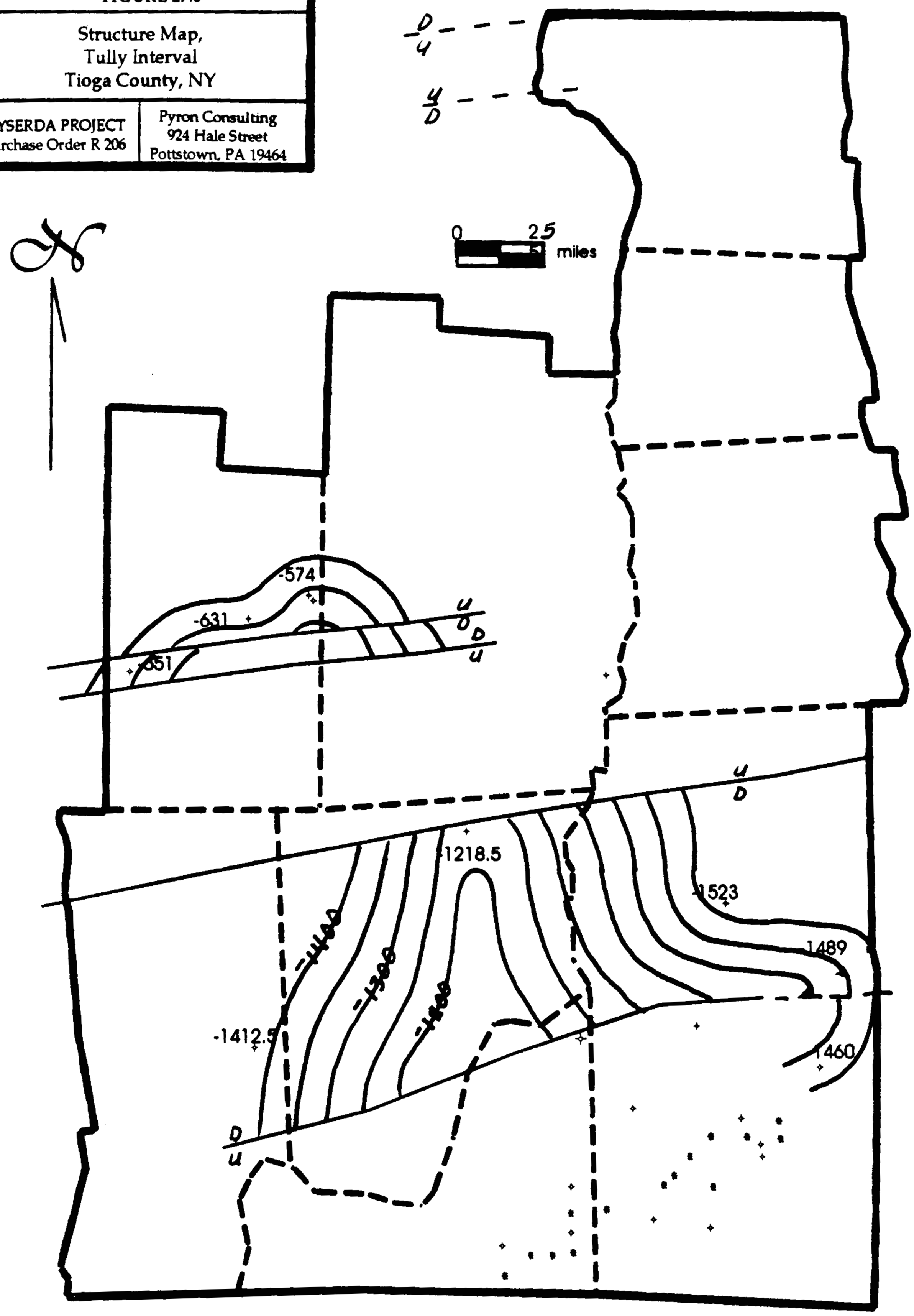


FIGURE 28.0

Structure Map,
Cherry Valley Datum
Tioga County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

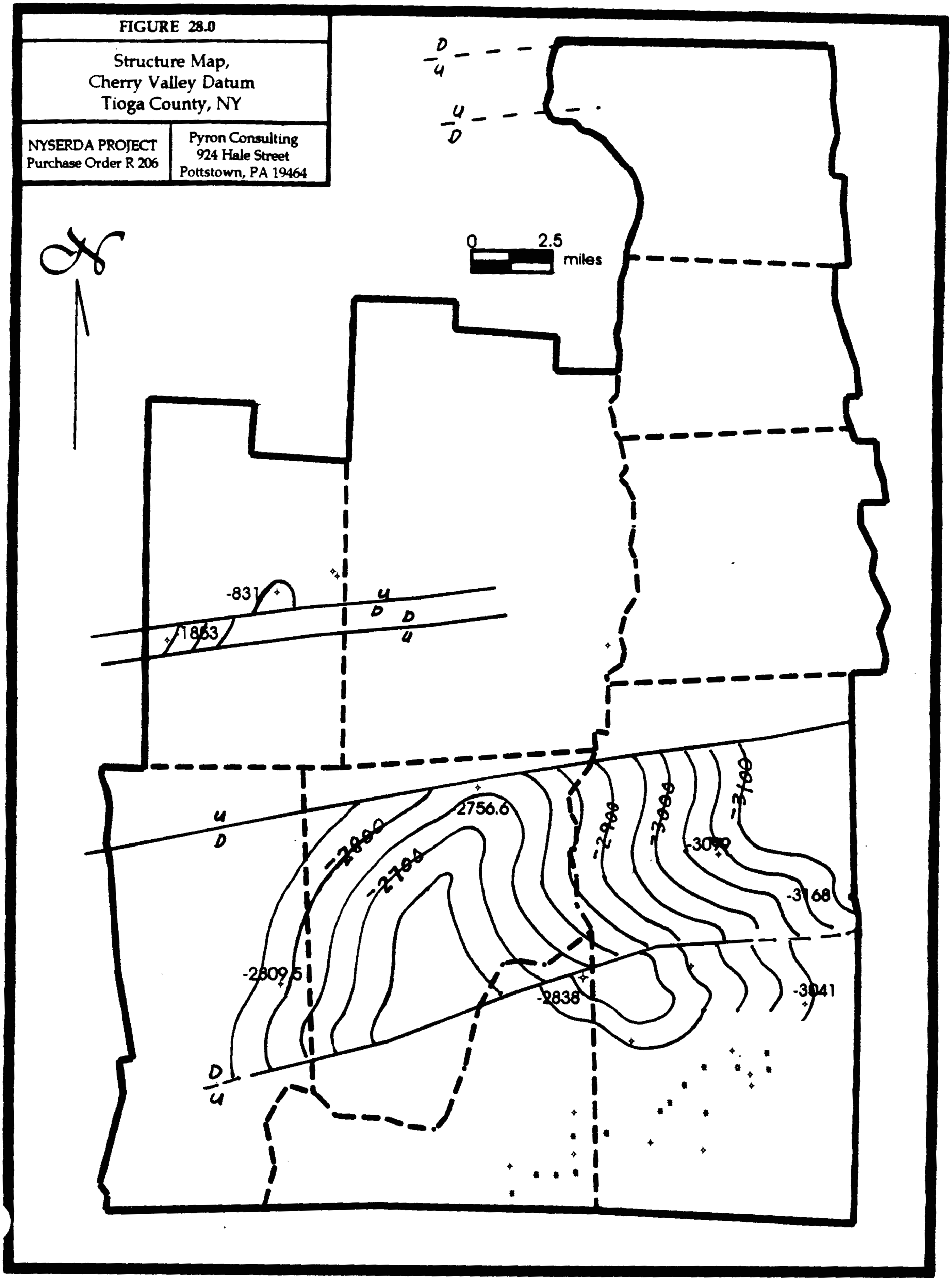


FIGURE 29.0

Structure Map,
Onondaga Datum
Tioga County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

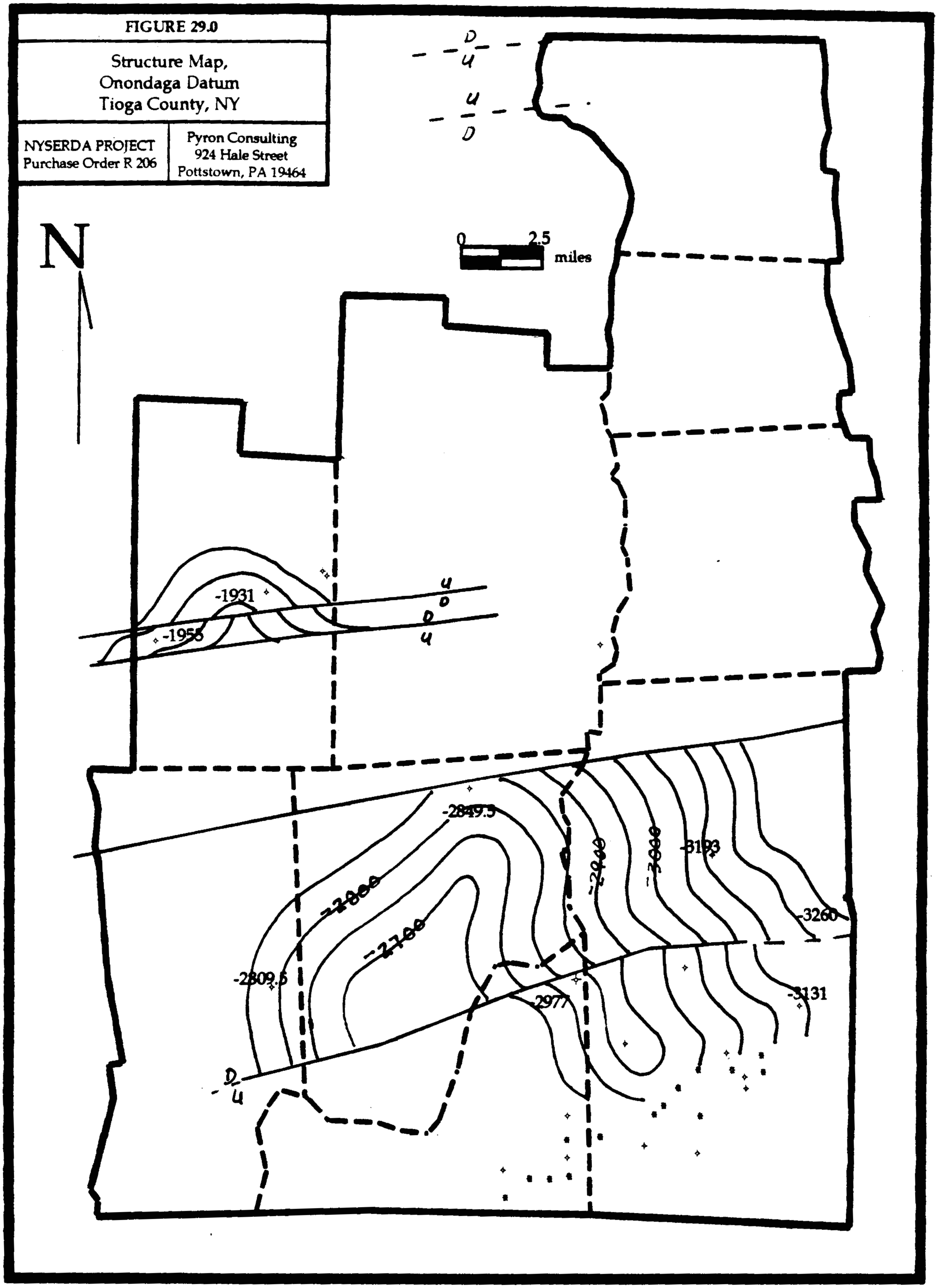


FIGURE 30.0

Structure Map,
Oriskany Sand Datum
Tioga County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

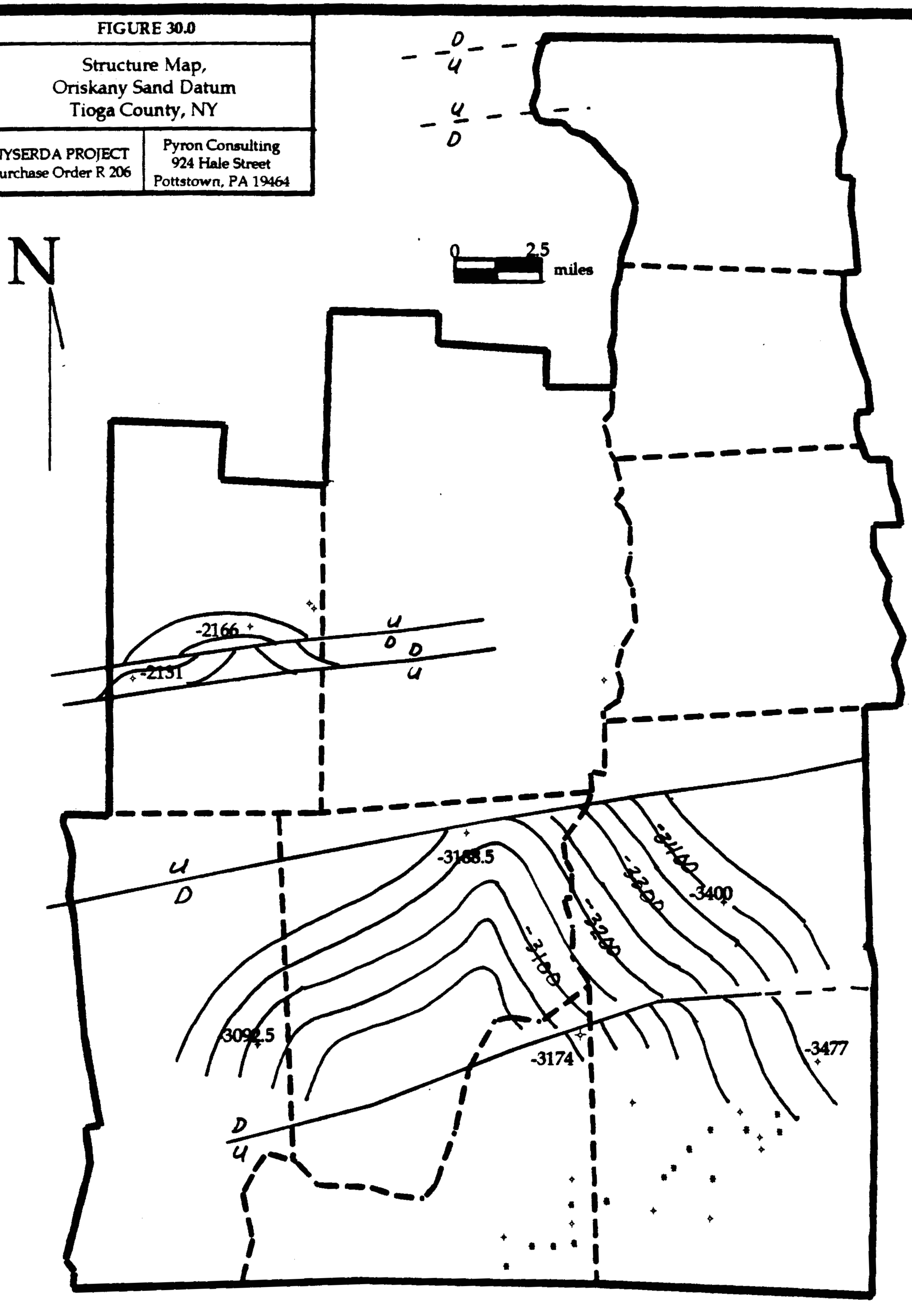


FIGURE 31.0

Structure Map,
Helderberg LS Datum
Tioga County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

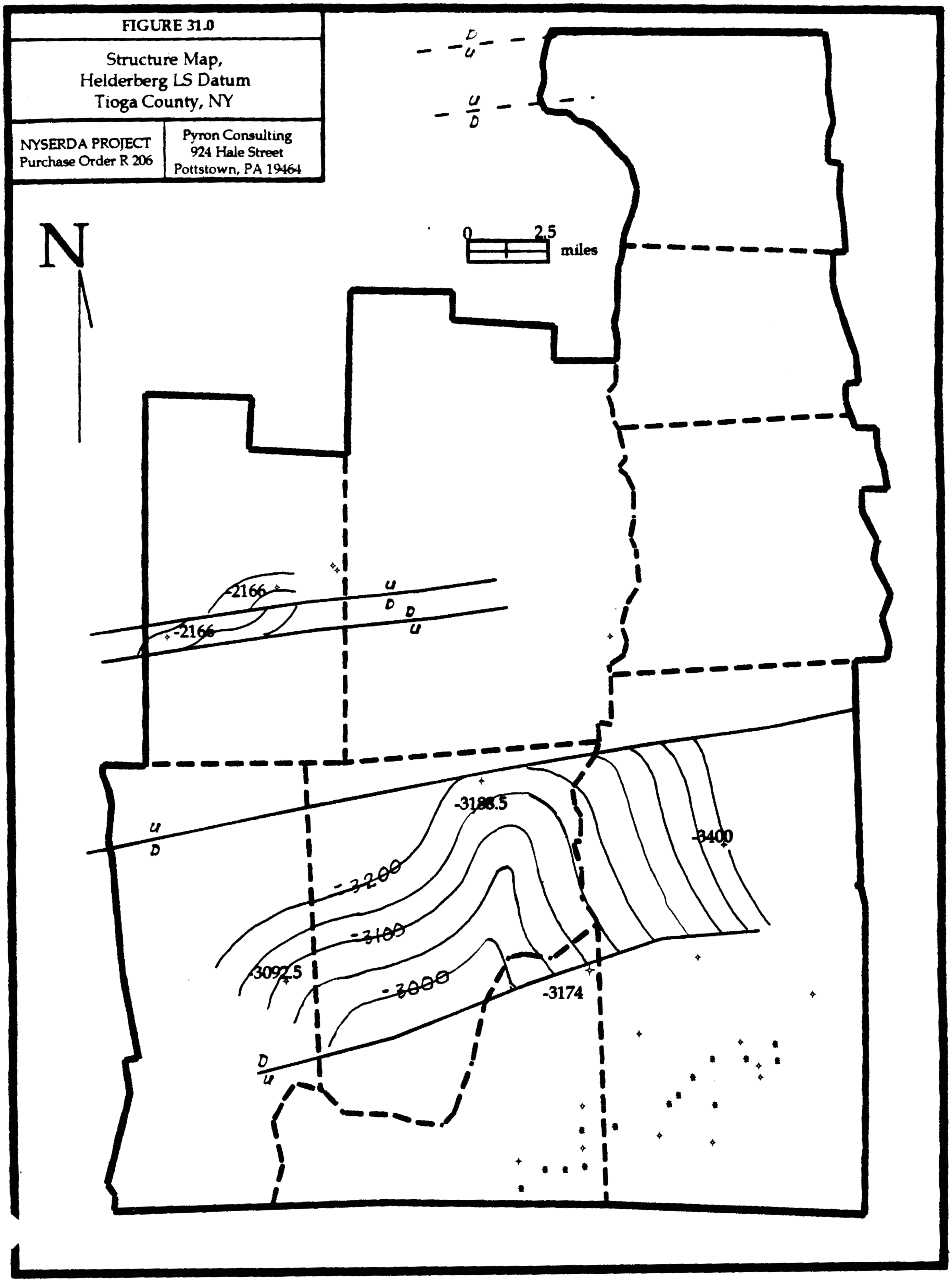


FIGURE 32.0

Isopach Map, Tully Thickness
Tioga County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

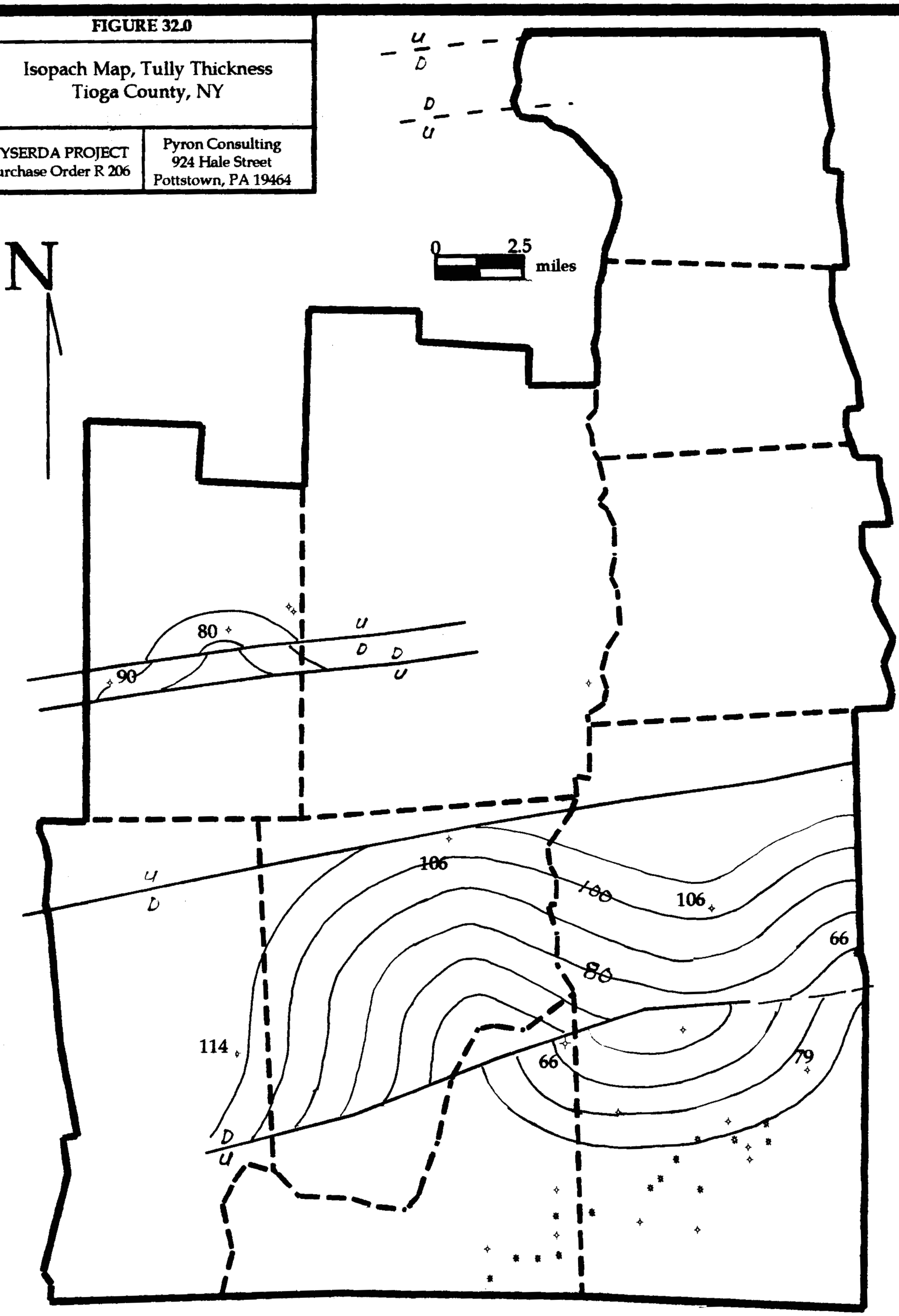


FIGURE 33.0

Isopach Map, Cherry Valley
Thickness
Tioga County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

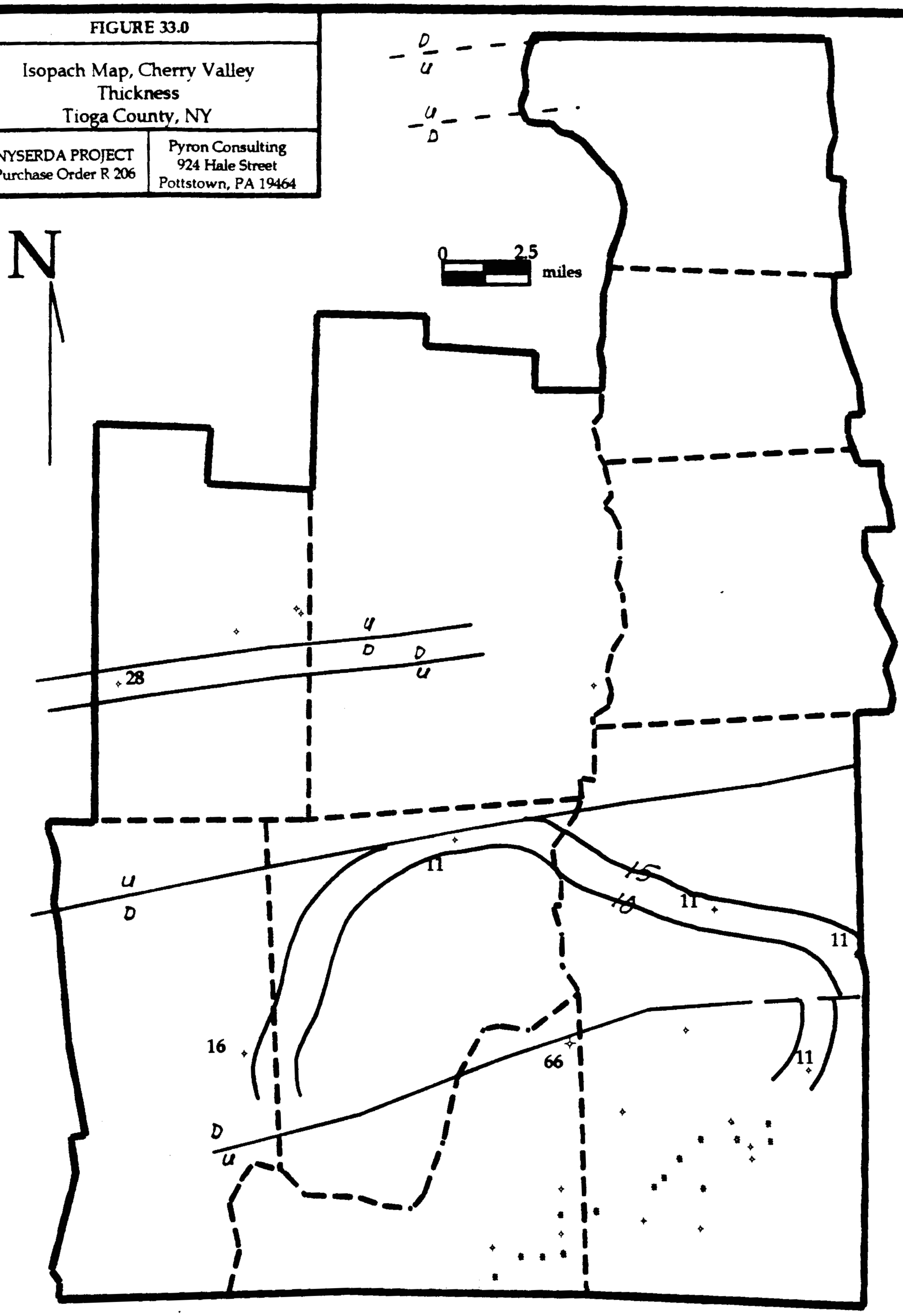


FIGURE 34.0

Isopach Map, Onondaga
Limestone Thickness
Tioga County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

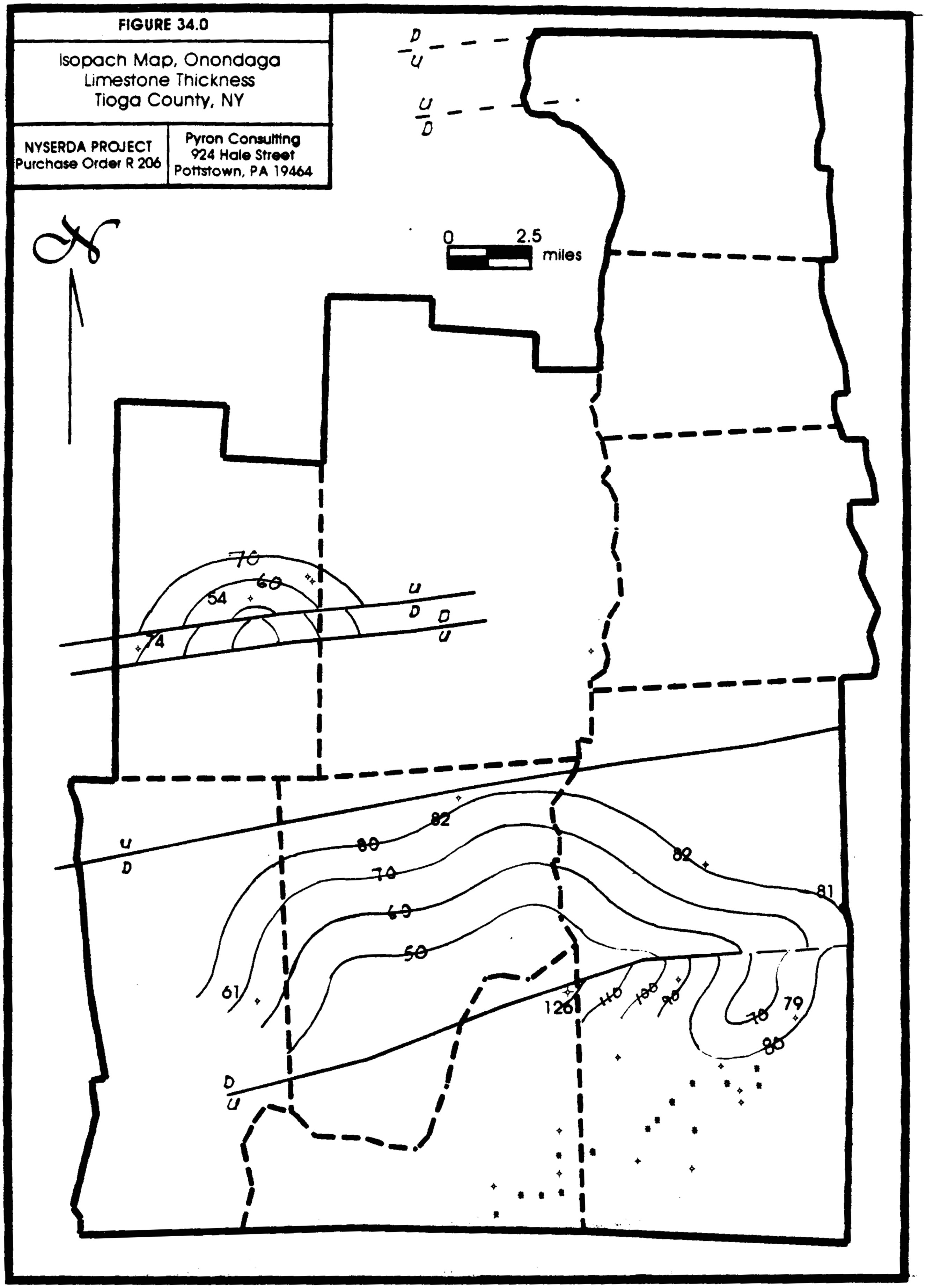


FIGURE 35.0

Isopach Map, Oriskany Sandstone Thickness Tioga County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

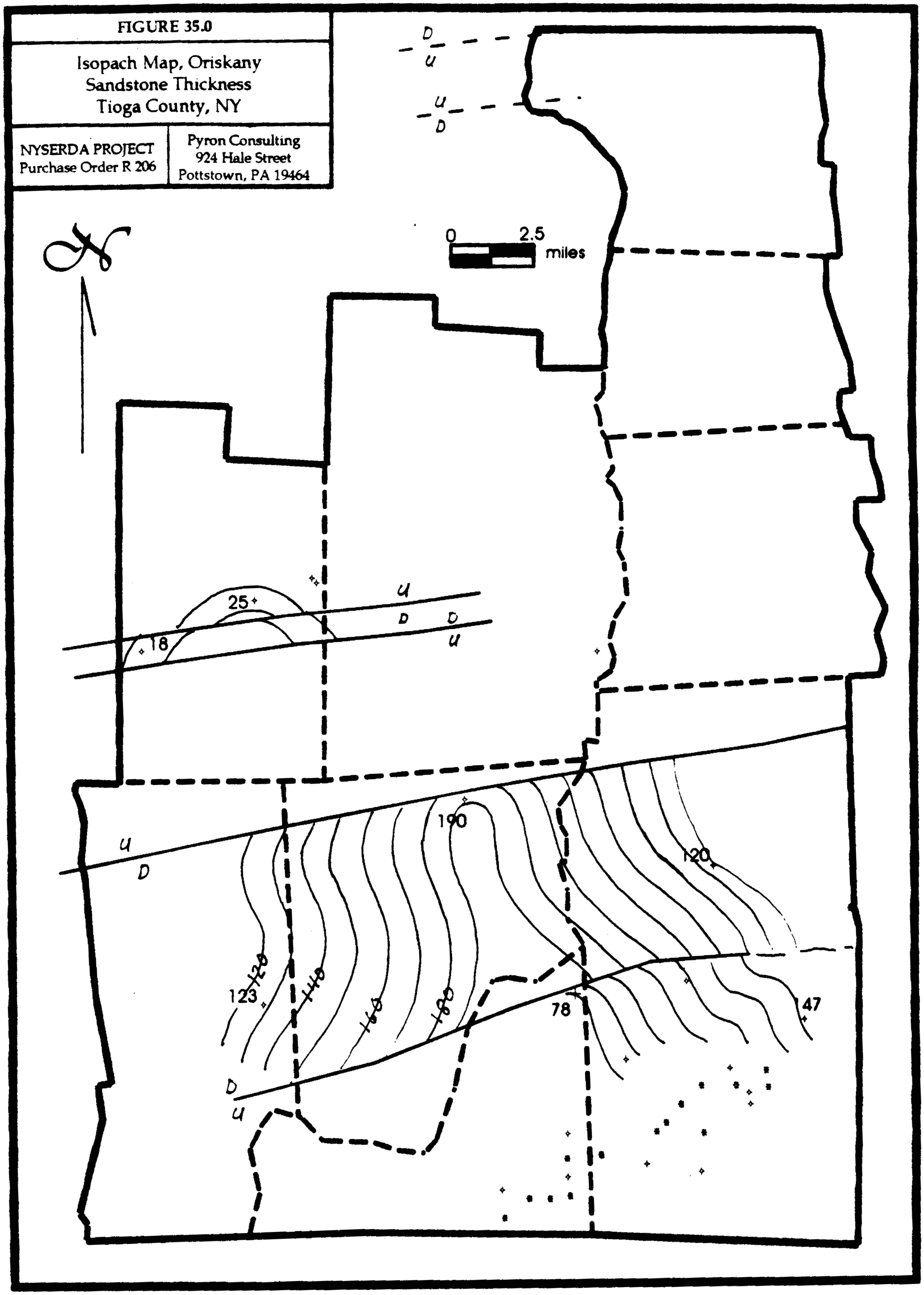
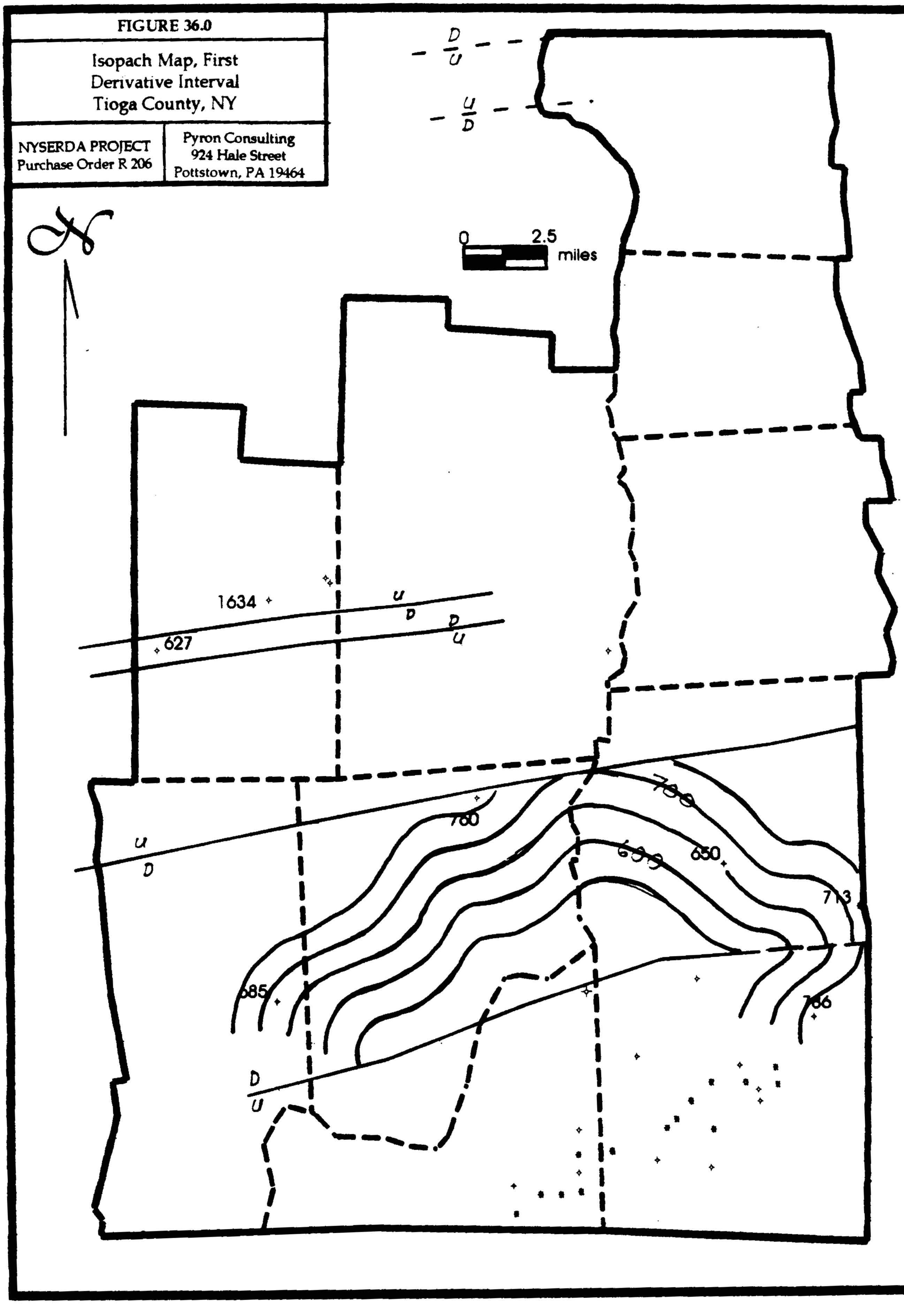


FIGURE 36.0

Isopach Map, First
Derivative Interval
Tioga County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464



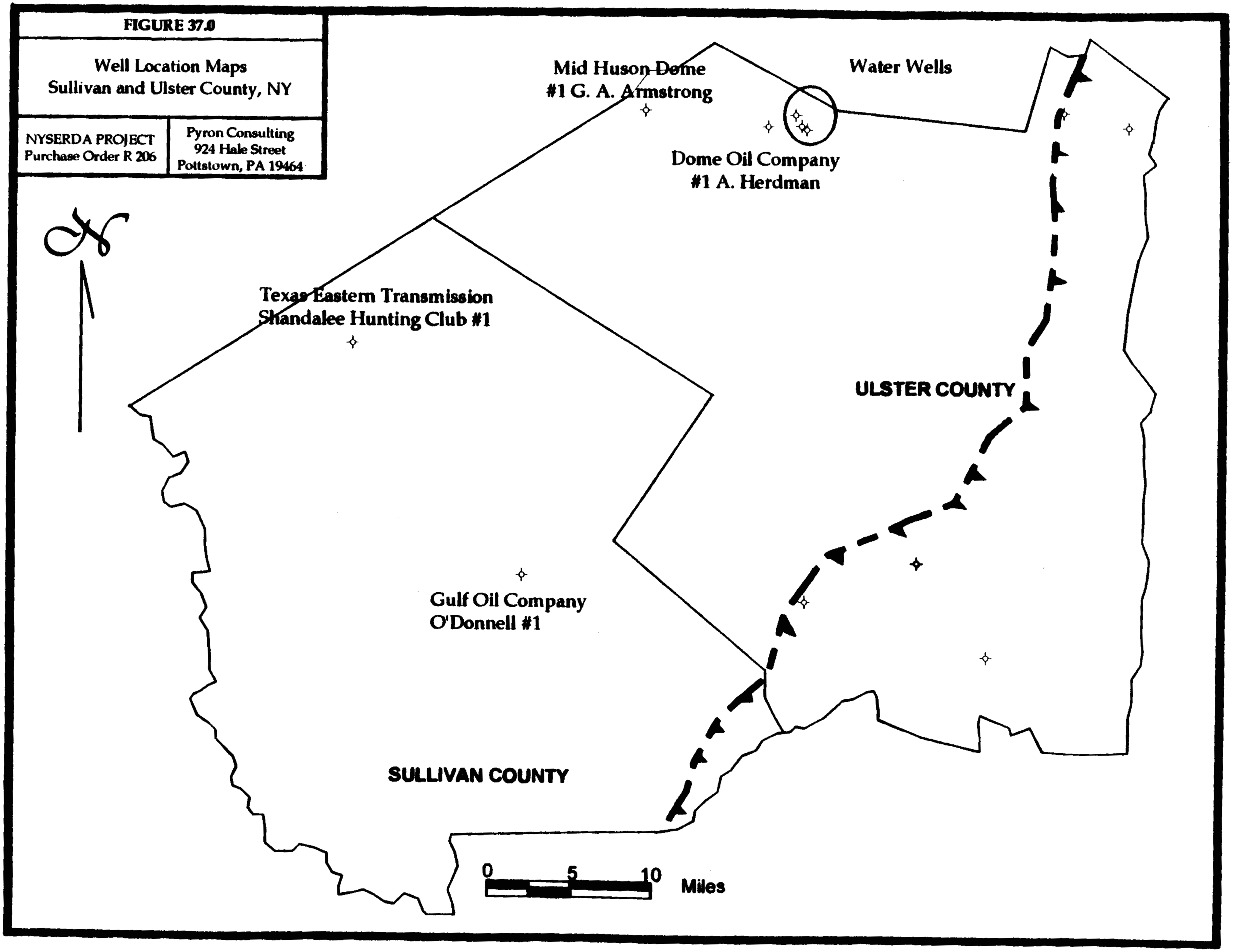


FIGURE 37.0

Well Location Maps
Sullivan and Ulster County, NY

NYSERDA PROJECT
Purchase Order R 206

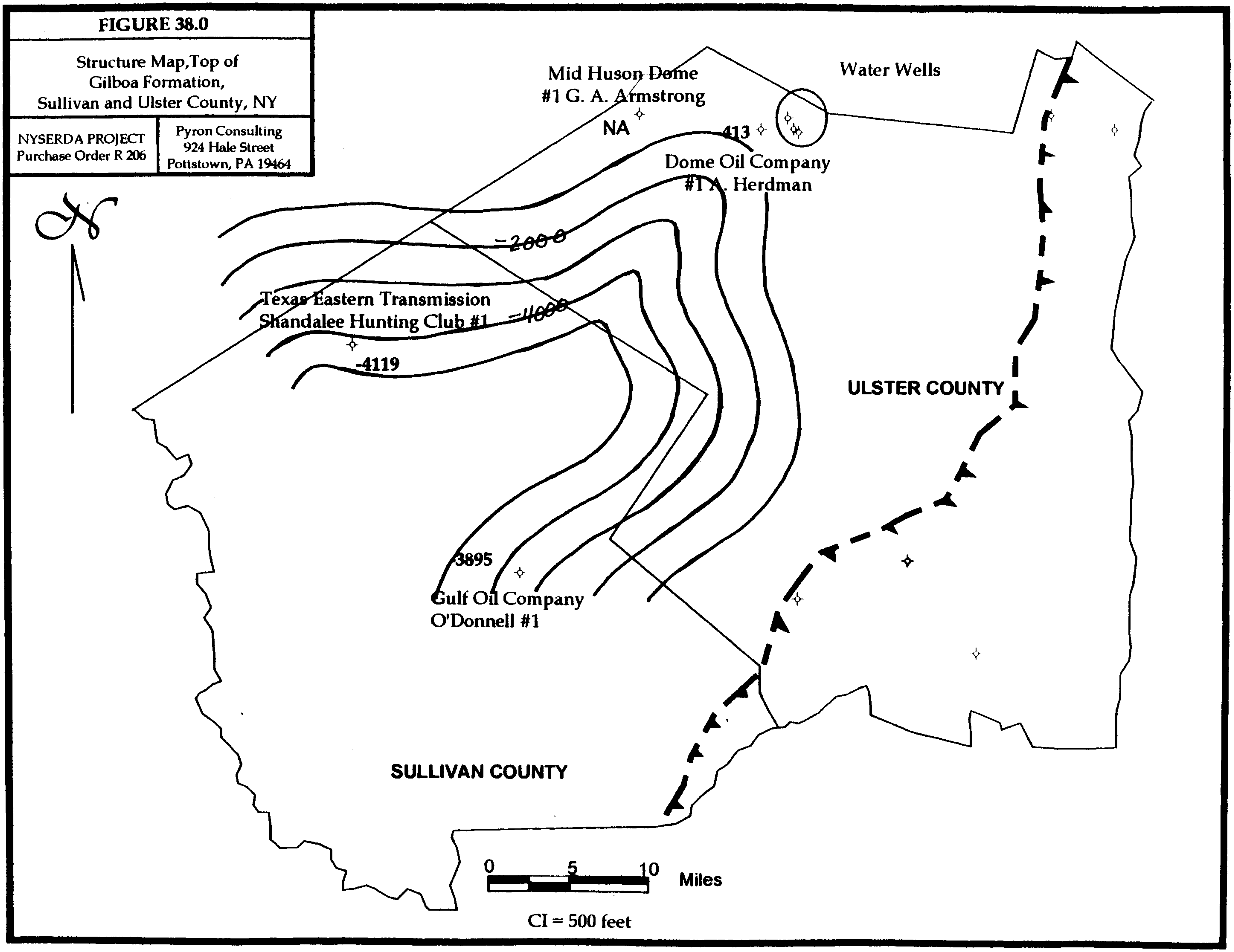
Pyron Consulting
924 Hale Street
Pottstown, PA 19464

FIGURE 38.0

Structure Map,Top of
Gilboa Formation,
Sullivan and Ulster County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464



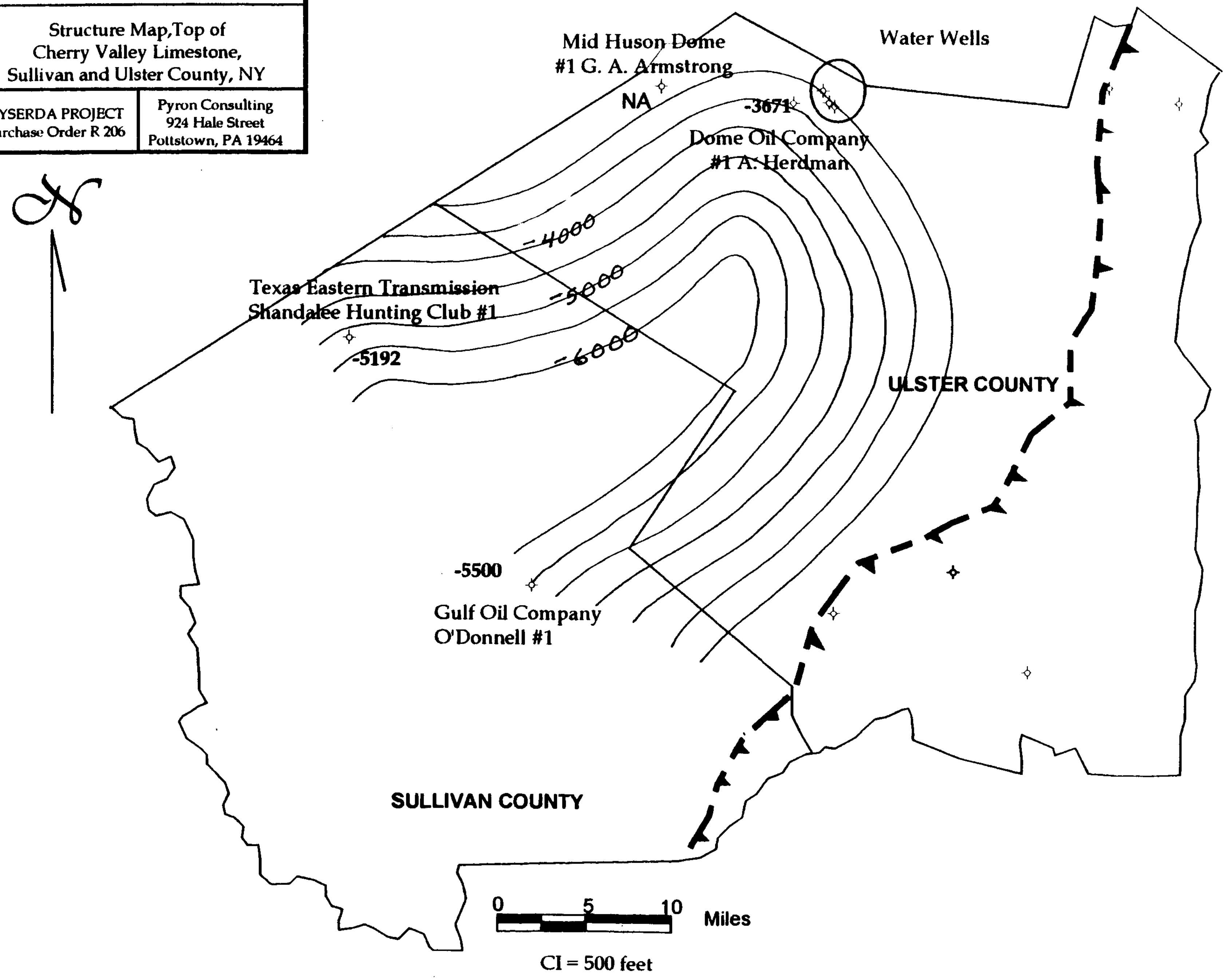
CI = 500 feet

FIGURE 39.0

Structure Map,Top of
Cherry Valley Limestone,
Sullivan and Ulster County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464



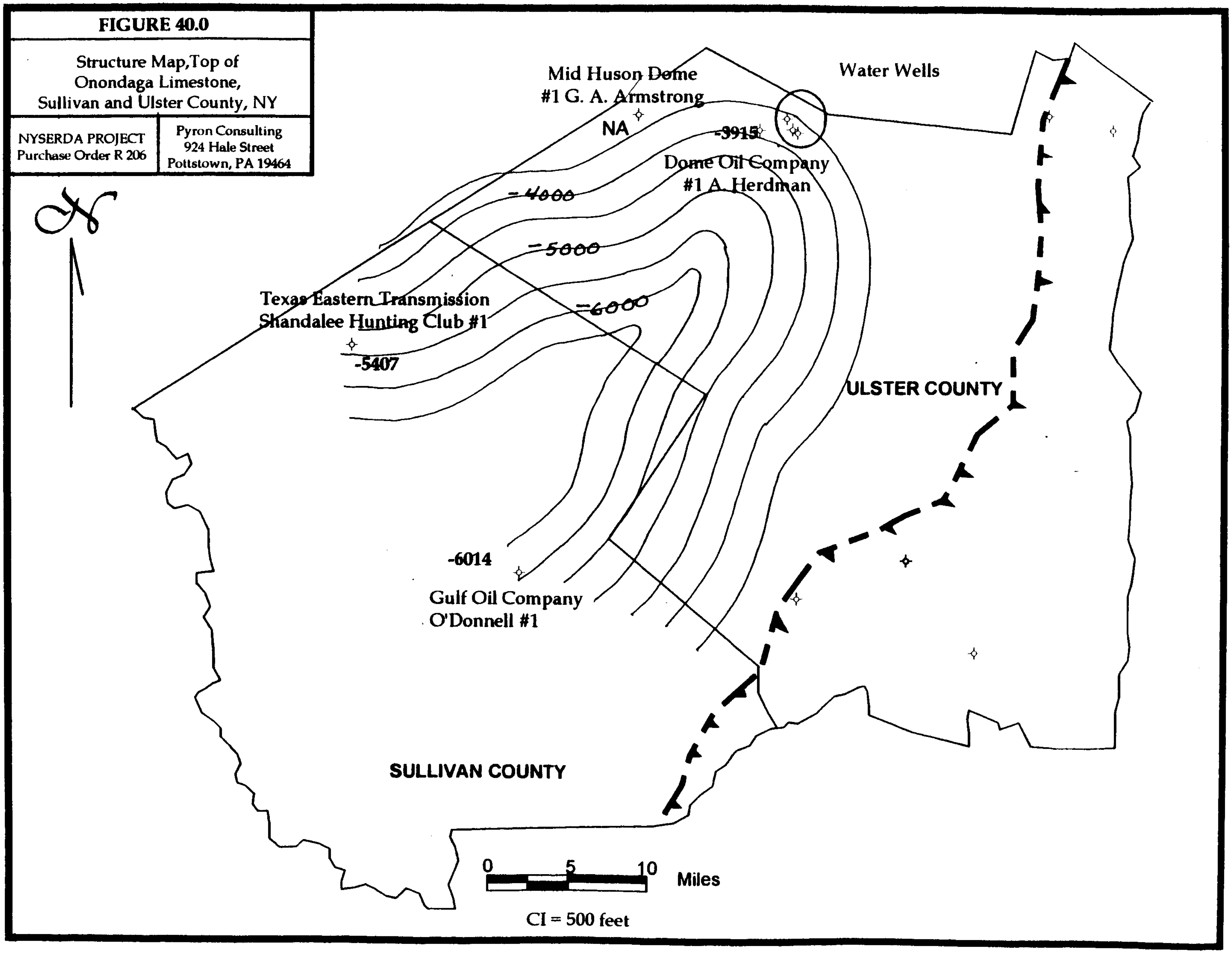
CI = 500 feet

FIGURE 40.0

Structure Map, Top of Onondaga Limestone, Sullivan and Ulster County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464



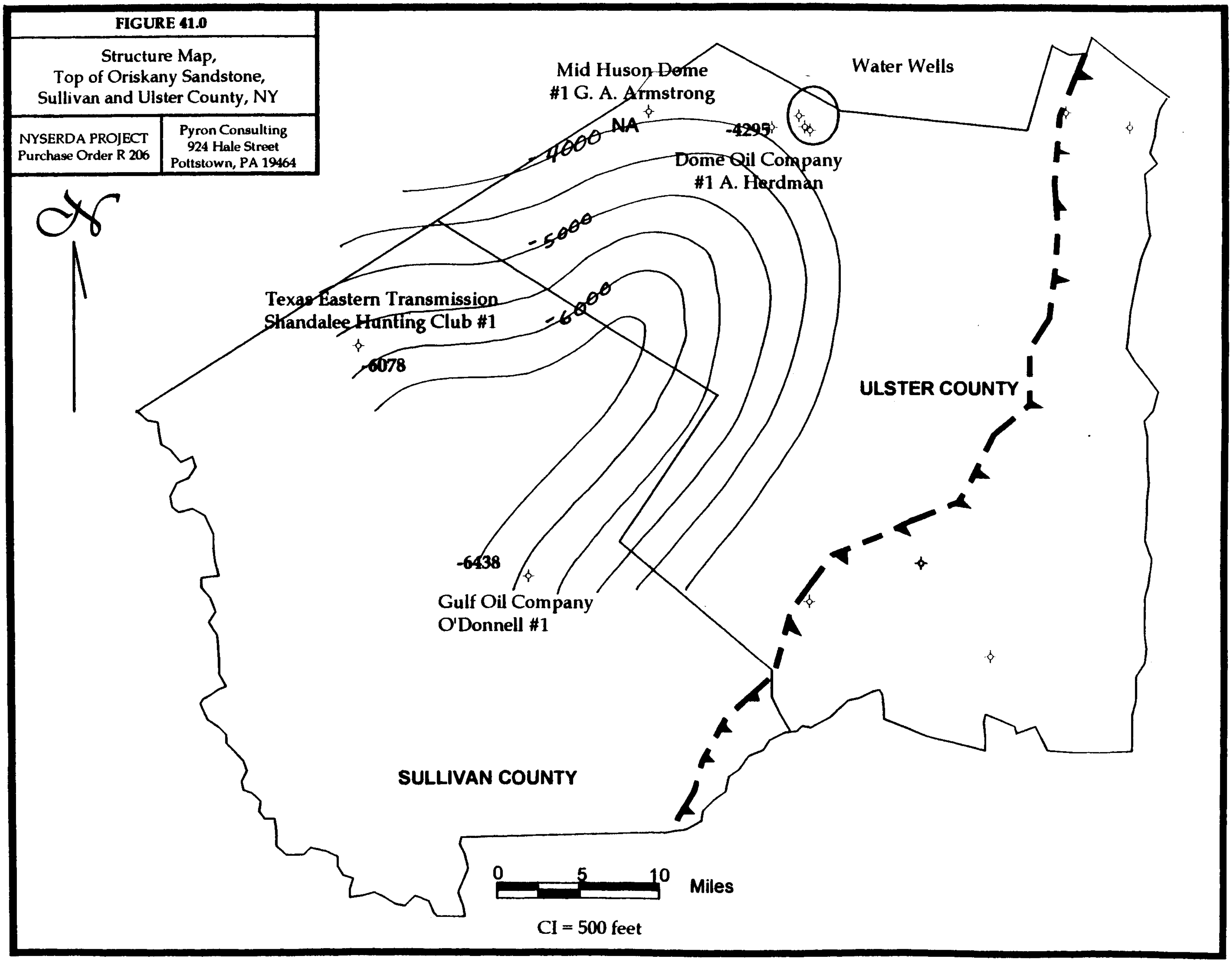


FIGURE 41.0

Structure Map,
Top of Oriskany Sandstone,
Sullivan and Ulster County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

CI = 500 feet

FIGURE 42.0

Structure Map,
Top of Helderberg Limestone,
Sullivan and Ulster County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

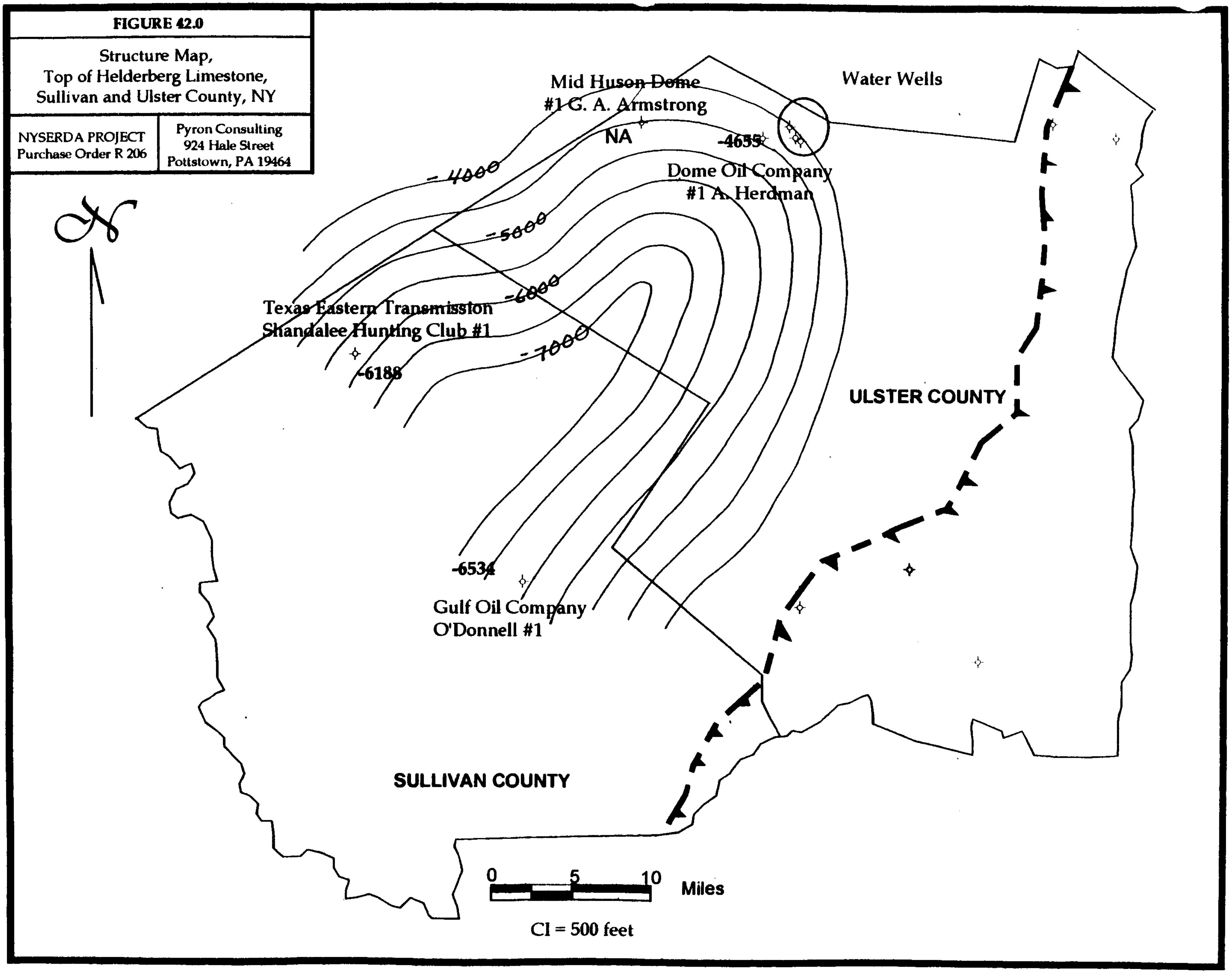
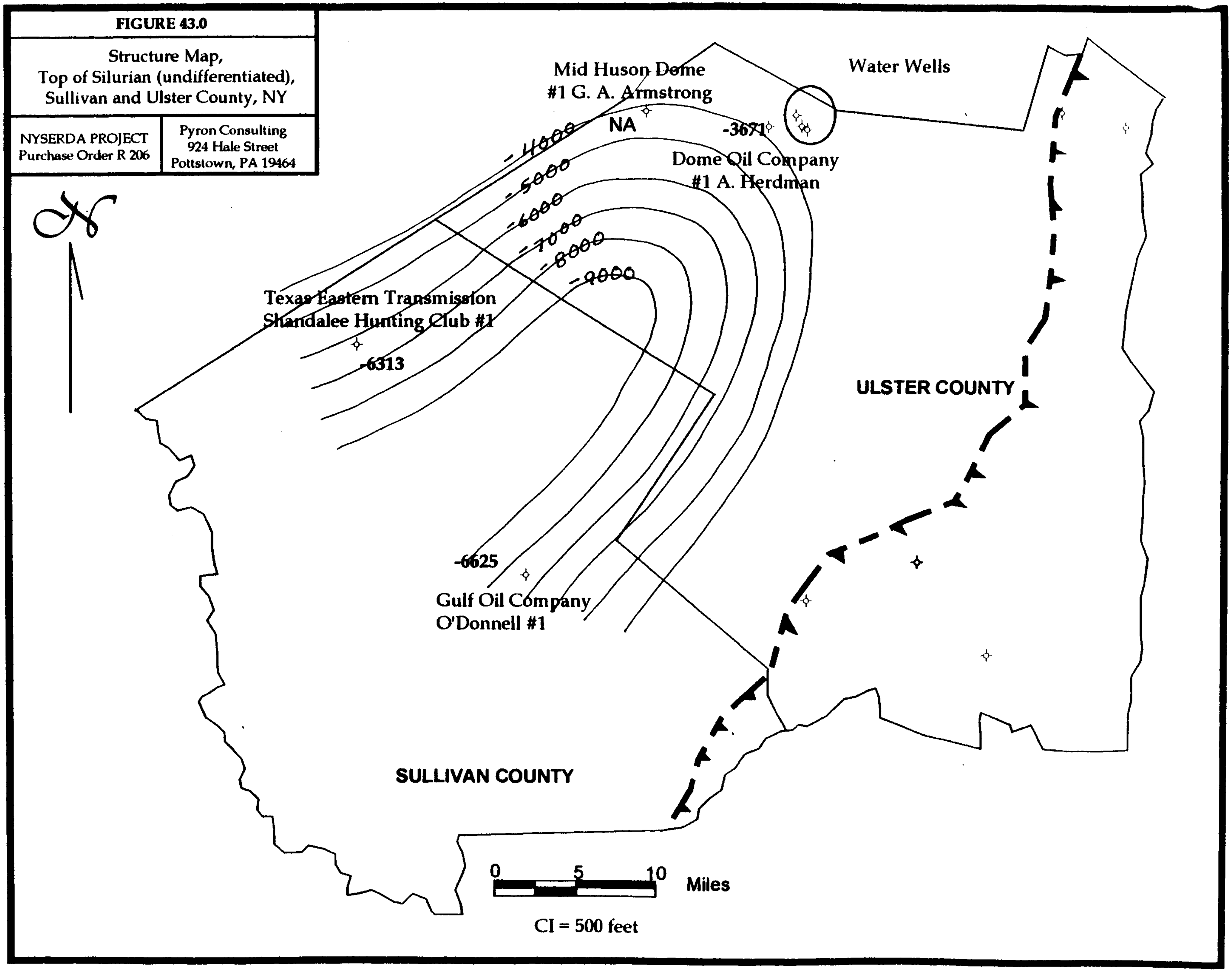


FIGURE 43.0

Structure Map,
Top of Silurian (undifferentiated),
Sullivan and Ulster County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464



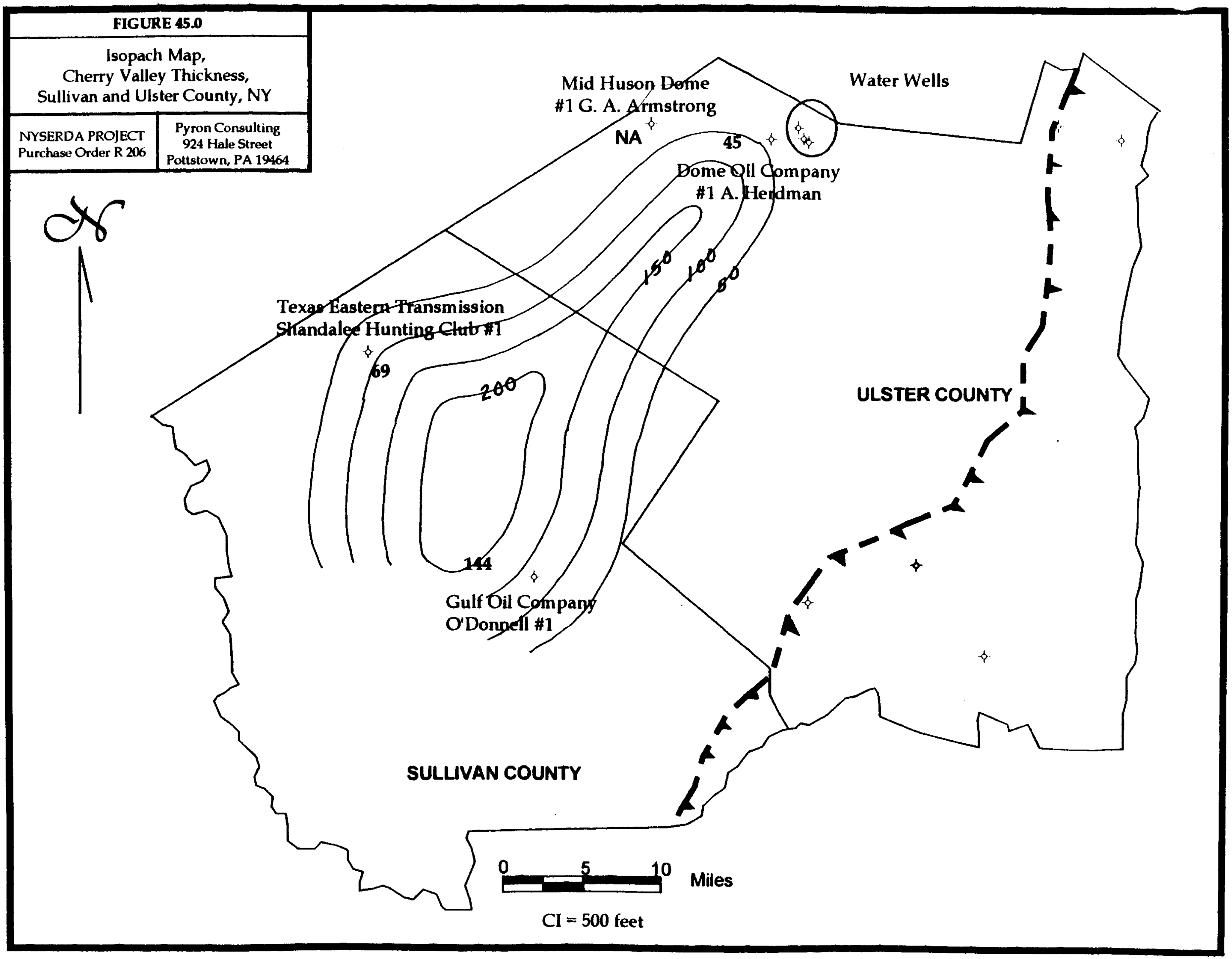
CI = 500 feet

FIGURE 45.0

Isopach Map,
Cherry Valley Thickness,
Sullivan and Ulster County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464



CI = 500 feet

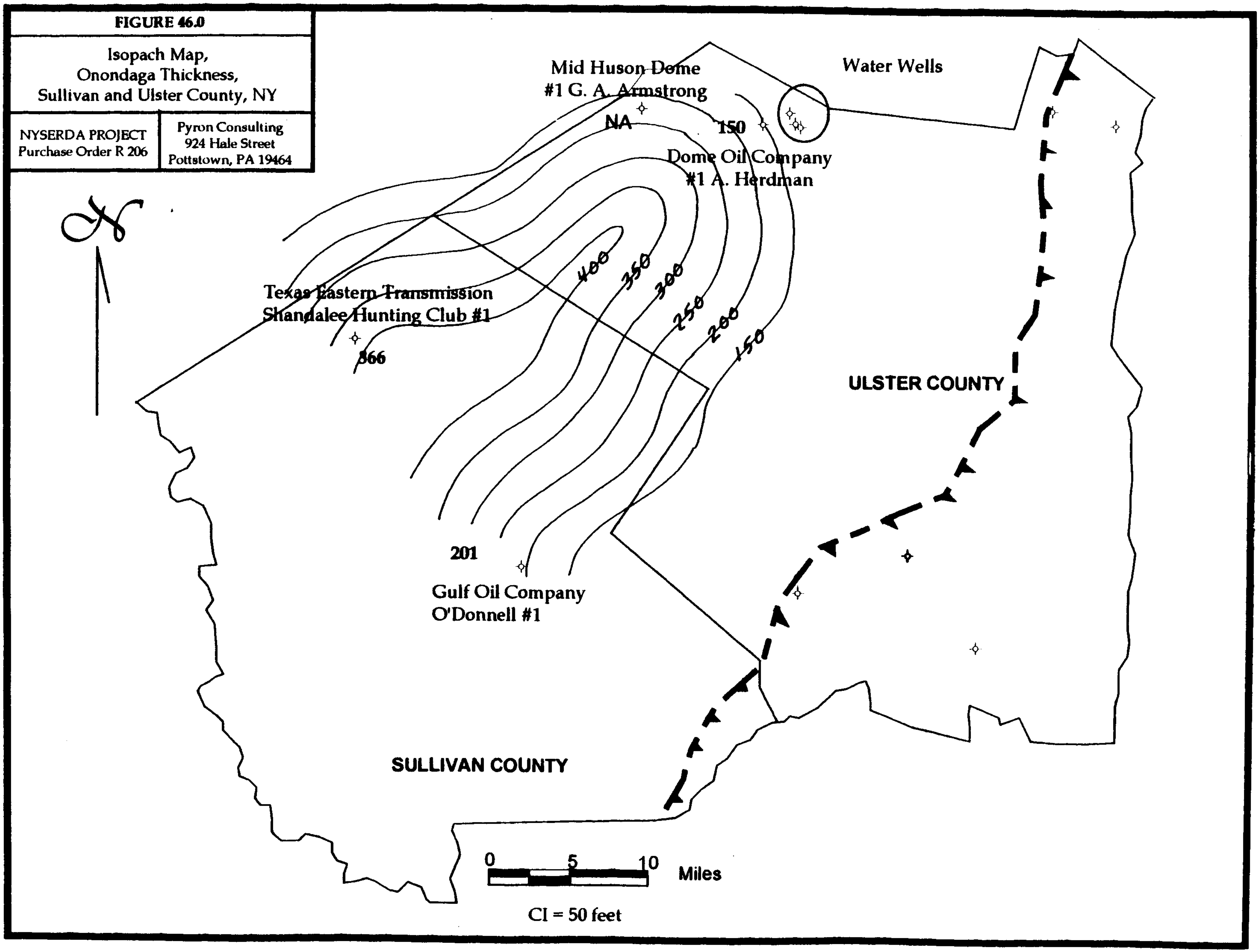


FIGURE 46.0

Isopach Map,
Onondaga Thickness,
Sullivan and Ulster County, NY

NYSERDA PROJECT
Purchase Order R 206

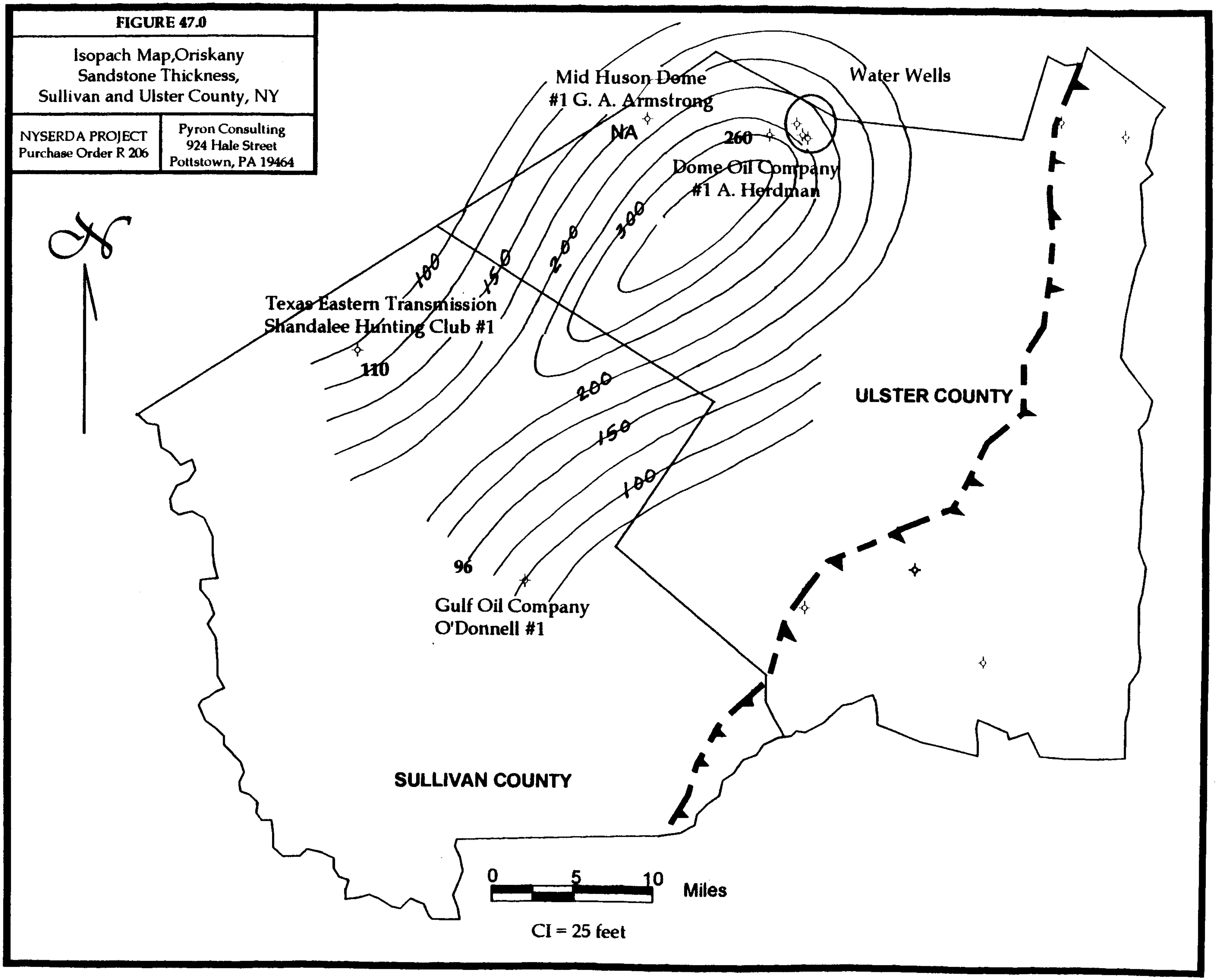
Pyron Consulting
924 Hale Street
Pottstown, PA 19464

FIGURE 47.0

Isopach Map,Oriskany
Sandstone Thickness,
Sullivan and Ulster County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464



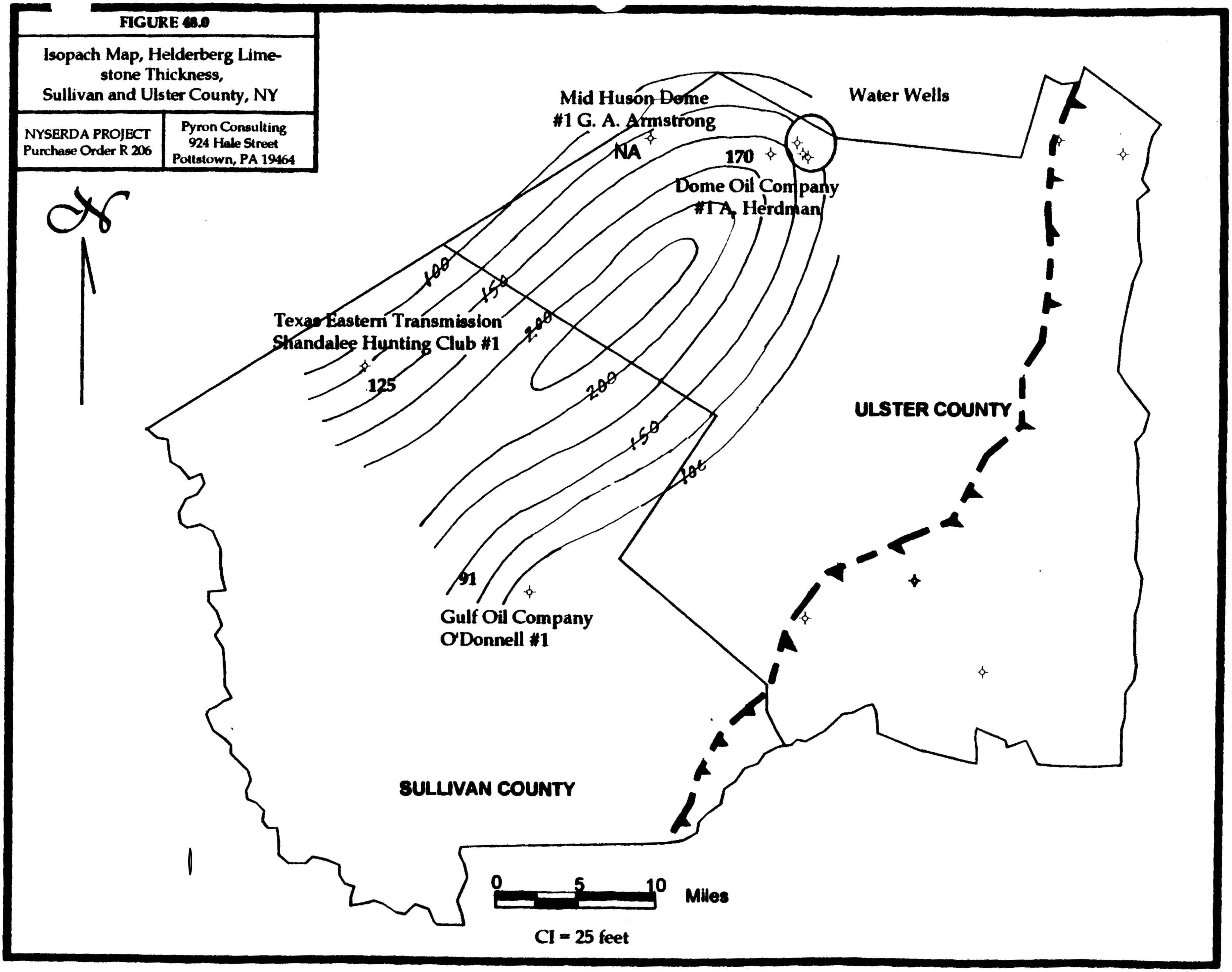
CI = 25 feet

FIGURE 48.0

Isopach Map, Helderberg Limestone Thickness, Sullivan and Ulster County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464



CI = 25 feet

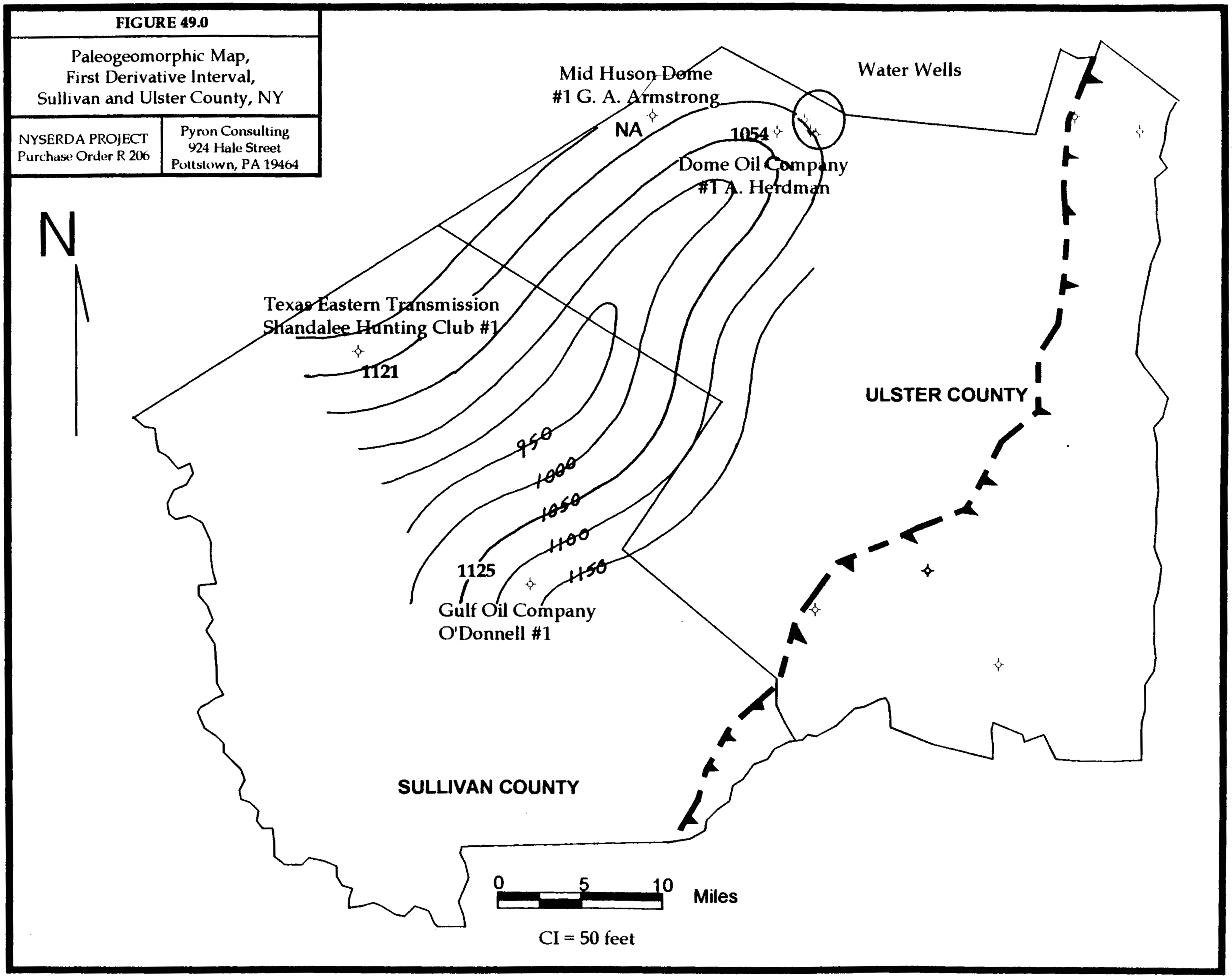


FIGURE 49.0

Paleogeomorphic Map,
First Derivative Interval,
Sullivan and Ulster County, NY

NYSERDA PROJECT
Purchase Order R 206

Pyron Consulting
924 Hale Street
Pottstown, PA 19464

Figure B - WELL DATA RECORDS, STAGECOACH FIELD

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-21420
COUNTY:	Tioga	**LOCATION:**	42° 05' 00" 76° 10' 00" 12100' FNL, 3200' FEL
OPERATOR:	Belden and Blake (Quaker State)	**WELL:**	#1 Merwyn Jones
FIELD:	Stagecoach	**AREA:**	

KB:	1043	**Gr. Level**	1035	**Spud:**	7/19/91	**Comp:**	8/6/91	**TD:**	4622	**Form:**	Helderberg

Casing: 11 3/4" 45', 8 5/8" @711' w 200 sx, 4 1/2" @ 4588', 2455 sx

Perforations: 4522-4542' IPF - 2.405 MMCFPD

Core Report: None

Formation Tests:

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1043					
Genesee Shale		68	975					
Tully LS		2555	-1512	75				
Hamilton Shale		2630	-1587					
Pyritic shale		4197	-3154					
Cherry Valley Lime		4238	-3195	10				
Marcellus Shale		4248	-3205					
Onondaga Limestone		4329	-3286	53				
Needmore Shale		4382	-3339					
Oriskany Sandstone		4430	-3387	81				
Helderberg Limestone		4511	-3468					
Derivative Interval #1								

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-21300
COUNTY:	Tioga	**LOCATION:**	42° 05' 00" 76° 10' 00" 12450' FNL, 8400' FEL
OPERATOR:	Belden and Blake (Quaker State)	**WELL:**	Wilbert Widell #1
FIELD:	Stagecoach	**AREA:**	

KB:	1160	**Gr. Level**	1150	**Spud:**	3/15/90	**Comp:**	6/26/90	**TD:**	4720	**Form:**	Helderberg

Casing: 11 3/4" 42', 8 5/8" @711' w 230 sx, 4 1/2" @ 4682', 1225 sx

Perforations: 4611-4629'

Core Report None

Formation Tests

✓ Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1160					
Genesee Shale		48	1112					
Tully LS		2687	-1527	71				
Hamilton Shale		2758	-1598					
Pyritic shale		4295	-3135					
Cherry Valley Lime		4326	-3166	12				
Marcellus Shale		4338	-3178					
Onondaga Limestone		4417	-3257	66				
Needmore Shale		4483	-3323					
Oriskany Sandstone		4532	-3372	78				
Helderberg Limestone		4610	-3450					
Derivative Interval #1								

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-21451
COUNTY:	Tioga	**LOCATION:**	42° 05' 00" 76° 07' 30" 12225' FNL, 9325' FEL
OPERATOR:	Belden and Blake (Quaker State)	**WELL:**	Pierce #1
FIELD:	Stagecoach	**AREA:**	

KB:	1148	**Gr. Level**	1140	**Spud:**	2/14/92	**Comp:**	9/2/92	**TD:**	4823	**Form:**	Helderberg

Casing:	11 3/8" 45', 8 5/8" @709' w 230 sx, 4 1/2" @ 4790', 245 sx
Perforations:	4611-4629'
Core Report	None
Formation Tests	

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1148					
Genesee Shale		70	1078					
Tully LS		2690	-1542	88				
Hamilton Shale		2778	-1630					
Pyritic shale		4348	-3200					
Cherry Valley Lime		4385	-3237	13				
Marcellus Shale		4398	-3250					
Onondaga Limestone		4475	-3327	62				
Needmore Shale		4537	-3389					
Oriskany Sandstone		4588	-3440	72				
Helderberg Limestone		4660	-3512					
Derivative Interval #1								

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-21424
COUNTY:	Tioga	**LOCATION:**	42° 05' 00" 76° 12' 30" 14900' FNL, 20' FEL
OPERATOR:	Belden and Blake (Quaker State)	**WELL:**	E. Campbell #1
FIELD:	Stagecoach	**AREA:**	

KB:	1365	**Gr. Level**	1355	**Spud:**	8/24/91	**Comp:**	9/21/91	**TD:**	5030	**Form:**	Helderberg

Casing: 11 3/8" 40', 8 5/8" @704' w 200 sx, 4 1/2" @ 5004', 245 sx

Perforations: 4913-4928' IPF - 3.113 MMCFPG

Core Report: None

Formation Tests:

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1365					
Genesee Shale		12	1353					
Tully LS		2930	-1565	79				
Hamilton Shale		3009	-1644					
Pyritic shale		4582	-3217					
Cherry Valley Lime		4617	-3252	11				
Marcellus Shale		4628	-3263					
Onondaga Limestone		4711	-3346	71				
Needmore Shale		4782	-3417					
Oriskany Sandstone		4833	-3468	71				
Helderberg Limestone		4904	-3539					
Derivative Interval #1								

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-21421
COUNTY:	Tioga	**LOCATION:**	42° 02' 30" 76° 15' 00" 11250' FNL, 9600' FEL
OPERATOR:	Belden and Blake (Quaker State)	**WELL:**	John Brenchley #1
FIELD:	Stagecoach	**AREA:**	

KB:	1445	**Gr. Level**	1435	**Spud:**	8/11/91	**Comp:**	11/20/91	**TD:**	5210	**Form:**	Helderberg

Casing: 11 3/4" 160', 8 5/8" @708' w 210 sx, 4 1/2" @ 5187', 245 sx

Perforations: 5063-5081' IPF - 0.633 MMCFPG

Core Report: None

Formation Tests:

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1445					
Genesee Shale		155	1290					
Tully LS		3250	-1805	80				
Hamilton Shale		3330	-1885					
Pyritic shale		4700	-3255					
Cherry Valley Lime		4760	-3315	13				
Marcellus Shale		4773	-3328					
Onondaga Limestone		4850	-3405	69				
Needmore Shale		4919	-3474					
Oriskany Sandstone		4967	-3522	92				
Helderberg Limestone		5059	-3614					
Derivative Interval #1								

Remarks:

WELL REPORT

STATE: New York
COUNTY: Tioga
OPERATOR: Belden and Blake (Quaker State)
FIELD: Stagecoach

SURVEY: API 31-107-20644
LOCATION: 42° 02' 30" 76° 15' 00" 5975' FNL, 1450' FEL
WELL: Barnhardt #1
AREA:

KB: 1495 **Gr. Level** 1485 **Spud:** 10/23/88 **Comp:** 11/15/88 **TD:** 5232 **Form:** Helderberg

Casing: 13 5/8" 86', 8 5/8" 519', 170 sx, 4 1/2" 5207', 370 sx

Perforations: 5113-5135' IPF 16.0 MMCFPD

Core Report None

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Synch.				Shows or Remarks
Alluvium		85	1410					
Tully LS		3188	-1693	71				
Hamilton Shale		3259	-1764					
Pyritic shale		4731	-3236					
Cherry Valley Lime		4770	-3275	11				
Marcellus Shale		4781	-3286					
Onondaga Limestone		4869	-3374	61				
Needmore Shale		4930	-3435					
Oriskany Sandstone		4992	-3497	100				
Helderberg Limestone		5092	-3597					
Derivative Interval #1								

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-21294
COUNTY:	Tioga	**LOCATION:**	42° 02' 30" 76° 15' 00" 10900' FNL, 6400' FEL
OPERATOR:	Belden and Blake (Quaker State)	**WELL:**	Irene Mead #1
FIELD:	Stagecoach	**AREA:**	

KB:	1425	**Gr. Level**	1415	**Spud:**	2/27/90	**Comp:**	9/5/90	**TD:**	5258	**Form:**	Helderberg

Casing: 13 3/8" 163', 8 5/8" @721' w 230 sx, 4 1/2" @ 5264', 1225 sx

Perforations: 5114-5132'

Core Report None

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1425					
Genesee Shale		163	1262					
Tully LS		3230	-1805	80				
Hamilton Shale		3310	-1885					
Pyritic shale		4753	-3328					
Cherry Valley Lime		4790	-3365	12				
Marcellus Shale		4802	-3377					
Onondaga Limestone		4887	-3462	71				
Needmore Shale		4958	-3533					
Oriskany Sandstone		5007	-3582	97				
Helderberg Limestone		5104	-3679					
Derivative Interval #1								

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-21394
COUNTY:	Tioga	**LOCATION:**	42° 02' 30" 76° 17' 30" 13800' FNL, 5650' FEL
OPERATOR:	Belden and Blake (Quaker State)	**WELL:**	L. Lacher #1
FIELD:	Stagecoach	**AREA:**	

KB: 1485 **Gr. Level** 1475 **Spud:** 11/19/90 **Comp:** 12/20/90 **TD:** 5293 **Form:** Helderberg

Casing: 16" 22' ,11 3/4" @42' w 230 sx, 8 5/8"2" @ 698', 125 sx

Perforations: 5114-5132'

Core Report: None

Formation Tests:

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1485					
Genesee Shale		61	1424					
Tully LS		3270	-1785	90				
Hamilton Shale		3360	-1875					
Pyritic shale		4756	-3271					
Cherry Valley Lime		4792	-3307	11				
Marcellus Shale		4803	-3318					
Onondaga Limestone		4883	-3398	76				
Needmore Shale		4959	-3474					
Oriskany Sandstone		5004	-3519	101				
Helderberg Limestone		5105	-3620					
Derivative Interval #1								

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-21264
COUNTY:	Tioga	**LOCATION:**	42° 02' 30" 76° 15' 00" 6500' FNL, 6900' FEL
OPERATOR:	Belden and Blake (Quaker State)	**WELL:**	Owen #1
FIELD:	Stagecoach	**AREA:**	

KB:	1590	**Gr. Level**	1580	**Spud:**	8/13/89	**Comp:**	8/29/89	**TD:**	5378	**Form:**	Helderberg

Casing: 11 3/4" 40', 8 5/8" @ 751', 210 sx, 4 1/2" @ 5327', 205 sx

Perforations: 5235-5243'

Core Report None

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1590					
Genesee Shale		41	1549					
Tully LS		3388	-1798	69				
Hamilton Shale		3457	-1867					
Pyritic shale		4900	-3310					
Cherry Valley Lime		4932	-3342	15				
Marcellus Shale		4947	-3357					
Onondaga Limestone		5027	-3437	69				
Needmore Shale		5096	-3506					
Oriskany Sandstone		5147	-3557	82				
Helderberg Limestone		5229	-3639					
Derivative Interval #1								

Remarks:

WELL REPORT

STATE: New York
COUNTY: Tioga
OPERATOR: Belden and Blake (Quaker State)
FIELD: Stagecoach

SURVEY: API 31-107-20531
LOCATION: 42° 02' 30" 76° 12' 30" 2960' FNL, 3875' FEL
WELL: Racht #1
AREA:

KB: 1495 **Gr. Level** 1485 **Spud:** 9/27/87 **Comp:** 10/16/87 **TD:** 5410 **Form:** Helderberg

Casing: 16" 20', 8/58" @ 966' w 410 sx, 4 1/2" @ 5191' w 250 sx

Perforations: 4987-5004'

Core Report None

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1495					
Genesee Shale		113	1382					
Tully LS		3105	-1610	82				
Hamilton Shale		3187	-1692					
Pyritic shale		4664	-3169					
Cherry Valley Lime		4700	-3205	12				
Marcellus Shale		4712	-3217					
Onondaga Limestone		4791	-3296	67				
Needmore Shale		4858	-3363					
Oriskany Sandstone		4904	-3409	81				
Helderberg Limestone		4985	-3490					
Silurian		5304	-5304					
Derivative Interval #1					640			

Remarks:

WELL REPORT

STATE: New York
COUNTY: Tioga
OPERATOR: Belden and Blake (Quaker State)
FIELD: Stagecoach

SURVEY: API 31-107-20427
LOCATION: 42° 02' 30" 76° 12' 30" 2000' FNL, 2350' FEL
WELL: Fyock #1
AREA:

KB: 1275 **Gr. Level** 1265 **Spud:** 12/3/86 **Comp:** 2/25/87 **TD:** 5515 **Form:** Helderberg

Casing: 16" 62', 11 3/4/@ 161' w 100 sx, 8/58" @ 1176' w 505 sx, 4 1/2" @ 5452' w 255 sx

Perforations: 4836-52' IPF - 0.411 MMCFPD

Core Report None

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1275					
Genesee Shale		80	1195					
Tully LS		2860	-1585	88				
Hamilton Shale		2948	-1673					
Pyritic shale		4490	-3215					
Cherry Valley Lime		4535	-3260	13				
Marcellus Shale		4548	-3273					
Onondaga Limestone		4629	-3354	67				
Needmore Shale		4696	-3421					
Oriskany Sandstone		4750	-3475	86				
Helderberg Limestone		4836	-3561					
Silurian		5253	-3978					
Derivative Interval #1					763			

Remarks:

WELL REPORT

STATE: New York
COUNTY: Tioga
OPERATOR: Belden and Blake (Quaker State)
FIELD: Stagecoach

SURVEY: API 31-107-21272
LOCATION: 42° 02' 30" 76° 17' 30" 11350' FNL, 1700' FEL
WELL: Cook #1
AREA:

KB: 1610 **Gr. Level** 1600 **Spud:** 2/3/90 **Comp:** 9/6/90 **TD:** 5455 **Form:** Helderberg

Casing: 11 3/4" 77', 8/58" @ 722' w 230 sx, 4 1/2" @ 5436' w 122 sx

Perforations: 5278-93' IPF - 0.44 MMCFPD

Core Report None

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1610					
Genesee Shale		217	1393					
Tully LS		3440	-1830	90				
Hamilton Shale		3530	-1920					
Pyritic shale		4940	-3330					
Cherry Valley Lime		4975	-3365	12				
Marcellus Shale		4987	-3377					
Onondaga Limestone		5069	-3459	69				
Needmore Shale		5138	-3528					
Oriskany Sandstone		5184	-3574	93				
Helderberg Limestone		5277	-3667					
Derivative Interval #1								

Remarks:

WELL REPORT

STATE: New York
COUNTY: Tioga
OPERATOR: Broome Tioga Gas
FIELD: Wildcat

SURVEY: API 31-107-0003
LOCATION: 42° 00', 76° 01' 16000 ' FS, 600' FEL
WELL: Kemp #3
AREA:

KB: 896 **Gr. Level** 886 **Spud:** 1/1/34 **Comp:** 3/1/34 **TD:** 1020 **Form:**

Casing: 13 3/8" 60', 8 5/8" - 700', 200 sx. 4 1/2"

Perforations:

Core Report

Formation Tests Reported show @ 835' in Genesee Fm. (20M)

Formation Name	Oper. Tops	Log Tops	Datum	Synch.				Shows or Remarks
Alluvium						No Tops reported		
Genesee Shale								
Tully LS								
Hamilton Shale								
Pyritic shale								
Cherry Valley Lime								
Marcellus Shale								
Onondaga Limestone								
Needmore Shale								
Oriskany Sandstone								
Helderberg Limestone								
Silurian								
Derivative Interval #1								

Remarks: NYS Geological Survey reports TD as "post Tully". Indications of faulting near well, show of gas set derrick on fire, could still light gas in 1945, initial rock pressure 225

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-21462
COUNTY:	Tioga	**LOCATION:**	42° 02' 30" 76° 07' 30" 10200' FNL, 9700' FEL
OPERATOR:	Belden and Blake (Quaker State)	**WELL:**	#2 Pierce
FIELD:	Stagecoach	**AREA:**	

KB: 990 **Gr. Level** 975 **Spud:** 2/11/93 **Comp:** 2/26/93 **TD:** 4574 **Form:** Helderberg

Casing: 16" 32', 11 3/4" @ 360' w 180 sx, 8/58" @ 715' w 200 sx, 4 1/2" @ 4570' w 200 sx

Perforations: 4464-80'

Core Report None

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	990					
Genesee Shale		16	974					
Tully LS		2485	-1495	81				
Hamilton Shale		2566	-1576					
Pyritic shale		4174	-3184					
C[illegible]rry Valley Lime		4184	-3194	9				
Marcellus Shale		4193	-3203					
Onondaga Limestone		4274	-3284	64				
Needmore Shale		4338	-3348					
Oriskany Sandstone		4387	-3397	67				
Helderberg Limestone		4454	-3464					
Derivative Interval #1								

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-20661
COUNTY:	Tioga	**LOCATION:**	42° 02' 30" 76° 10' 00" 7425' FNL, 8175' FEL
OPERATOR:	Quaker State	**WELL:**	Dodge #1
FIELD:	Stagecoach	**AREA:**	

KB: 1300 **Gr. Level** 1290 **Spud:** 11/29/88 **Comp:** 12/11/88 **TD:** 5123 **Form:** Helderberg

Casing: 11 3/4" @ 90', 8/58" @ 580' w 250 sx

Perforations: D & A

Core Report None

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1300					
Genesee Shale		82	1218					
Tully LS		2909	-1609	71				
Hamilton Shale		2980	-1680					
Pyritic shale		4498	-3198					
Cherry Valley Lime		4634	-3334	66				
Marcellus Shale		4700	-3400					
Onondaga Limestone		4759	-3459	83				
Needmore Shale		4842	-3542					
Oriskany Sandstone		4540	-3240	10				
Helderberg Limestone		4550	-3250					
Derivative Interval #1					-4498			

Remarks:

WEL PORT

STATE:	New York	**SURVEY:**	API 31-107-20532
COUNTY:	Tioga	**LOCATION:**	42° 05' 00" 76°12' 30" 9760' FNL, 9060' FEL
OPERATOR:	Quaker State	**WELL:**	Torbert #1
FIELD:	Stagecoach	**AREA:**	

KB: 1270 **Gr. Level** 1260 **Spud:** 10/20/87 **Comp:** 10/28/87 **TD:** 5150 **Form:** Helderberg

Casing: 16" 40', 8/58" @ 994' w 340 sx

Perforations: D & A

Core Report None

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1270					
Genesee Shale		142	1128					
Tully LS		2838	-1568	72				
Hamilton Shale		2910	-1640					
Pyritic shale		4380	-3110					
Cherry Valley Lime		4402	-3132	9				
Marcellus Shale		4411	-3141					
Onondaga Limestone		4490	-3220	63				
Needmore Shale		4553	-3283					
Oriskany Sandstone		4600	-3330	151				
Helderberg Limestone		4751	-3481					
Derivative Interval #1								

Remarks:

WELL REPORT

STATE: New York
COUNTY: Tioga
OPERATOR: Quaker State
FIELD: Stagecoach

SURVEY: API 31-107-20645
LOCATION: 42° 02' 30" 76° 10' 00" 2750' FNL, 8230' FEL
WELL: Tracey Mead #1
AREA:

KB: 1410 **Gr. Level** 1400 **Spud:** 11/4/88 **Comp:** 12/29/88 **TD:** 5229 **Form:** Helderberg

Casing: 11 3/4" w 121', 8/58" @ 873' w 220 sx, 4 1/2" @ 5074' w 580 sx

Perforations: 4928-4955', 4859-4863' IPF 0.285 MMCFPD

Core Report None

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1410					
Genesee Shale		140	1270					
Tully LS		2973	-1563	84				
Hamilton Shale		3057	-1647					
Pyritic shale		4575	-3165					
Cherry Valley Lime		4618	-3208	11				
Marcellus Shale		4629	-3219					
Onondaga Limestone		4711	-3301	69				
Needmore Shale		4780	-3370					
Oriskany Sandstone		4833	-3423	80				
Helderberg Limestone		4913	-3503					
Derivative Interval #1								

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-21497
COUNTY:	Tioga	**LOCATION:**	42° 02' 30" 76°15' 00" 8650' FNL, 6700' FEL
OPERATOR:	Quaker State	**WELL:**	I. Mead #2
FIELD:	Stagecoach	**AREA:**	

KB:	1465	**Gr. Level**	1450	**Spud:**	9/2/93	**Comp:**	9/11/93	**TD:**	5338	**Form:**	Helderberg

Casing: 11 3/4" 97', 8/58" @ 770' w 230 sx

Perforations: D & A

Core Report None

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1465					
Genesee Shale		80	1385					
Tully LS		3271	-1806	87				
Hamilton Shale		3358	-1893					
Pyritic shale		4880	-3415					
Cherry Valley Lime		4983	-3518	11				
Marcellus Shale		4994	-3529					
Onondaga Limestone		5011	-3546	79				
Needmore Shale		5090	-3625					
Oriskany Sandstone		5140	-3675	83				
Helderberg Limestone		5223	-3758					
Derivative Interval #1								

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-20534
COUNTY:	Tioga	**LOCATION:**	42° 02' 30" 76°12' 30" 7000' FNL, 5400' FEL
OPERATOR:	Quaker State	**WELL:**	Hakes #1
FIELD:	Stagecoach	**AREA:**	

KB:	1480	**Gr. Level**	1470	**Spud:**	10/9/87	**Comp:**	1/17/89	**TD:**	5484	**Form:**	Helderberg

Casing: 11 3/4" 161', 8/58" @ 1002' w 340 sx, 4 1/2" @ 5231' w 270 sx

Perforations: D & A

Core Report: None

Formation Tests:

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1480					
Genesee Shale		158	1322					
Tully LS		3110	-1630	80				
Hamilton Shale		3190	-1710					
Pyritic shale		4678	-3198					
Cherry Valley Lime		4707	-3227	13				
Marcellus Shale		4720	-3240					
Onondaga Limestone		4800	-3320	65				
Needmore Shale		4865	-3385					
Oriskany Sandstone		4920	-3440	88				
Helderberg Limestone		5008	-3528					
Derivative Interval #1								

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-21357
COUNTY:	Tioga	**LOCATION:**	42° 02' 30" 76°17' 30" 10350' FNL, 6000' FEL
OPERATOR:	Quaker State	**WELL:**	Truman Kittle #1
FIELD:	Stagecoach	**AREA:**	

KB: 1195 **Gr. Level** 1185 **Spud:** 10/20/90 **Comp:** 10/31/90 **TD:** 5597 **Form:** Helderberg

Casing: 11 3/4" 114', 8/58" @ 532' w 265 sx

Perforations: D & A

Core Report None

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1195					
Genesee Shale		115	1080					
Tully LS		3042	-1847	89				
Hamilton Shale		3131	-1936					
Pyritic shale								
Cherry Valley Lime		4563	-3368	12				
Marcellus Shale		4575	-3380					
Onondaga Limestone		4654	-3459	48				
Needmore Shale		4702	-3507					
Oriskany Sandstone		4770	-3575	37				
Helderberg Limestone		4807	-3612					
Silurian		5170	-3975					
Derivative Interval #1					607			

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-21547
COUNTY:	Tioga	**LOCATION:**	42° 02' 30" 76°15' 00"
OPERATOR:	Quaker State	**WELL:**	Faber #1
FIELD:	Stagecoach	**AREA:**	

KB: 1525 **Gr. Level** 1510 **Spud:** 8/20/94 **Comp:** 8/27/94 **TD:** 5435 **Form:** Helderberg

Casing: 11 3/4" 75', 8/58" @713' w 190 sx

Perforations: P & A

Core Report None

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1525					
Genesee Shale		286	1239					
Tully LS		3363	-1838	727				
Hamilton Shale		4090	-2565					
Pyritic shale								
Cherry Valley Lime								
Marcellus Shale		5044	-3519					
Onondaga Limestone		5088	-3563	72				
Needmore Shale		5160	-3635					
Oriskany Sandstone		5190	-3665	68				
Helderberg Limestone		5258	-3733					
Silurian		5170	-3645					
Derivative Interval #1					5170			

Remarks: Tops from scout tickets and other well records

WELL REPORT

STATE: New York
COUNTY: Tioga
OPERATOR: Quaker State
FIELD: Stagecoach

SURVEY: API 31-107-21452
LOCATION: 42° 05' 00" 76° 10' 00" 10200' FNL, 4100' FEL
WELL: R. Bell #1
AREA:

KB: 1145 **Gr. Level** 1130 **Spud:** 2/28/95 **Comp:** 3/12/93 **TD:** 4813 **Form:** Helderberg

Casing: 11 3/4" @ 124', 8/58" @ 699' w 200 sx

Perforations: P & A

Core Report None

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1145					
Genesee Shale		118	1027					
Tully LS		2704	-1559	83				
Hamilton Shale		2787	-1642					
Pyritic shale		4393	-3248					
Cherry Valley Lime		4428	-3283	11				
Marcellus Shale		4439	-3294					
Onondaga Limestone		4518	-3373	62				
Needmore Shale		4580	-3435					
Oriskany Sandstone		4632	-3487	69				
Helderberg Limestone		4701	-3556					
Derivative Interval #1								

Remarks:

WELL REPORT

STATE: New York
COUNTY: Tioga
OPERATOR: Quaker State
FIELD: Stagecoach

SURVEY: API 31-107-21376
LOCATION: 42° 02' 30" 76° 20' 00" 14150' FNL, 350' FEL
WELL: K. Smith #1
AREA:

KB: 970 **Gr. Level** 980 **Spud:** 11/8/90 **Comp:** 11/17/90 **TD:** 4888 **Form:** Helderberg

Casing: 16" 28', 11 3/4" @ 98' , 8/58" @ 675' w 200 sx

Perforations: D & A

Core Report None

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	970					
Genesee Shale		10	960					
Tully LS		2809	-1839	94				
Hamilton Shale		2903	-1933					
Pyritic shale								
Cherry Valley Lime		4360	-3390	10				
Marcellus Shale		4370	-3400					
Onondaga Limestone		4453	-3483	53				
Needmore Shale		4506	-3536					
Oriskany Sandstone		4575	-3605	37				
Helderberg Limestone		4612	-3642					
Derivative Interval #1					0			

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-21265
COUNTY:	Tioga	**LOCATION:**	42° 02' 30" 76°15' 00" 3550' FNL, 6925' FEL
OPERATOR:	Quaker State	**WELL:**	Owen #2
FIELD:	Stagecoach	**AREA:**	

KB:	1450	**Gr. Level**	1440	**Spud:**	8/23/89	**Comp:**	9/3/89	**TD:**	5300	**Form:**	Helderberg

Casing: 11 3/4" 47', 8/58" @ 686' w 220 sx

Perforations: D & A

Core Report None

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Alluvium		0	1450					
Genesee Shale		49	1401					
Tully LS		3253	-1803	84				
Hamilton Shale		3337	-1887					
Pyritic shale		4807	-3357					
Cherry Valley Lime		4840	-3390	13				
Marcellus Shale		4853	-3403					
Onondaga Limestone		4938	-3488	71				
Needmore Shale		5009	-3559					
Oriskany Sandstone		5057	-3607	83				
Helderberg Limestone		5140	-3690					
Derivative Interval #1								

Remarks:

Appendix C - WELL DATA RECORDS, TIOGA COUNTY

WELL REPORT

STATE: New York
COUNTY: Tioga
OPERATOR: Ardent Resources
FIELD: Wildcat

SURVEY: API 31-107-21502
LOCATION: 42° 05', 76° 07' 30" 4000 ' FS, 3150' FWL
WELL: #1 Frazenburg Unit
AREA:

KB: 1115 **Gr. Level** 1105 **Spud:** 9/1/93 **Comp:** **TD:** 4679 **Form:**

Casing: 13 3/8" 60', 8 5/8" - 700', 200 sx. 4 1/2"

Perforations:

Core Report

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Synch.				Shows or Remarks
Alluvium		65	1047					
Genesee Shale		762	353					
Tully LS		2575	-1460	79				
Hamilton Shale		2654	-1539					
Pyritic shale		4112	-2997					
Cherry Valley Lime		4156	-3041	11				
Marcellus Shale		4167	-3052					
Onondaga Limestone		4246	-3131	85				
Needmore Shale		4331	-3216					
Oriskany Sandstone		4445	-3330	147				
Helderberg Limestone		4592	-3477					
Silurian		4952						
Derivative Interval #1				796				

Remarks:

WELL REPORT

STATE: New York
COUNTY: Tioga
OPERATOR: Arlington Exploration
FIELD: Cafferty Hill

SURVEY: API 31-107-17788
LOCATION: 42° 07' 30", 76° 05' 5490 ' FN, 7550' FEL
WELL: Genn O. Tiffany #1
AREA:

KB: 1149 **Gr. Level** 1140 **Spud:** 8/17/82 **Comp:** 12/19/82 **TD:** 4453 **Form:**

Casing: 8 5/8" - 511' 150 sx, 4 1/2"- 4448 - 430 sx

Perforations: 4280-4390 ' - 9 MCFPD

Core Report

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Synch.				Shows or Remarks
Alluvium		0						
Genesee Shale		30	1119					
Tully LS		2638	-1489	71				
Hamilton Shale		2709	-1560					
Pyritic shale		4287	-3138					
Cherry Valley Lime		4317	-3168					
Marcellus Shale		4328	-3179					
Onondaga Limestone		4409	-3260					
Needmore Shale								
Oriskany Sandstone								
Helderberg Limestone								
Silurian								
Derivative Interval #1								

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-21378
COUNTY:	Tioga	**LOCATION:**	42° 15' 00", 76° 25' 12700 ' FS, 10100' FWL
OPERATOR:	Fault Line Oil	**WELL:**	Spencer et al Unit #1
FIELD:	Wildcat	**AREA:**	

KB:	1109	**Gr. Level**	1100	**Spud:**	10/3/90	**Comp:**	10/6/90	**TD:**	3246	**Form:**	

Casing: 8 5/8" - 336'

Perforations:

Core Report

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Synch.				Shows or Remarks
Alluvium		0						
Genesee Shale		4	1105					
Tully LS		1740	-631	80				
Hamilton Shale		1820	-711					
Pyritic shale								
Cherry Valley Lime		2940	-1831					
Marcellus Shale		2986	-1877					
Onondaga Limestone		3040	-1931					
Needmore Shale		3115	-2006					
Oriskany Sandstone		3200	-2091	25				
Helderberg Limestone		3225	-2116					
Silurian		3574	-2465					
Derivative Interval #1				634				

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-21349
COUNTY:	Tioga	**LOCATION:**	42° 12' 30", 76° 30' 3400 ' FN, 6500' FEL
OPERATOR:	Fault Line Oil	**WELL:**	Van Riper Unit #1
FIELD:	Wildcat	**AREA:**	

KB: 1059 **Gr. Level** 1050 **Spud:** 8/28/90 **Comp:** 9/5/90 **TD:** 3293 **Form:**

Casing: 8 5/8" - 344', 185 sx

Perforations:

Core Report

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Synch.				Shows or Remarks
Alluvium		0						
Genesee Shale		21	1038					
Tully LS		1710	-651	90				
Hamilton Shale		1800	-741					
Pyritic shale								
Cherry Valley Lime		2912	-1853					
Marcellus Shale		2940	-1881					
Onondaga Limestone		3014	-1955					
Needmore Shale		3120	-2061					
Oriskany Sandstone		3172	-2113	18				
Helderberg Limestone		3190	-2131					
Silurian		3539	-2480					
Derivative Interval #1				627				

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	
COUNTY:	Tioga	**LOCATION:**	42° 05', 76° 01' 100 ' FS, 11,000' FWL
OPERATOR:	Dwight D. Decker	**WELL:**	Decker #1
FIELD:	Wildcat	**AREA:**	

KB:		**Gr. Level**		**Spud:**	8/31/97	**Comp:**	13/31	**TD:**		**Form:**	

Casing:

Perforations:

Core Report

Formation Tests Well Abandoned

Formation Name	**Oper. Tops**	**Log Tops**	**Datum**	**Synch.**				**Shows or Remarks**
Alluvium						No Tops reported		
Genesee Shale								
Tully LS								
Hamilton Shale								
Pyritic shale								
Cherry Valley Lime								
Marcellus Shale								
Onondaga Limestone								
Needmore Shale								
Oriskany Sandstone								
Helderberg Limestone								
Silurian								
Derivative Interval #1								

Remarks:

WELL REPORT

STATE: New York
COUNTY: Tioga
OPERATOR: Sawyer
FIELD: Wildcat

SURVEY:
LOCATION:
WELL: Sawyer #1
AREA:

KB: **Gr. Level** **Spud:** 3/3/09 **Comp:** **TD:** 1350 **Form:**

Casing:

Perforations:

Core Report

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Synch.				Shows or Remarks
Alluvium						No Tops reported		
Genesee Shale								
Tully LS								
Hamilton Shale								
Pyritic shale								
Cherry Valley Lime								
Marcellus Shale								
Onondaga Limestone								
Needmore Shale								
Oriskany Sandstone								
Helderberg Limestone								
Silurian								
Derivative Interval #1								

Remarks: No information available

WELL REPORT

STATE: New York
COUNTY: Tioga
OPERATOR: New York State Natural Gas
FIELD: Wildcat

SURVEY: API 31-107-00007
LOCATION: 42° 15', 76° 25' 10100 ' FN, 900' FEL
WELL: W.E. Stevens #1
AREA:

KB: 970 **Gr. Level** 960 **Spud:** 3/17/47 **Comp:** 5/28/47 **TD:** 3150 **Form:**

Casing: 13 3/8" 22', 10" 73' , 8 5/8" - 840'

Perforations:

Core Report

Formation Tests Reported show of gas @ 3059' reported show @ 263' and 270'

Formation Name	Oper. Tops	Log Tops	Datum	Synch.				Shows or Remarks
Alluvium		0						
Genesee Shale								
Tully LS		1544	-574	80				
Hamilton Shale		1624	-654					
Pyritic shale								
Cherry Valley Lime								
Marcellus Shale								
Onondaga Limestone		2994	-2024					
Needmore Shale								
Oriskany Sandstone		3046	-2076					
Helderberg Limestone								
Silurian								
Derivative Interval #1								

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-20425
COUNTY:	Tioga	**LOCATION:**	42° 07' 30', 76° 10' 500 ' FN, 7750' FEL
OPERATOR:	Quaker State	**WELL:**	Robinson #1
FIELD:	Wildcat	**AREA:**	

KB: 1350 **Gr. Level** 1340 **Spud:** 11/17/86 **Comp:** 12/1/86 **TD:** 5266 **Form:**

Casing: 16'/8" 64', 11 3/4" 417' 275 sx, 8 5/8" - 1164', 50 sx

Perforations: D & A

Core Report

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Synch.				Shows or Remarks
Alluvium		0						
Genesee Shale								
Tully LS		2873	-1523	66				
Hamilton Shale		2939	-1589					
Pyritic shale		4410	-3060					
Cherry Valley Lime		4449	-3099					
Marcellus Shale		4461	-3111					
Onondaga Limestone		4543	-3193					
Needmore Shale		4601	-3251					
Oriskany Sandstone		4630	-3280	120				
Helderberg Limestone		4750	-3400					
Silurian		5099	-3749					
Derivative Interval #1				650				

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-107-09557
COUNTY:	Tioga	**LOCATION:**	42° 10', 76° 20' 7510 ' FN, 1070' FEL
OPERATOR:	Shell Oil Company	**WELL:**	Klasner #1
FIELD:	Wildcat	**AREA:**	

KB:	1501.5	**Gr. Level**	1485	**Spud:**	4/16/73	**Comp:**	5/7/79	**TD:**	5140	**Form:**	

Casing: 16" 54', 8 5/8" - 1585', 925 sx

Perforations:

Core Report

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Synch.				Shows or Remarks
Alluvium		0						
Genesee Shale								
Tully LS		2720	-1218.5	105				
Hamilton Shale		2825	-1323.5					
Pyritic shale		4200	-2698.5					
Cherry Valley Lime		4258	-2756.5					
Marcellus Shale		4269	-2767.5					
Onondaga Limestone		4351	-2849.5					
Needmore Shale		4434	-2932.5					
Oriskany Sandstone		4500	-2998.5	190				
Helderberg Limestone		4690	-3188.5					
Silurian		5018	-3516.5					
Derivative Interval #1				760				

Remarks:

WELL REPORT

STATE: New York
COUNTY: Tioga
OPERATOR: Shell Oil Company
FIELD: Wildcat

SURVEY: API 31-107-09848
LOCATION: 42° 05', 76° 25' 2720 ' FS, 9600' FWL
WELL: F. Robinson Unit #1
AREA:

KB: 1309 **Gr. Level** 1292 **Spud:** 5/22/73 **Comp:** 6/3/73 **TD:** 6220 **Form:**

Casing: 16" @ 54', 8 5/8" 1600', 600 sx

Perforations: D & A

Core Report

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Synch.				Shows or Remarks
Alluvium		0						
Genesee Shale								
Tully LS		2721	-1412	114				
Hamilton Shale		2835	-1526					
Pyritic shale		4028	-2719					
Cherry Valley Lime		4118	-2809					
Marcellus Shale		4134	-2825					
Onondaga Limestone		4195	-2886					
Needmore Shale								
Oriskany Sandstone		4278	-2969	123				
Helderberg Limestone		4401	-3092					
Silurian		4770	-3461	652				
Derivative Interval #1								

Remarks:

WELL REPORT

STATE: New York
COUNTY: Tioga
OPERATOR: Susquehanna Natural Gas
FIELD: Wildcat

SURVEY: API 31-107-00006
LOCATION: 42° 05', 76° 15' 200 ' FS, 5900' FEL
WELL: K. Pompelly #1
AREA:

KB: 927 **Gr. Level** 917 **Spud:** 1/1/31 **Comp:** 1/1/31 **TD:** 4130 **Form:**

Casing: 8 1/2" 4101

Perforations:

Core Report

Formation Tests Cored Oriskany - rec' 8 ft of Oriskany Sand dry

Formation Name	Oper. Tops	Log Tops	Datum	Synch.				Shows or Remarks
Alluvium		0						
Genesee Shale		500	427					
Tully LS		2264	-1337	66				
Hamilton Shale		2330	-1403					
Pyritic shale								
Cherry Valley Lime		3765	-2838					
Marcellus Shale		3778	-2851					
Onondaga Limestone		3904	-2977					
Needmore Shale		3953	-3026					
Oriskany Sandstone		4023	-3096	78				
Helderberg Limestone		4101	-3174					
Silurian		4450						
Derivative Interval #1				685				

Remarks: Original Operator - American Canadian Utilities #1

WELL REPORT

STATE: New York
COUNTY: Tioga
OPERATOR: Tioga Utilities
FIELD: Wildcat

SURVEY:
LOCATION:
WELL: C. Miller #1
AREA:

KB: 1030 **Gr. Level** 1020 **Spud:** **Comp:** 11/1/31 **TD:** 4360 **Form:**

Casing: 10" 24', 8 1/4" - 560', 6 5/8" 1065'

Perforations:

Core Report

Formation Tests

Formation Name	Oper. Tops	Log Tops	Datum	Synch.				Shows or Remarks
Alluvium		0						
Genesee Shale								
Tully LS		2100	-1070	45				
Hamilton Shale		2145	-1115					
Pyritic shale								
Cherry Valley Lime								
Marcellus Shale		3120	-2090					
Onondaga Limestone								
Needmore Shale								
Oriskany Sandstone		3390	-2360					
Helderberg Limestone								
Silurian								
Derivative Interval #1								

Remarks: In "blue shale" at 3,300 feet

Appendix D - WELL DATA RECORDS, SULLIVAN AND ULSTER COUNTY

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-105-12861-0000
COUNTY:	Sullivan	**LOCATION:**	41°45', 74° 40' ,13100' FNL, 3950' FEL
OPERATOR:	Gulf Oil Corporation	**WELL:**	F.E. O'Donnell
FIELD:	Wildcat	**AREA:**	

KB:	1575	**Gr. Level**	1564	**Spud:**	9/27/77	**Comp:**	10/28/77	**TD:**	8275	**Form:**	Oriskany

Casing: 20" 121', 13 3/8", 1835' w 975 sx

Perforations: None

Core Report:
6640-6690' core 50' recovered, Marcellus
7200-7246' Core, 45' recovered, Onondaga

Formation Tests: None

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Catskill Group		1852	-277					
Genesee Gp.		2323	-748					
Gilboa Formation		5470	-3895	144				
Hamilton Shale		5614	-4039					
Cherry Valley Lime		7075	-5500	123				
Marcellus Shale		7198	-5623					
Onondaga Limestone		7589	-6014	201				
Needmore Shale		7790	-6215					
Oriskany Sandstone		8013	-6438	96				
Helderberg Limestone		8109	-6534	91				
Silurian		8200	-6625					
Derivative Interval #1					1125			

Remarks:

WELL REPORT

STATE: New York
COUNTY: Sullivan
OPERATOR: Texas Eastern Transmission
FIELD: Wildcat

SURVEY: API 31-105-04000-000
LOCATION: 41°55', 74° 50' ,1850' FNL, 11500' FEL
WELL: Shandalee Hunting Club #1
AREA:

KB: 1815 **Gr. Level** 1803 **Spud:** 8/23/71 **Comp:** 12/31/71 **TD:** 9993 **Form:**

Casing: 16" 20', 7 5/8", 8297'

Perforations: 7892-8116' - 80 shots, 7614-7692' - 124 shots, 7216-7226' 48 shots

Core Report Not reported

Formation Tests 7892-8116' Acid recovered, no gas, no fluid, 7614-7692', Acid recovered, no gas no fluid, 7216-7226', Acid, no gas, no fluid, 7016-7114' acid, no gas, no fluid

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Devonian		0						
Gilboa Formation		5934	-4119	76				
Hamilton Shale		6010	-4195					
Cherry Valley Lime		7007	-5192	69				
Marcellus Shale		7076	-5261					
Onondaga Limestone		7222	-5407	220				
Needmore Shale		7442	-5627					
Seneca		7687	-5872					
Oriskany Sandstone		7893	-6078	110				
Helderberg Limestone		8003	-6188	125				
Silurian		8128	-6313					
Manlius *		8157	-6342					
Camillus *		8370	-6555					
Vernon *		8810	-6995					
Oneida *		9668	-7853					
Martinsburg *		9961	-8146					
Derivative Interval #1					1121			

Remarks:

WELL REPORT

STATE:	New York	**SURVEY:**	API 31-111-00005-000
COUNTY:	Ulster	**LOCATION:**	42°05', 74° 25' ,6200' FSL, 8800' FWL
OPERATOR:	Dome Oil and Gas Company	**WELL:**	#1 A. Herdman
FIELD:	Wildcat	**AREA:**	Shandaken Twp.

KB:	1285	**Gr. Level**	1270	**Spud:**	1/1/53	**Comp:**	6/1/55	**TD:**	6400	**Form:**	Normanskill

Casing:

Perforations:

Core Report

Formation Tests 5350' - 50 mcfpd, show of gas

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Devonian		0						
Gilboa Formation		1698	-413	152				
Hamilton Shale		1850	-565					
Cherry Valley Lime		4956	-3671	45				
Marcellus Shale		5001	-3716					
Onondaga Limestone		5200	-3915	150				
Needmore Shale		5350	-4065					
Oriskany Sandstone		5580	-4295	260				
Helderberg Limestone		5840	-4555	170				
Silurian		6010	-4725					
Normanskil		6340	-5055					
Derivative Interval #1					1054			

Remarks:

WELL REPORT

STATE: New York
COUNTY: Ulster
OPERATOR: Mid-Hudson Dome Oil and Gas Company
FIELD: Wildcat

SURVEY: API 31-111-00007-000
LOCATION: 42°05', 74° 30' ,10650' FSL, 9350' FEL
WELL: #1 G. Armstrong
AREA:

KB: 1965 **Gr. Level** 1940 **Spud:** 1/1/57 **Comp:** 12/31/57 **TD:** 3809 **Form:**

Casing: 10 3/4" 97', 8 5/8", 987'

Perforations: Not reported

Core Report Not reported

Formation Tests Not reported

Formation Name	Oper. Tops	Log Tops	Datum	Thickness	Synch.			Shows or Remarks
Devonian		0						

Remarks: Well starts in Lakawaxen Shale (Chemung Group Equivalent) and TD's in Manorkill or Mahantango Formation (Genesee Equivalent)