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EVALUATION OF THE OHIO VALLEY REGION BASAL SANDSTONE AS A WASTEWATER INJECTION INTERVAL

Prepared by the Geological Surveys of Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania and West Virginia, and the Department of Geological Engineering, University of Missouri — Rolla.

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OHIO RIVER VALLEY WATER SANITATION COMMISSION

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WATER RESOURCES DIVISION, U. S. GEOLOGICAL SURVEY

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SUMMARY

ORSANCO involvement in the study of underground wastewater injection began in 1967 and, during 1967-1973 resulted in the publication of two reports documenting the findings of that period. They were "Perspective on the Regulation of Underground Injection of Wastewater" and "Underground Injection of Wastewaters in the Ohio Valley Region." Whereas the previous efforts were directed toward policy and administrative procedures, the present study describes regional characteristics and utilization potentials. These efforts are directed to form a basis for location, design and engineering of wastewater wells in the basal Cambrian age sandstone units.

The present project produced a series of geologic and physical characteristic maps and geologic cross sections that have been formulated from a large number of observations and measurements made in wells throughout the Ohio Valley. Data used in preparation of the maps and cross sections are included in tables.

The mapping revealed that basal sandstone is present throughout the Ohio Valley region, with the exception of small areas where it was never deposited. It lies at the base of the stratigraphic sequence and is not exposed at the surface anywhere within the region. This vertical location in combination with the lack of usable resources contained in the basal sandstone cause it to be favorable for wastewater injection. Only in northern Illinois, where it contains fresh water, and in the few localities where gas is stored or hydrocarbons have been found, is the basal sandstone precluded for wastewater injection because of its value for other uses.

In addition to the restrictions mentioned above, the basal sandstone is too deep for practical consideration in southern Illinois and Indiana, in most of Pennsylvania and West Virginia, and in southern New York. Zones of major faulting in southern Illinois and Indiana and across Kentucky considerably restrict the potential for injection in those areas. Occasional major faults that require consideration are also present at a few other locations in the region.

The reservoir properties of thickness, porosity and permeability, and areal extent determine the quality of a rock unit for wastewater injection. The wide areal extent of the basal sandstone has been mentioned. Generally, the other properties are present in the most favorable combination in northeast Illinois and northwest Indiana and become less favorable eastward and southward from that area. This does not eliminate locations other than northern Illinois and Indiana from consideration, but it does suggest caution in selecting the basal sandstone as a potential injection interval throughout the rest of the region.

Vertical confinement of injected wastewater is necessary to prevent its escape from the injection interval and entering fresh-water aquifers or strata containing valuable mineral deposits of stored gas. Because the basal sandstone is underlain by Pre-Cambrian age crystalline rock, downward migration is not possible. The basal sandstone is overlain by several hundred feet of shale and siltstone with varying percentages of sandstone and carbonate throughout most of Illinois and Indiana and in western Ohio. Although local confirmation is always necessary, for preliminary purposes, the basal sandstone would be considered suitably confined in these areas. Elsewhere, the degree of confinement, though possibly adequate, is less certain before drilling and testing have been accomplished.

Earthquake history in an area must be considered because an earthquake might potentially damage injection well facilities or alter geohydrologic conditions. In addition, it is now believed possible to stimulate seismic activity by fluid injection and the susceptibility of an area to such induced seismic events should be examined. Within and near the Ohio Valley region, two localities stand out as having been affected by significant earthquakes during recorded time. These areas include extreme southern Illinois, adjacent western Kentucky and western New York.

Evaluation of the possible effect of earthquakes on wastewater injection operations and the relation between wastewater injection and earthquake stimulation is less certain than reservoir evaluation because of the limited experiences in this technology. However, the generalization can be made that extra precautions should be taken in system construction and operation in areas of high seismic risk and that care should be exercised in injection operations sited near faults which could be the source of earthquake generation.

C O N T E N T S

ILLUSTRATIONS

TABLES

INTRODUCTION

ORSANCO involvement in underground wastewater injection began in 1967 at the initiation of Dr. Edward J. Cleary, then Executive Director and Chief Engineer at ORSANCO. This first effort culminated in 1969 with the publication of the report "Perspective on the Regulation of Underground Injection of Wastewaters" (Cleary and Warner, 1969). A recommendation of this report was that an ORSANCO committee be formed to develop policy guidelines, regulatory procedures and technical criteria pertaining to underground injection of wastewaters in the Ohio Valley. The Commission adopted this recommendation and the Advisory Committee on Underground Injection of Wastewaters was organized. The report of that committee was submitted to the Commission in late 1972 and the committee's policy recommendations were adopted by the Commission in January, 1973. This policy statement and the regulatory guidelines and technical criteria to support it are contained in the publication "Underground Injection of Wastewaters in the Ohio Valley Region" (ORSANCO, 1973).

Upon completion of its original assignment, the Advisory Committee on Underground Injection of Wastewaters considered how it might further contribute to the advancement of the technology in the area of its responsibility. A possible project, the detailed delineation of the geologic and engineering potential of the basal Cambrian age sandstone unit for wastewater injection, was selected and a proposal for this project developed. All state geological agencies of the ORSANCO states expressed their willingness to participate in the study, with technical corrdination to be provided by Dr. D. L. Warner of the University of Missouri, Rolla. Under ORSANCO's sponsorship, a proposal for the project was submitted to the U. S. Geological Survey in order to obtain the funds necessary to defray expenses for travel, meetings, and report preparation and publication. The project was funded by the U.S.G.S., and work began early in 1974.

The broad objective of the project was the determination, in as much detail as possible, of the geological and utilization characteristics of the basal sandstone for wastewater injection in the Ohio Valley area. This interval was selected for study because it was generally known to have many of the characteristics favorable for use as an injection in a number of locations, and because it could be anticipated that there would be an interest in using it more extensively for this pupose in the future. A further reason for selecting the basal sandstone for study was the fact that it is present throughout most of the Ohio Valley area and would, therefore, present maximum opportunity for cooperative study among the ORSANCO states.

At a meeting of the Committee on Underground Injection of Wastewater, the detailed objectives of the present study were established and the procedures for their accomplishment agreed on. During the study, some minor adjustments in the original plan were made. The actual scope of the study as it has been completed is reflected by the list of maps, cross sections and tables.

The data for maps 1-4, 8, and 9 were obtained by the Geological Surveys of each of the participating states and, where enough points were available, state maps were drawn by the respective agencies. The data and maps were supplied to the University of Missouri, where they were compiled to form the regional maps presented here. Maps 5-7 were prepared at the University of Missouri, using data supplied by the states and well logs obtained from commercial suppliers. Map 10 is the same map that was used in previous ORSANCO (1973) report. The cross sections were prepared by the respective state agencies.

Each of the maps and the cross sections will be discussed individually and their significance for underground wastewater injection planning and regulation analyzed.

DEFINITION OF THE

THE BASAL SANDSTONE

For this study, an unusual geologic procedure was followed in that the rock unit being mapped is not a conventional geologic formation. Rather, it is a hydrogeologic or engineering unit equivalent in character to an aquifer or petroleum reservoir.

The relationships of the geologic formations that comprise the basal sandstone unit in four of the Ohio Valley states and in three other adjacent states are shown in Figure 1. In Figure 1, the basal sandstone includes the Mt. Simon Sandstone and sandstones in the lower Eau Claire Formation in Illinois, Indiana, Kentucky and Ohio.

The Mt. Simon Sandstone consists principally of fine- to coarse-grained sandstone. It is commonly poorly sorted and contains conglomeritic zones. Cross bedding is often visible in cores. It ranges in color from clear in quartzose portions to pink in the arkosic intervals. It may be only slightly cemented and friable or silica cemented and very hard. Although the formation is primarily sandstone, shale beds are often present, particularly near the top or the base. These beds are from a few inches to more than 50 feet thick. Generally, the Mt. Simon Sandstone rests unconformably on Precambrian age igneous or metamorphic rocks, but some geologists have recognized a so-called "granite wash" unit below the Mt. Simon; and, it has been interpreted that the Mt. Simon lies on older Cambrian or Precambrian age sandstones in some localities.

For the purpose of this report, all sandstones that rest upon the Precambrian basement are included with the basal sandstone. Its upward extent is determined by the point at which it becomes overlain by more than about 100 feet of rocks that are dominantly (>50%) siltstone, shale, or carbonate, as determined by examination of cores, cuttings, and geophysical logs. Formations comprising the basal sandstone in western Ohio are the same as in eastern Indiana, but toward central Ohio a sandstone facies of the Rome Formation in combination with the Mt. Simon Formation forms the basal sandstone. In Pennsylvania, the basal sandstone is known as the Gatesburg Formation. In New York, the Potsdam and lower Galway (or Theresa) Formations comprise the basal sandstone. The West Virginia Geological Survey designated the basal sandstone as the Mt. Simon in this study, but other terminology has been used previously.

MAP PRESENTATIONS

Well Locations

The locations of wells penetrating the basal sandstone in the Ohio Valley region and used in this study are shown in Map 1, and data for these wells are given in Tables 1-7. Information in the tables includes: the well operator and well name; year completed; location; reference elevation (at or near ground surface); total depth; well status; available logs; availability of water and core analyses; depth, thickness, and characteristics of the confining unit and basal sandstone; and depth of the Precambrian basement. The wells in each state are numbered consecutively and the well number appears in Map 1. Locations of the cross sections are also shown.

In addition to the locations, the purpose for which each well was constructed is shown by symbol. From this information, it is possible to infer the extent of potential conflicts between wastewater injection and other uses, including oil and gas production, natural gas storage, and water supply.

One of the outstanding characteristics of the basal sandstone for waste disposal is the relatively little use it receives for other purposes in the Ohio River Basin region. In northern Illinois, the basal sandstone is used for water supply. This is reflected by the numerous water supply wells shown in that area. Storage of natural gas is also practiced in northern and central Illinois and northwestern Indiana. More such storage areas will be developed, but they are limited to anticlinal structures and no appreciable quantity of the total subsurface volume will be consigned to this use. Exploration for oil and gas in the basal sandstone has proven to be disappointing and only six exploratory wells in the entire Ohio Valley area are known to have encountered significant amounts of hydrocarbons. Three wells in Illinois and two in Kentucky have encountered gas. One oil discovery has been drilled in Kentucky. These six wells are shown in Map 1.

Elevation of the Top of the Precambrian Basement Surface

Map 2 depicts the relief on the Precambrian basement surface. The reference datum is sea level. The contour interval is generally 1,000 feet. Some 500 foot contours appear in Illinois.

The map is used to estimate the total thickness of sedimentary rocks and unconsolidated deposits that are present at a location. This is done by determining the approximate ground surface elevation at the location, then adding this elevation to the subsea elevation of the Precambrian basement surface. In this case, the basal sandstone is the objective for injection purposes; therefore, this computation will yield the approximate total well depth if the entire formation is penetrated. Because of the large contour interval used, the estimate is obviously not a precise one, but it is sufficiently accurate for feasibility studies. It should be noted that the map is not equally reliable everywhere, because its reliability depends on the density of data. The relative reliability at any particular location, however, is easily determined by combined reference to the well location map and the data tables.

The map shows that the depth to the Precambrian surface is well within a reasonable drilling range of about 5,000 to 6,000 feet for a disposal well in much of Illinois, Indiana, Ohio, and Kentucky, but only in northern New York, Pennsylvania, and extreme western West Virginia is this true. In the central Illinois basin portion of Illinois and Indiana, the Precambrian surface is at depths of 12,000 to 15,000 feet and in the central Appalachian basin of Pennsylvania and West Virginia, depths rapidly reach beyond 12,000 feet and may ultimately reach more than 30,000 feet.

Faults that are known and are judged to be significant are also shown. Only representative faults are shown in southern Illinois, extreme southwestern Indiana, and central Kentucky, because there are too many to depict at the map scale used. A highly faulted mineralized area is shown in southeastern Illinois and western Kentucky, where geologic conditions are particularly complex. Faults affect the potential of a site for injection by complicating geologic conditions, by acting as possible flow barriers or conduits, and by creating planes of weakness along which tectonic stresses may be relieved, thus causing earthquakes. The latter topic will be discussed in greater detail later in this report.

Not all faults are of equal significance in evaluating the quality of a site and each case must be evaluated individually. However, the generalization can be made that the more extensive the faulting at a site, the less desirable the site is for an injection well because of the difficulty of predicting the fate of the injected waste.

Elevation of the Top of the Basal Sandstone

Elevation of the top of the basal sandstone is shown in Map 3. The reference datum is sea level. The contour interval is 1,000 feet.

When the ground surface elevation is known, the map can be used to estimate the depth to the top of the basal sandstone and thus the potential disposal interval. Depth to the basal sandstone ranges from less than 1,000 feet in northern Illinois to more than 13,000 feet in the center of the Illinois basin. Depth to the basal sandstone rapidly increases to beyond 12,000 feet in the Appalachian basin of Pennsylvania and West Virginia. Generally, potential of the basal sandstone for injection becomes very limited at a depth greater than about 5,000 to 6,000 feet because of well construction costs. Its potential is also limited where it is very near the surface, because it may contain fresh water and is less well confined than where it is more deeply buried.

Several areas are shown where the basal sandstone is absent. This probably occurred because such areas were topographically high, perhaps islands, during the deposition of the sandstone. As it is necessary for a well to strike these areas before they are known to exist, only a few of these have been identified. It is, therefore, reasonable to expect that the basal sandstone is absent from more portions of the Ohio Valley area than are indicated in Map 3.

Thickness of the Basal

Sandstone

The thickness of the basal sandstone and throughout the Ohio River Valley is shown (in May 4) by contours of equal sandstone thickness (Map 4) (isopach map). The contour interval ranges from 50 to 500 feet, depending on the total sandstone thickness in the area. The basal sandstone reaches a maximum thickness of more than 2,500 feet in northeastern Illinois, but it thins in all directions from there. Thinning results both from lack of deposition of sediment and from lateral change from sandstone to shale or dolomite. The basal sandstone is completely absent north of the zero isopach line in extreme northern New York. It is also known to be absent in several local areas as previously mentioned and as is shown in Map 4.

The thickness of the basal sandstone is an important factor in determining its adequacy as an injection interval. If other characteristics are equal, the thicker it is, the greater the volume of wastewater it can accept without the development of excess pressure. Also, the rate of lateral spread of waste away from the injection well is inversely related to the thickness of the reservoir.

Porosity and Permeability of the Basal Sandstone

Porosity is the volume of pores in a rock divided by the total rock volume. It is expressed either as a ratio or a percent. Porosities of over 35 percent are found in newly deposited sands, while porosities of less than 5 percent occur in lithified, well-cemented sandstones. Dense limestones and dolomites may have almost no porosity. Porosity is not a measure of the fluid transporting capability of a rock, but a sandstone with high porosity is a better reservoir than one with low porosity, because the greater the amount of pore space the smaller the radius to which the injected waste will spread.

Porosity can be determined by laboratory analysis of core samples obtained during drilling and by examination of borehole geophysical logs run in drilled wells. Where core analysis data were available, as indicated in Tables 1 to 7, they were used, checked, and supplemented by log examination. In wells where core samples were not taken, log examination was performed and, if the logs were believed to be reliable, average porosity values were determined. Map 5 was constructed by contouring the average porosities (in percent) obtained from laboratory and log data. Average porosities ranged from slightly over 20 percent to less than 5 percent. Whereas a porosity of over 20 percent is very good for a lithified sandstone, a porosity of less than 5 percent is very poor. Although Map 5 should not be relied upon too heavily, it does show trends in porosity useful for judging the probable quality of the basal sandstone as a disposal reservoir. These trends will be interpreted in combination with other reservoir properties.

It should be mentioned that average porosity values were used for some Illinois wells which only partially penetrate the basal sandstone. Before using figures from these, a comparison was made between average values for the upper part of the basal sandstone and vaules for the entire unit in fully penetrating, nearby wells. It was found, in the cases examined, that sampling of the upper several hundred feet would yield values representative of the entire unit. An additional important consideration is that, where the basal sandstone is more than several hundred feet thick, significant zones with good porosity may occur even where the average porosity of the total unit is fair or poor.

Permeability is the capacity of a porous medium to transmit a fluid. The unit of permeability used in evaluating deep aquifers is the darcy. Because most deep aquifers have permeabilities of much less than a darcy, the millidarcy (0.001 darcy) is most frequently reported. Permeability can be evaluated by core analysis and formation testing. Log analysis can sometimes be used also, but was not attempted in this study because of its relative unreliability. Most of the available permeability values were from gas storage fields in Illinois. A few values were also obtained from wastewater disposal wells in Illinois and other states, but too few were available for preparation of a contour map. Therefore, the individual values are listed in the tables, but not shown on a map. For wastewater injection, permeabilities of more than 100 millidarcys are very good, those of 10 to 100 millidarcys fair to good, those of less than 10 millidarcys indicate a relatively poor reservoir, and of less than 0.1 millidarcy, an aquiclude. A thick sandstone, like a porous one, can have poor average permeability, but may still be an adequate reservoir, if it has a few good permeability zones.

Most of the available permeability values are for the upper 100 to 300 feet of the basal sandstone. As with porosity, it is believed that an average for the upper part of the basal sandstone is representative of the entire unit, but this assumption may not always be valid. Examination of Table 1 shows that the average permeabilities of the basal sandstone in Illinois are quite variable, ranging from a low of 15 millidarcys to a high of 185 millidarcys, values which would be categorized as fair to good. As indicated in the table, some of these values are average for an entire gas storage field, which causes them to be unusually reliable.

The basal sandstone in two waste disposal wells in northwestern Indiana has exceptional permeability (300 to 420 millidarcys), but the basal sandstone in a third disposal will in the same area has only fair permeability (45 millidarcys).

Values were obtained for only three other wells in Indiana and these wells are located along the eastern border. The values are 48, 13, and 11 millidarcys (Table 2).

Permeability values were obtained for the basal sandstone in five Ohio disposal wells that penetrate the basal sandstone and for one oil and gas exploration well (Table 5). The high value was 80 millidarcys in one of the Vistron Company wells and the low value was 11.6 millidarcys in the Calhio Chemical Company well.

Only three additional permeability values were obtained for the basal sandstone in the Ohio Valley area. These were 230 millidarcys for the Hammermill Paper Company well in Pennsylvania (Table 6) and 113 and 7 millidarcys respectively for the Bethlehem Steel Company and Hooker Chemical Company wells in New York (Table 4).

In summary, average permeabilities for 37 wells or gas storage fields were obtained. These ranged from a high of 420 millidarcys to a low of 7. No obvious pattern of permeability distribution could be deduced from this small number of values.

Pore Volume and Flow Capacity of the Basal Sandstone

The average porosity multiplied by the total thickness of sandstone yields the pore volume. This number provides a means of readily comparing the storage capacity of a formation at various locations. In Map 6, an isoval map, equal values of sandstone pore volume have been contoured. No criteria have been developed, however, for classification of the quality of a reservoir based on its pore volume. Such a classification may not be possible, because a thick sandstone with a low porosity can have the same pore volume as a thinner sandstone with a high pore volume yet the reservoirs will not be of equal quality for injection purposes. Nevertheless, a reservoir with a high pore volume will generally be of better quality than a reservoir with a low pore volume.

The pattern in Map 6 shows that the greatest reservoir volumes are present in northeastern Illinois, where the basal sandstone is thickest (Map 4) and where it also has the highest average porosity (Map 5). In areas of west-central Ohio and everywhere east of central Ohio, pore volumes of less than 10 prevail. These have only one-thirtieth the volume available to a well in northeastern Illinois. As discussed above, these values do not provide an absolute measure of reservoir quality, but they do indicate that the basal sandstone of northern Illinois and Indiana and western Ohio is much more promising than it is elsewhere in the Ohio Valley area. The values shown in Map 6 can be directly entered into equations that require a porosity-foot term, e.g., equations for distance of waste travel and pressure buildup during injection.

Perhaps the most significant measure of the quality of the basal sandstone as a disposal reservoir is its flow capacity[1], which is its average permeability multiplied by the effective thickness of sandstone. Although flow capacity values are not given, they can easily be obtained by multiplying the average permeabilities in the data tables by the total thickness of basal sandstone and the sandstone percent, which are also in the tables. Although the

[1]Flow capacity (permeability x thickness) is similar to, but not exactly the same as transmissivity (hydraulic conductivity x thickness). Flow capacity is a property of the aquifer only, whereas transmissivity considers the density and viscosity of the aquifer water as well.

average permeability of the basal sandstone in northern Illinois and Indiana is clearly not always higher than in other areas, the thickness of the unit is so much greater there than elsewhere that its flow capacity will be many times greater than elsewhere in the region. The highest value for the region can be calculated to be about 92 darcy-feet for the U.S. Steel well in northern Indiana, and the lowest, 0.65 darcy-feet for the Hooker Chemical Company well in New York.

Salinity of Water in the Basal Sandstone

Evaluation of injection feasibility includes consideration of the 1) salinity, 2) density, 3) chemistry of the formation water. This may also be a factor in designing a waste pretreatment plan and in predicting the extent and direction of travel of injected wastes.

Tables 8-12 contain values of total dissolved solids content and density that were collected or determined during the study. Water for analysis was collected by well operators during well construction by means of drill stem testing or swabbing (a form of pumping). The values from water analyses were obtained through laboratory determinations of both total dissolved solids and density. The results from logs are based almost entirely on resistivities from induction logs. No other electric log was found to be usable in the Ohio Valley area. Accurate conversion from resistivity to dissolved solids requires a knowledge of the ionic composition of a water. During this study, it was assumed that the waters were sodium chloride solutions, an assumption that was considered sufficiently accurate in view of other inherent limitations in well log analysis. Data obtained by water analysis are not always reliable either, given the difficulty of obtaining representative and uncontaiminated samples. Whenever possible, comparisons made of the results of the two methods were consistent enough to give confidence in the general reliability of the data in Tables 8-12. However, it should be realized that any particular value may be subject to considerable error. Confidence in a particular value is greatest where several consistent values are given for the same well, where several wells that are in the same vicinity yielded approximately the same values, and where both laboratory and log analyses are given. Confidence is least where log analysis alone was possible, where values in a particular well differ considerably, and where only one well is present or values in nearby wells differ considerably.

Map 7 is a contour map of equal total dissolved solids content (isocon map) for water in the upper 100 feet of the basal sandstone. This was used for comparison because it normally has the lowest salinity of water at any level in the formation, thus making it controlling for injection purposes, and because more analyses and logs were available for this interval than for any other.

Map 7 shows that in the Ohio Valley states the basal sandstone contains very saline water except in northern Illinois and possibly near fault zones in southern Kentucky. It was known that water in the basal sandstone is generally saline, but the areal variation in salinity had previously been determined only in Illinois, and even in that state, the data given are now more extensive than previously reported. Within the region, values range from fresh potable water in northern Illinois to water with a total dissolved solids content of 300,000 mg/l which is about 30 percent. No state or Federal agency has suggested that waters with dissolved solids contents greater than 10,000 mg/l need be protected for water supply purposes; injection is therefore not precluded by that factor except in the limited areas mentioned.

During injection, if the injected water is less dense than the formation water, the injected water will tend to flow updip as a wedge. If the opposite is true, flow will be downdip. While this is not significant in most cases, it would have to be taken into account where the extent of spread of an injected waste is considered important. In such a case, adjustment of waste density to that of the formation fluid might be contemplated, or, as has been suggested, the waste might be made more dense than the formation fluid and injected into a synclinal area where it would tend to be trapped.

In addition to lateral variation in formation water salinity, there is considerable vertical variation, as can be seen by examination of the data in Tables 8-12. In general, salinities increase with increasing depth, but reversals in this pattern can be found. The apparent reversals that are shown are all the result of log interpretation; none that are shown are confirmed by water analysis. The fact that water of varying salinity occurs within the basal sandstone is evidence that vertical flow is restricted even within that unit. This is favorable for disposal because it suggests that wastewater flow may be restricted in the same way.

Thickness of the Confining Unit

The characteristics of the confining units are also important to the suitability of a potential disposal interval. It is essential that injected waste be prevented from escaping from the basal sandstone and entering fresh-water aquifers or strata containing minerals or stored gas. Because the basal sandstone is underlain by Precambrian age crystalline rock, downward migration is not possible. In various portions of the Ohio Valley area, the basal sandstone is immediately overlain by shale, by siltstone, or by carbonates (dolomite or limestone). Map 8 shows, by contours of equal thickness, the amount of shale and siltstone that directly overlies the basal sandstone.

Where a sufficient thickness of unfractured shale or siltstone is present, it is probable that injected waste would be completely confined to the basal sandstone. While it is not possible to state exactly what constitutes a sufficient thickness of shale or siltstone without performing an engineering analysis of the particular injection program, it can be calculated that, under typical circumstances, approximately 50 years would be required for any waste to migrate through a 100 foot shale or siltstone confining bed. In most cases an injection well will have been shut down and all driving pressure will have been dissipated before 50 years have passed, so that the waste would never have reached the top of the confining bed. This calculation indicates that 100 feet of shale or siltstone should provide adequate confinement in most cases. A lesser amount may be sufficient in some instances and a greater amount required in others. It should be noted that, by virtue of its position at the base of the stratigraphic sequence, several thousand feet of beds containing no usable resources will often overlie the basal sandstone and that absolute confinement to the immediate basal sandstone may not be necessary.

Where dolomite or limestone immediately overlie the basal sandstone, no confining unit is shown to be present for two reasons. First, where carbonates are present over the basal sandstone in the Ohio Valley, there is commonly a very substantial thickness, perhaps interbedded with minor sandstone and shale. This makes definition of the boundaries of the confining unit difficult. Second, it it not possible to assume that all limestones or dolomites will act as aquicludes. In many cases they will, but in others they are porous and permeable, thus acting as aquifers. Therefore, when limestones or dolomites immediately overlie the basal sandstone, their confining properties must be locally determined by examination of geologic and engineering information obtained during drilling and testing of any proposed disposal well. This should also be done when shales or siltstones are present, but considerable confidence in these lithologies has already been established because a number of gas storage fields have been developed and operated in Illinois and Indiana, demonstrating the capability of the shale and siltstone units overlying the basal sandstone to provide confinement for injected fluids.

Ratio of Lithologies in the Confining Unit

As previously discussed, a characteristic which may influence the effectiveness of a waste confining unit is its lithology. It has already been established that only within the limits shown in Map 8 is a confining unit accepted as being present. It is within these limits that the basal sandstone is directly overlain by shale and siltstone. However, even within the area where a shale and siltstone unit is present, the lithology is variable. By definition, geologists consider a rock that contains more than 50 percent clay- and silt-sized clastic grains to be shale and siltstone. A shale or siltstone may be composed entirely of such grains or may consist of only fifty-one percent. Without specific testing, a confining unit would be thought to be of better quality the greater the percent of shale and siltstone. Therefore, an estimate was made of the relative percents of shale and siltstone, sandstone, and carbonate that compose the confining unit.

Map 9 depicts the results of these estimates by use of a numerical rating scheme. In the areas assigned the number 1, the confining unit is greater than 79 percent shale and siltstone. In the areas designated 2 and 3, the confining unit is greater than 66 percent shale and siltstone. In area 2 the remaining 34 percent is predominantly sand and in area 3, predominantly carbonate. The same rationale applies to areas 4 and 5. Outside of the numbered areas, the rocks overlying the basal sandstone are predominantly carbonate or sandstone. Although these assigned numbers do not constitute a quantitative ranking, the confining unit in area 1 would be thought to be qualitatively superior to that unit in areas 2 and 3, and so forth. Furthermore, gradation into sandstone would be thought to be more detrimental to the quality of the confining unit than would gradation into carbonate.

It is apparent that the confining units in Northern Illinois and Indiana grade into sandstone and in southern Illinois and Indiana into carbonate. At the eastern boundary, in Ohio, there is a very rapid change from shale and siltstone to carbonate.

Zones of Seismic Risk and Earthquake Generation

The past history of earthquake activity in an area must be considered because an earthquake might potentially damage injection well facilities or alter geohydrologic conditions. In addition, it is now believed possible to stimulate seismic activity by fluid injection; thus, the susceptibility of an area to such induced seismic events should be examined.

Within and near the Ohio Valley region, two localities stand out as having been affected by significant earthquakes during recorded time. Three of the most intense earthquakes recorded in this country were centered near New Madrid, Missouri, and occurred in December 1811, and January and February 1812. All three of these earthquakes were of greater intensity than any that have occurred in California, the 1906 San Francisco earthquake included. A total area of at least 2,000,000 square miles was shaken and significant topographic changes occurred, including the formation of Reelfoot Lake, Tennessee. Because the epicenter area was largely a wilderness, few lives were lost. The area of southeast Missouri and portions of adjoining states are still active and more than one hundred earthquakes have been reported there since 1812.

An earthquake occurred November 9, 1968, near Broughton, Hamilton County, Illinois, about 100 miles northeast of the epicenter of the New Madrid earthquakes. The intensity was about 7 (modified Mercalli scale) as compared to an estimated intensity of 12 for the New Madrid earthquakes. These values are equivalent to 5.5 and 8.1 on the Richter scale. Reports from the oil and gas industry (Heigold, 1968) reveal that subsurface hydrologic changes and minor damage to well facilities occurred.

A second area in the Ohio Valley where relatively intense earthquakes have been recorded is in western New York. Here earthquakes with intensities of 8 were recorded in 1929 and 1944. These two earthquakes were centered near Attica and Massena, New York, respectively, and related changes in groundwater conditions reportedly occurred in 1929. A less intense 1966 earthquake was also centered near Attica, New York.

Data from the most recently published seismic risk map of the United States are reproduced in Map 10. These data agree with the above discussion and indicate a possibility of major earthquake damage in the extreme southeast and northeast portions of the Ohio Valley and of moderate to minor damage elsewhere in the area.

The first observation of an apparent relationship between fluid injection and seismic activity was made at the Rocky Mountain Arsenal injection well near Denver, Colorado in the early 1960's. Since that time, similar relationships have been documented at Rangely, Colorado, and Dale, New York. The former related to water injection for secondary recovery of oil and the latter to disposal of brine from solution mining of salt.

It has been erroneously stated by many that these seismic events have been stimulated by "lubrication" of a fault zone by injected fluids. What has happened, if injection has been involved, is that the water pressure on a fault plane has been increased, thus decreasing the friction on that plane and allowing movement and consequent release of stored seismic energy.

Based on this interpretation of the mechanism of earthquake triggering by fluid injection, the following conditions would necessarily be present for the earthquake to occur:

1. A fault with forces acting to cause movement of the blocks on either side of the fault plane, but which are being successfully resisted by frictional forces.
2. An injection well constructed close enough, vertically and horizontally, to the fault so that the fluid pressure changes caused by injection will be transmitted to the fault plane.
3. Injection at a sufficiently great rate and for a sufficiently long time to increase fluid pressure on the fault plane to the point that frictional forces resisting movement become less than the forces tending to cause movement. At this time movement will occur and stored seismic energy will be released. That is, an earthquake will occur.

There is no known precedent for regulatory policy and requirements that will take seismic risk and earthquake generation into account. Tentative suggestions are:

1. If possible, sites should be avoided where risk of major earthquake damage is possible, as suggested by Map 10;
2. Where a well is constructed in a zone of major or moderate seismic risk, special attention should be given to standby facilities;
3. In areas of major or moderate seismic risk, wells should not be constructed so that they pass through fault planes because of the danger of shifting along the fault plane during an earthquake and consequent possible damage to well casing;

4. When wells are constructed in the vicinity of a major fault or faults that could be a source of earthquake occurrence, injection pressures should be kept to a minimum and a seismic monitoring network should be considered to provide early warning by detection of initial minor movements.

DISCUSSION OF CROSS SECTIONS

Eight cross sections were prepared. The locations of the lines of cross section are given in Map 1. The purposes of the cross sections are to show lateral variations in the thickness and lithology of the basal sandstone and the immediately overlying strata and characteristic responses of these units in the various types of geophysical logs that are used. For convenience in showing these relations, the sections are drawn with the top of the Mt. Simon Sandstone as a horizontal datum. This is conventional practice with such illustrations, but it is misleading to those not familiar with construction of cross sections. Actually, the top of the Mt. Simon occurs at widely varying depths from well to well, as can be determined by observing the depth markings in the log of each well or by consulting the appropriate table among Tables 1-7. Each of the cross sections is briefly discussed below.

Illinois

Two cross sections were prepared for Illinois. In the east-west cross section across northern Illinois (Cross Section 1), the basal sandstone ranges in thickness from about 900 feet in Well No. 17 on the west side to about 2300 feet on the east side in Well No. 23. The 2300 feet of basal sandstone represents nearly the maximum thickness at any location in the Ohio Valley.

In this cross section, the basal sandstone is almost entirely sandstone, with a few scattered shale beds, mostly thin ones. The log of Well No. 21 clearly shows the difference between the Mt. Simon Sandstone, and the basal sandstone in northern Illinois. The Mt. Simon Sandstone includes the sandstones below 3110 feet, and the basal sandstone includes the sandstones and shales below 2900 feet. The confining unit is also very well displayed in the log of this well and, as the legend indicates, is principally shale and siltstone, with a few beds of sandstone and dolomite.

Cross Section 2 ranges from northeastern to southeastern Illinois. The northermost well, Well No. 3, was drilled for use as an injection well and would probably have been satisfactory for that purpose, except that the water in the upper part of the sandstone is fresh enough to be used for water supply. The sandstone in that well is thick, porous, and relatively free of shale. The basal sandstone thins progressively as it is traced southward from Well 35 to Well 22. This thinning is partly a result of the passage of sandstone to carbonate. It can be seen that carbonate is present in and above the confining unit in these wells.

Indiana

Cross Section 3 proceeds from west to east across northern Indiana from Well No. 9 to Well No. 60 in Mercer County, Ohio. The basal sandstone can be seen to grade upward into silstone and sandy dolomitic silstone in the logs of several of the wells. The contact between the basal sandstone and the confining unit is not clearly defined in these wells and was established by use of all available evidence as to the permeability of the beds. The lithology of the confining unit is also variable. In some wells, it is nearly all shale and silstone whereas in others it becomes dolomitic. As the cross section proceeds from the northern Illinois-Indiana area, where the basal sandstone reaches its maximum thickness, toward the east, it becomes progressively thinner and therefore has less reservoir capacity. Wells No. 9 and 15 are both being used successfully for injection into the basal sandstone.

The basal sandstone shows no major variation in thickness or lithologic character in the four wells in Cross Section 4, which progresses from north-central Indiana to northeast Kentucky. The confining unit also retains about the same thickness in these wells. It does exhibit some variation in dolomite and sandstone content, but this is probably not sufficient to be significant in determining its adequacy to provide waste confinement. The cross section terminates on the south with the E.I. DuPont disposal well in Jefferson County, Kentucky. It was originally intended to inject into the basal sandstone in this well, but it was found to be inadequate for accepting the waste volume produced by the plant; thus, a shallower zone was used.

The basal sandstone shows little variation in thickness or lithology as it is traced from northern Indiana to southern Indiana in Cross Section 5. The Cross Section proceeds along the eastern border of Indiana and terminates in western Kentucky with the DuPont well, which is also the southermost well in Cross Section 4. The basal sandstone is almost entirely sandstone and ranges from about 350 to 500 feet in thickness in the Indiana wells. It is about 800 feet thick in the DuPont well. The confining unit has, however, changed in character as it has been traced eastward and, while it is still shale and silstone, it has become dolomitic, as is shown in the logs of the Indiana wells in this cross section.

Ohio

Cross Section 6 begins on the west with Well No. 60, the extreme eastern well in Cross Section 3. From there it proceeds eastward across northern Ohio to Well No. 8, in extreme northeastern Ohio. Throughout this cross section, the basal sandstone and the Mt. Simon Sandstone are the same. The only variation in the basal sandstone in this figure is the progressive thinning from about 350 feet in the west to just over 100 in the east. However, the confining unit can be seen to pass by facies change from shale and silstone in the west to dolomite in the east. As previously discussed, dolomite may provide adequate confinement, but this must be verified locally.

Pennsylvania

Conditions shown by Cross Section 7, which is comprised by wells in northwest Pennsylvania, are little different from those in northeastern Ohio. The basal sandstone is thin and is overlain by dolomite and sandy dolomite. Well No. 3 is the now-abandoned disposal well of the Hammermill Paper Company. The basal sandstone (Mt. Simon Sandstone) was used in this well, in addition to other intervals, for waste injection.

West Virginia

Cross Section 8 proceeds northeastward through extreme western West Virginia and into southeastern Ohio. The basal sandstone in Cross Section 8 is thin, as it is in Cross Sections 6 and 7, but it becomes an even poorer reservoir because it is interbedded sandstone and carbonate with resultant probably low porosity and permeability. The basal sandstone is also overlain by carbonate strata in this cross section as in the previous two. It is noteworthy that the depths shown in the well logs suggest the unlikelyhood that the basal sandstone would be used for injection in this immediate area.

SUMMARY OF THE ADEQUACY OF THE BASAL SANDSTONE FOR WASTEWATER INJECTION

The data tables, maps, and cross sections, and the discussion of them provide a basis for the evaluation of the basal sandstone as an injection interval in the Ohio Valley region.

The basal sandstone is present throughout the Ohio Valley region, with the exception of areas where it was never deposited, some of which are shown in Map 3. It lies at the base of the stratigraphic sequence, on the Precambrian basement surface. This vertical location, in combination with the lack of usable resources found in the basal sandstone, cause it to be favorable for wastewater injection. Only in northern Illinois, where it contains fresh water, and in the few localities where gas is stored or hydrocarbons have been found is the basal sandstone precluded for wastewater injection because of its value for other uses. Such locations are indicated by the well symbols in Map 1.

Another restriction on the use of the basal sandstone for waste injection is indicated in Maps 2 and 3, which show that in southern Illinois and Indiana, in most of Pennsylvania and West Virginia, and in southern New York, the unit is too deep to be practical for wastewater injection. These maps also show the presence of zones of major faulting in southern Illinois and Indiana and across Kentucky, which considerably restrict the potential for injection in those areas. Occasional major faults that require consideration are also shown in other parts of the region.

The reservoir properties of thickness, porosity, and pore volume are shown in Maps 4, 5, and 6, and data on permeability are provided in Tables 1-7. Generally, the maps and tables show that the basal sandstone is most favorable for wastewater injection in northeast Illinois, and northwest Indiana, and that it becomes less favorable eastward and southward from those areas. Experience supports this conclusion, because wastewater injection and gas storage have been extensively and successfully practiced in northeast Illinois and northwest Indiana, while attempts in other areas have met with mixed results. This by no means eliminates from consideration locations other than northern Illinois and Indiana, but it does suggest caution in projecting the potential of wells throughout the rest of the region. Map 7 shows that, except for the areas north of the 10,000 mg/l isocon line in northern Illinois and perhaps near fault zones in other locations, there need be no concern with contamination of usable water in the basal sandstone.

Maps 8 and 9 show that the basal sandstone is directly overlain by several hundred feet of shale and siltstone with varying percentages of sandstone and carbonate throughout most of Illinois, Indiana, and in western Ohio. Although local confirmation is always necessary, for preliminary purposes, the basal sandstone would be considered suitably confined in these areas. Elsewhere, dolomite or limestone overlie the basal sandstone and the degree of confinement, though very possibly adequate, is less certain before drilling and testing has been accomplished.

Areas of relative seismic risk are shown in Map 10. Evaluation of the possible effect of earthquakes on wastewater injection operations and the relationship between wastewater injection and earthquake stimulation is less certain than reservoir evaluation because of limited experience in this technology. However, the generalization can be made that extra precautions should be taken in system construction and operation in areas of high seismic risk and that care should be exercised in injection operations that are sited near faults which could be the source of earthquake generation.

The cross sections provide a more graphic portrayal of the data presented in Maps 4, 8, and 9 and show the lithic variations occurring in the basal sandstone. They supplement the maps and data tables. In addition, the cross sections show the response of the units under study in the geophysical borehole logs typically used in the region.

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ABBREVIATIONS USED IN WELL DATA TABLES

KB	kelly bushing
DF	derrick floor
GL	ground level
TM	topographic map
ETM	estimated from topographic map
THL	
O/G ABD	drilled for oil or gas - abandoned
OIL	producing oil
GAS	producing gas
GAS STG	drilled and utilized for gas storage or storage field observation
GAS STG ABD	abandoned gas storage well
SWD	salt water disposal well
DISP	industrial disposal well
DISP ABD	abandoned industrial disposal well
WTR	water supply well
WTR ABD	abandoned water supply well
NI	not identified
ND	not determined
NP	not penetrated
i	incomplete section
(?)	information unknown or questionable
MD	millidarcys

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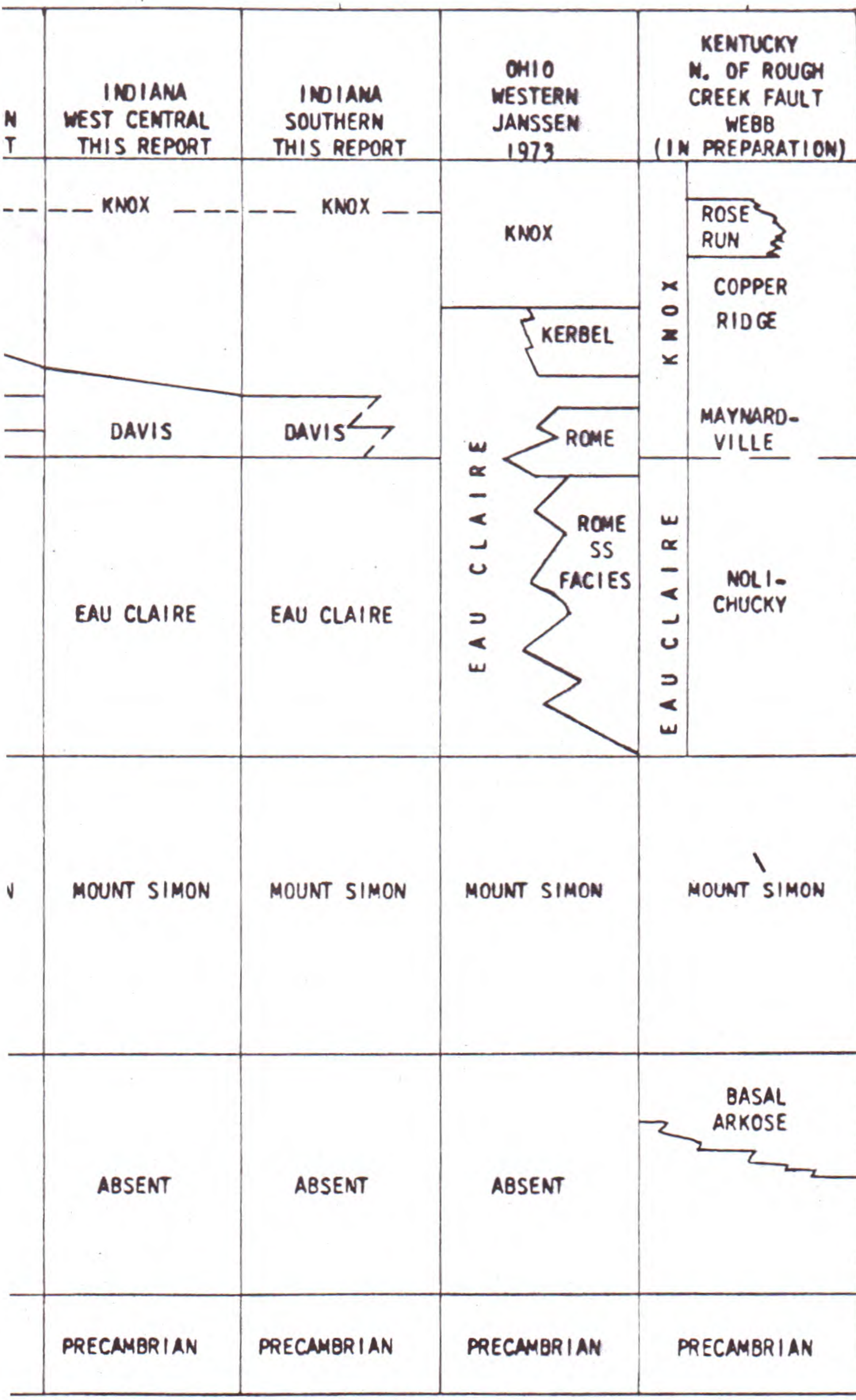
Francis A. Kohout, Project Officer

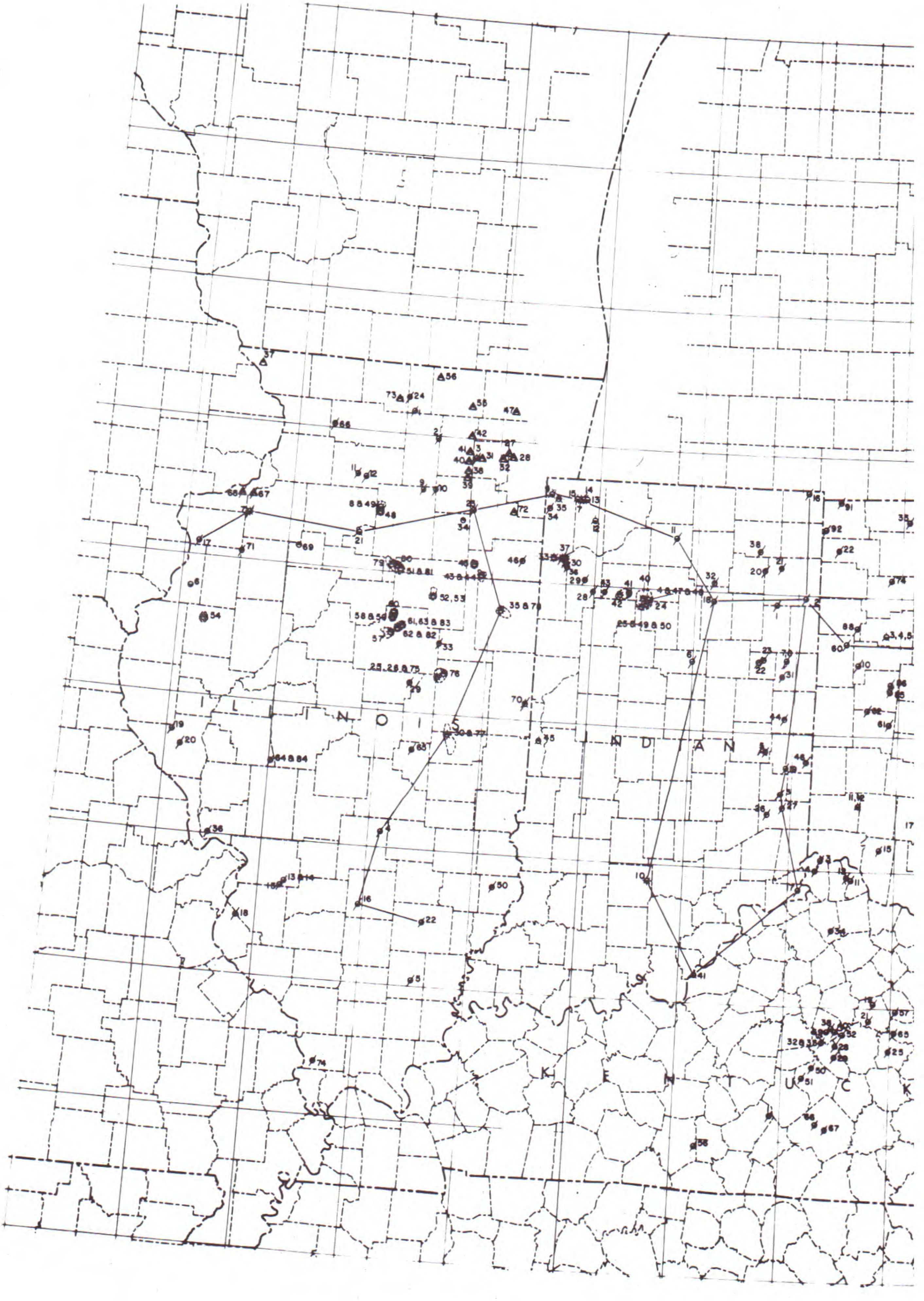
Leonard A. Wood, Project Officer

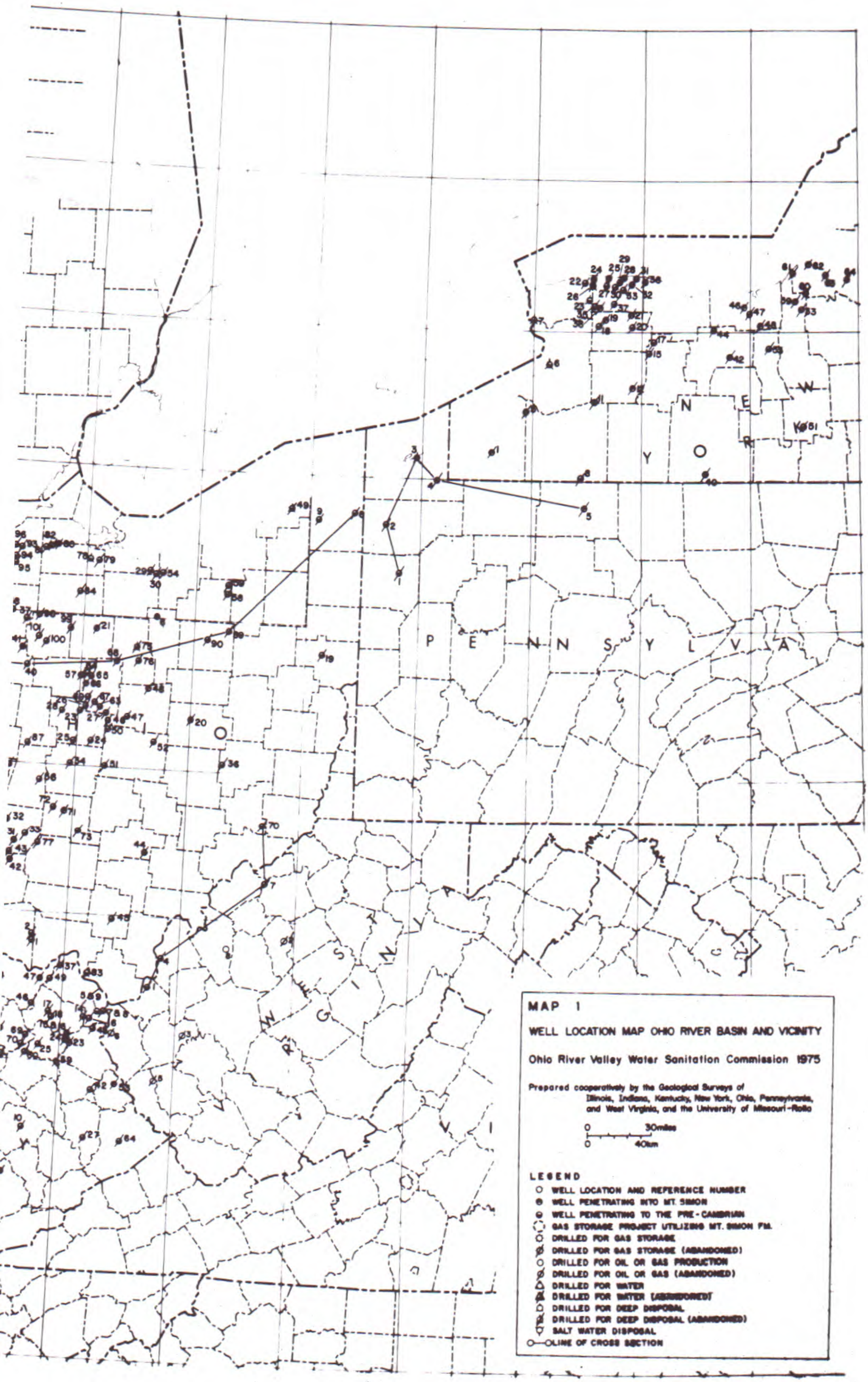
SYSTEM	SERIES	MISSOURI OZARK REGION HOWE, KURTZ, AND ANDERSON 1972		ILLINOIS NORTHEASTERN BUSCHBACH 1964		WISCONSIN WESTERN OSTROM 1966	MICHIGAN SOUTHWESTERN ELLS 1967	INDIAN NORTHWEST THIS REF
ORD.	CANA-DIAN	EMINENCE		GUNTER		ONEOTA	ONEOTA	KNOX
CAMBRIAN	ST. CROIXAN			EMINENCE		JORDON	EMINENCE	
		POTOSI		POTOSI		ST. LAWRENCE	POTOSI	
		ELVINS	DERBY DOERUN	FRANCONIA		MAZO-MANIE LONE ROCK	FRANCONIA	FRANCONI
			DAVIS	IRONTON		WONEWOC	IRONTON	IRONTO
				GALESVILLE			GALESVILLE	GALESVIL
		UPPER BONNETERRE		EAU CLAIRE	PROVISO	EAU CLAIRE	EAU CLAIRE	EAU CLAI
		BONNETERRE			LOMBARD			
		BASAL			ELMHURST			
		LAMOTTE		MOUNT SIMON		MOUNT SIMON	MOUNT SIMON	MOUNT SI
	?ALBERTAN			ABSENT		ABSENT	ABSENT	ABSENT
		PRECAMBRIAN		PRECAMBRIAN		PRECAMBRIAN	PRECAMBRIAN	PRECAMBRI

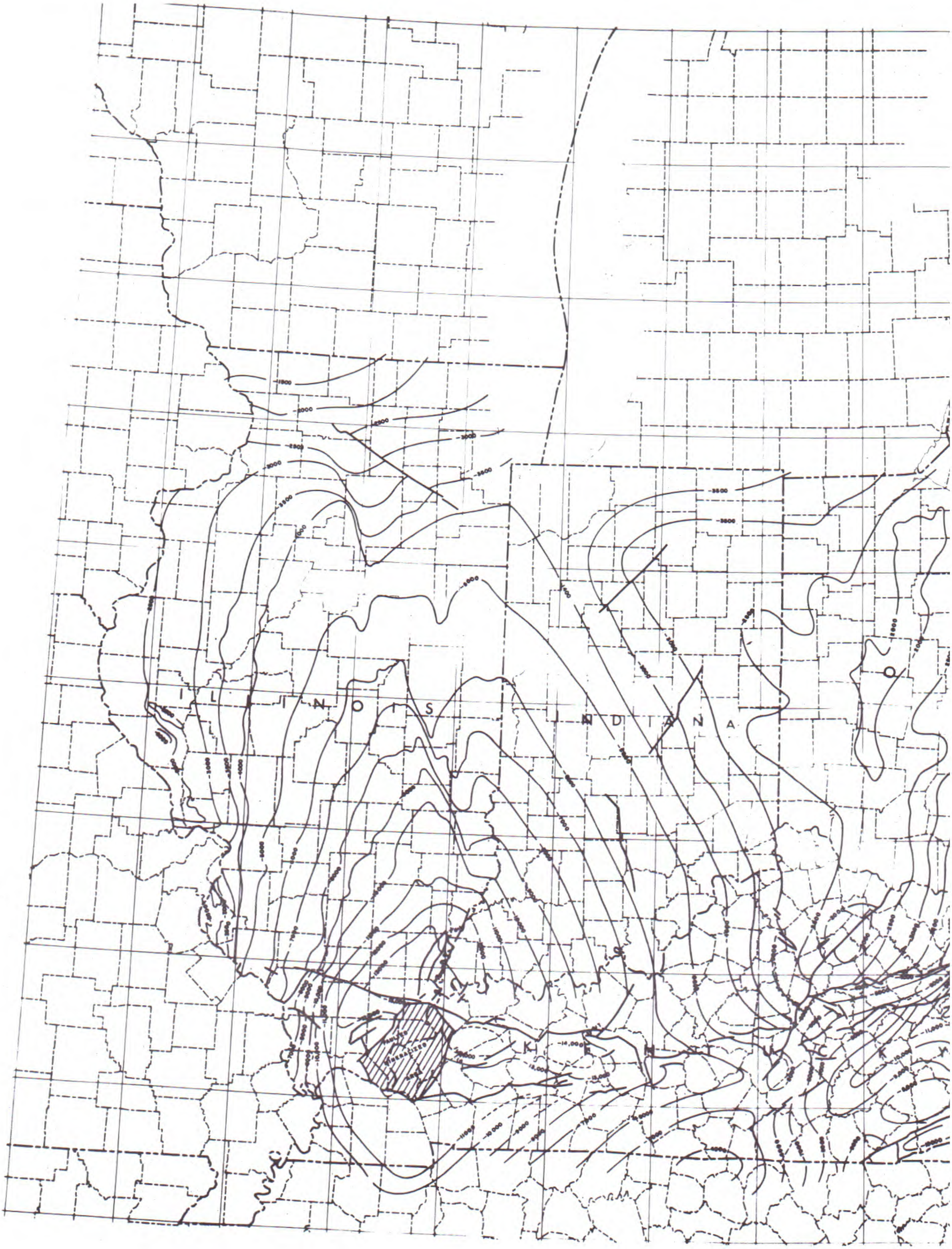
FIGURE 1. CORRELATION CHART OF CAMBRIAN ROCKS IN INDIANA AND ADJACENT
"PRE-KNOX (CAMBRIAN) STRATIGRAPHY IN INDIANA," BY LEROY E. B

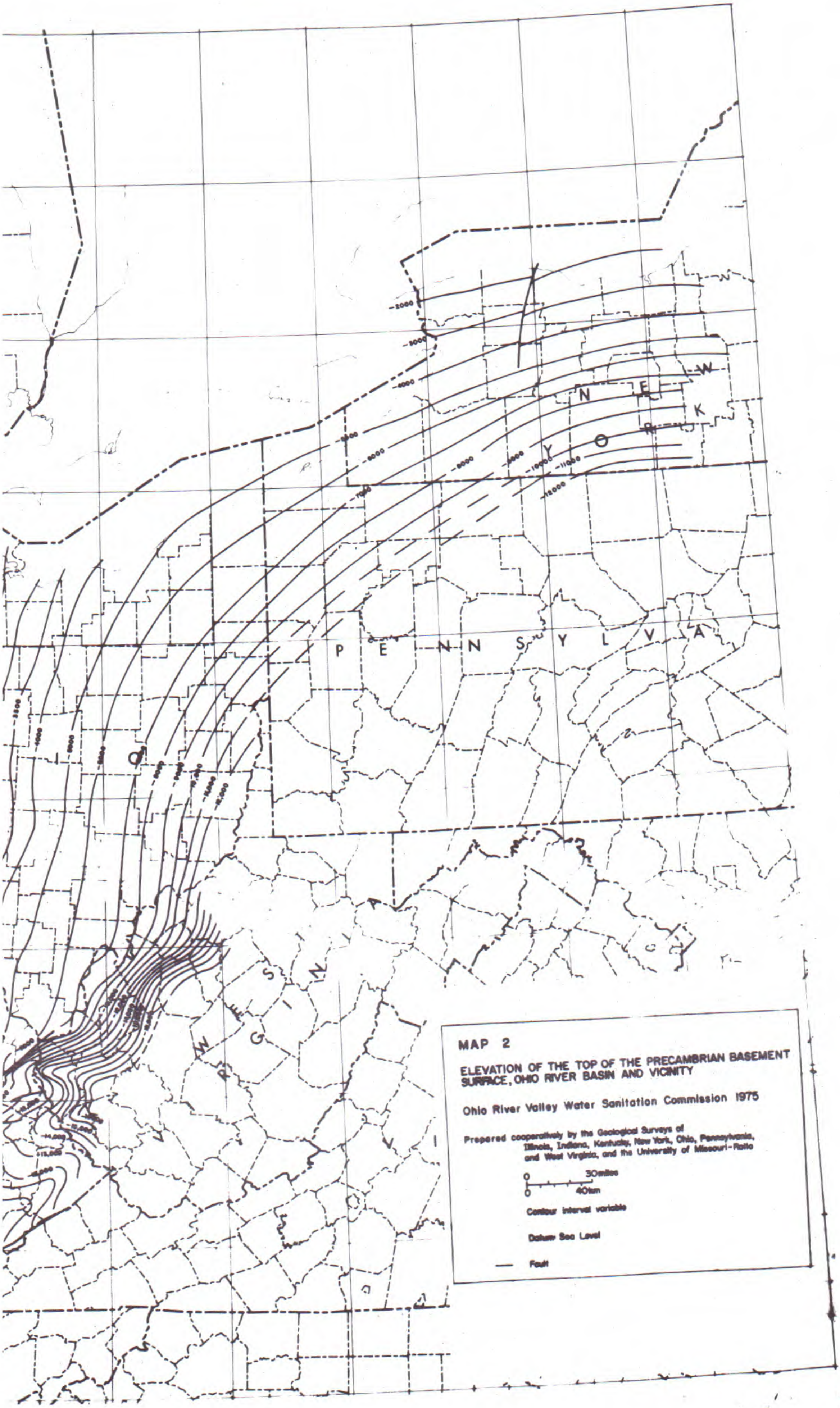


ATES. FROM INDIANA GEOLOGICAL SURVEY BULLETIN
KER, ANDREW J. HREHA, AND T. A. DAWSON, IN PREPARATION.

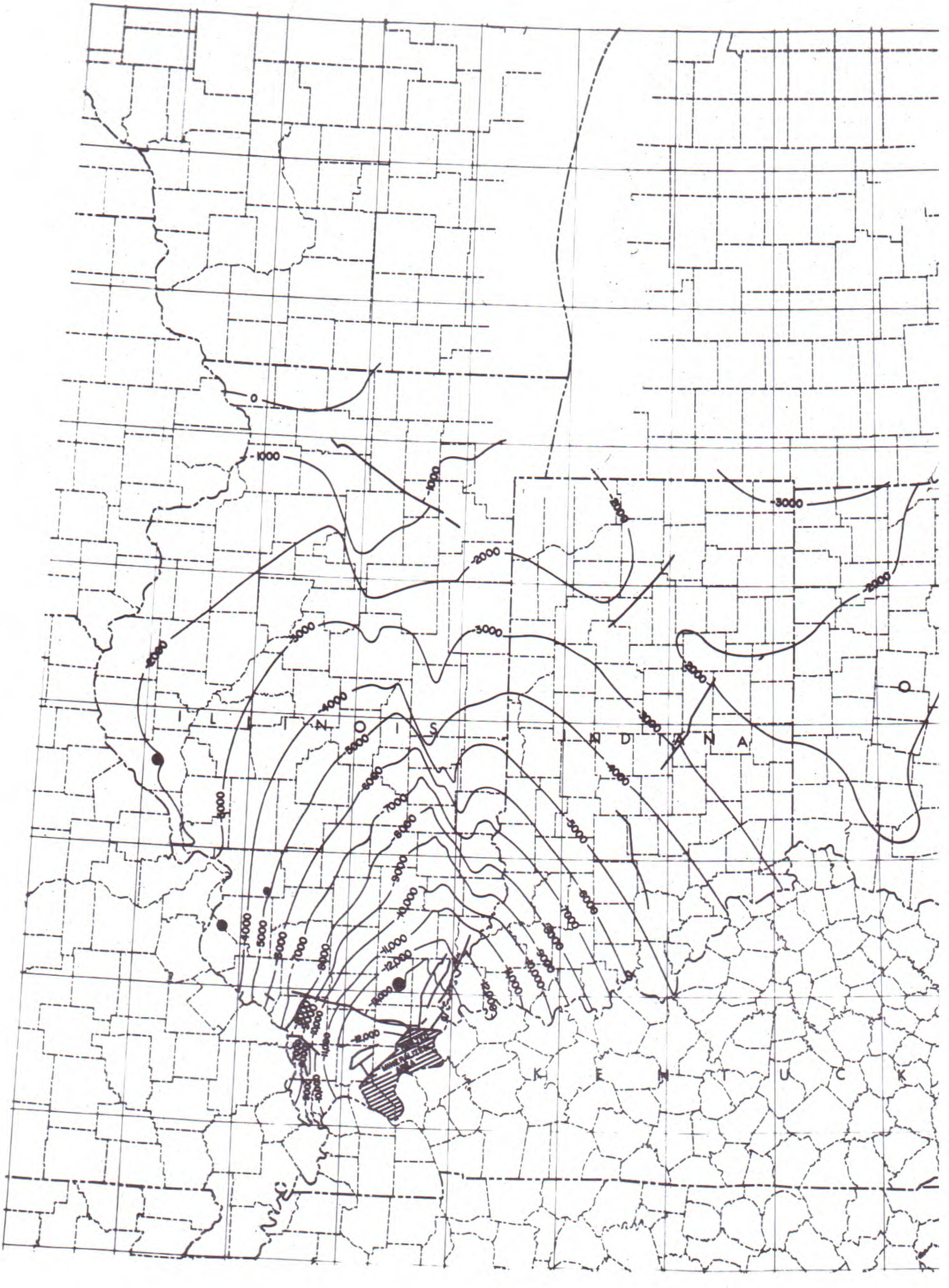

I L L I N O I S
I N D I A N A
K E N T U C K

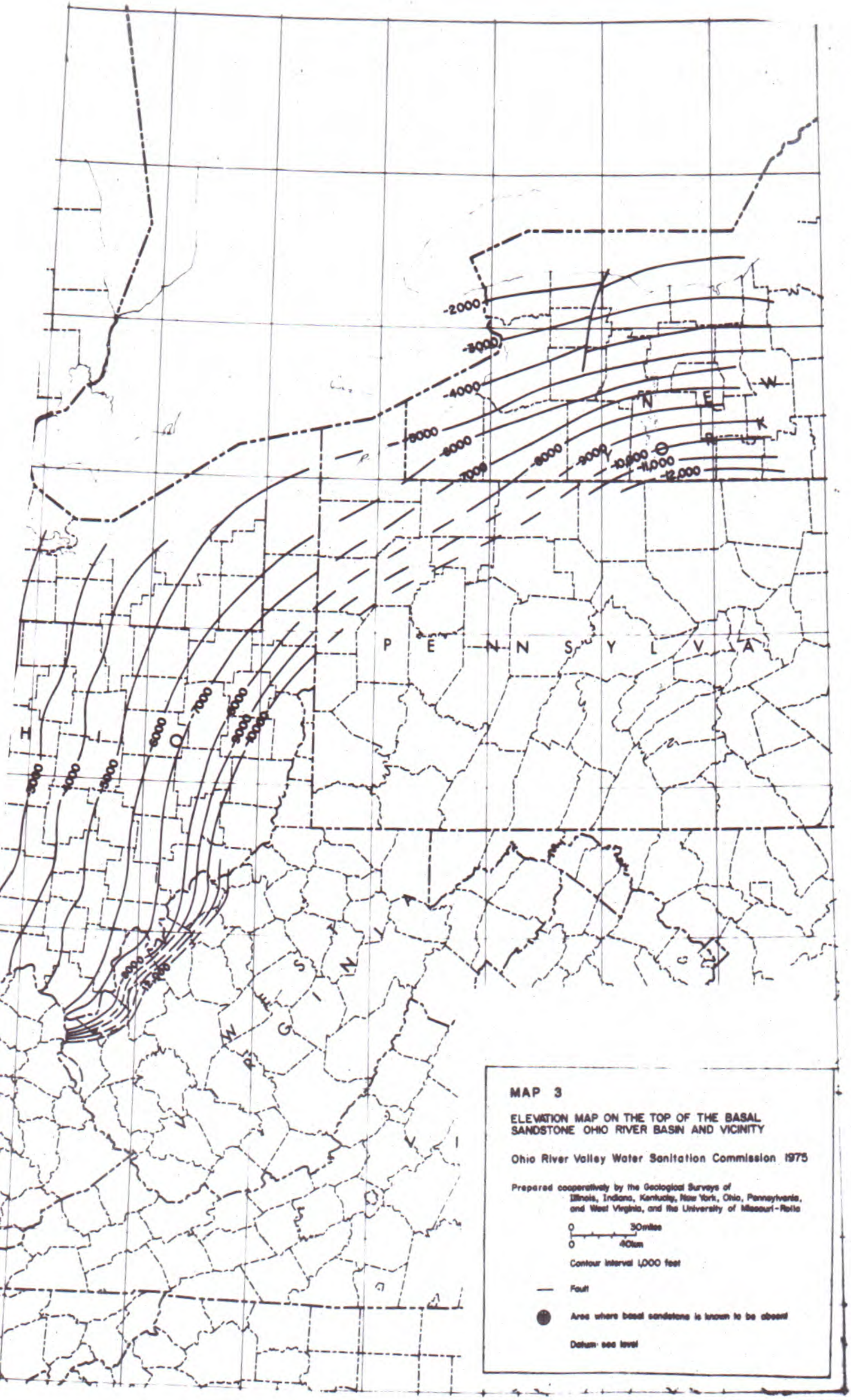

NEW YORK
PENNSYLVANIA
OHIO
WEST VIRGINIA
MAP 1
WELL LOCATION MAP OHIO RIVER BASIN AND VICINITY
Ohio River Valley Water Sanitation Commission 1975
Prepared cooperatively by the Geological Surveys of Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, and West Virginia, and the University of Missouri-Rolla
0 30miles
0 40km
LEGEND
WELL LOCATION AND REFERENCE NUMBER
WELL PENETRATING INTO MT. SIMON
WELL PENETRATING TO THE PRE-CAMBRIAN
GAS STORAGE PROJECT UTILIZING MT. SIMON FM.
DRILLED FOR GAS STORAGE
DRILLED FOR GAS STORAGE (ABANDONED)
DRILLED FOR OIL OR GAS PRODUCTION
DRILLED FOR OIL OR GAS (ABANDONED)
DRILLED FOR WATER
DRILLED FOR WATER (ABANDONED)
DRILLED FOR DEEP DISPOSAL
DRILLED FOR DEEP DISPOSAL (ABANDONED)
SALT WATER DISPOSAL
LINE OF CROSS SECTION

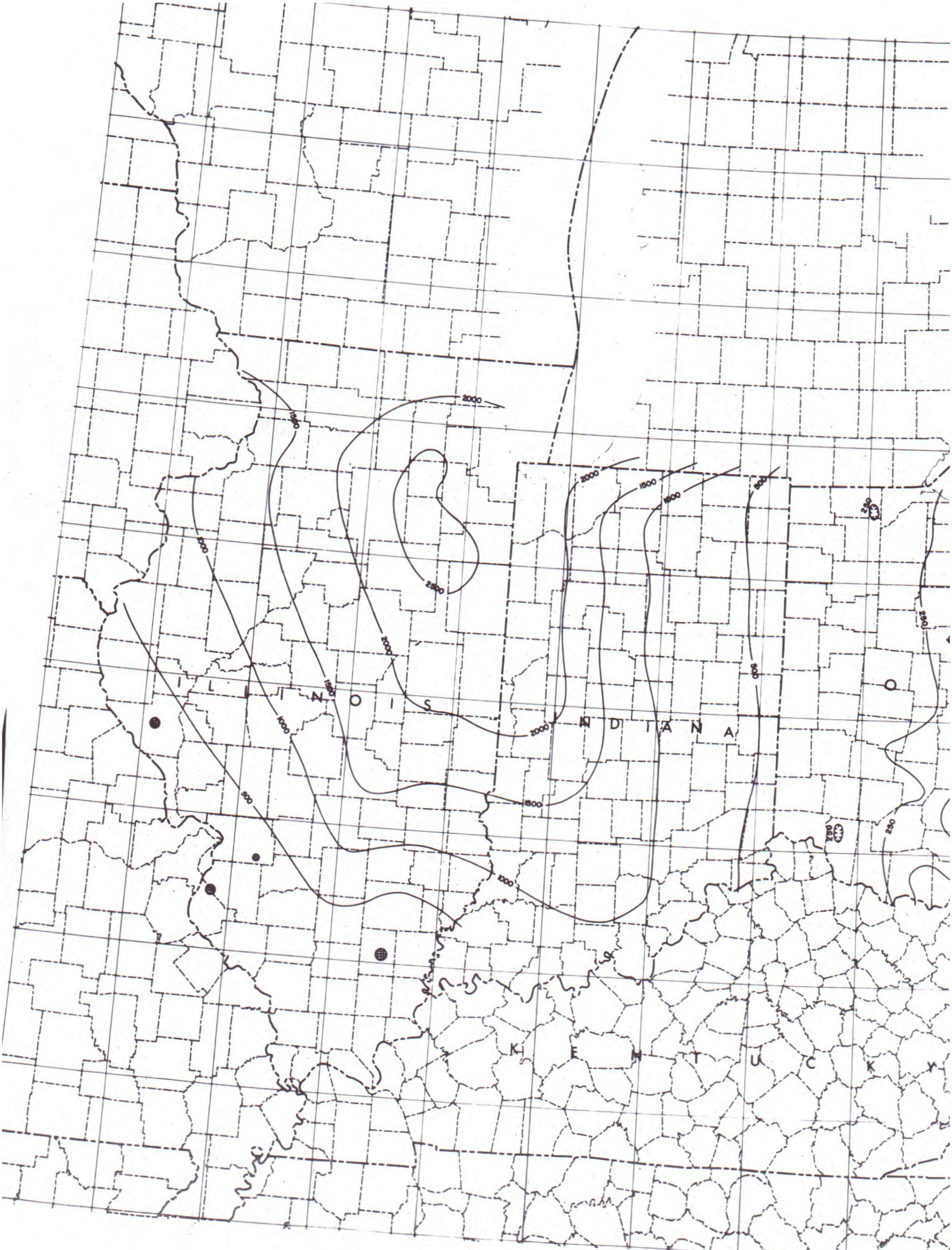

I L L I N O I S
I N D I A N A
O
K E N T U C K Y

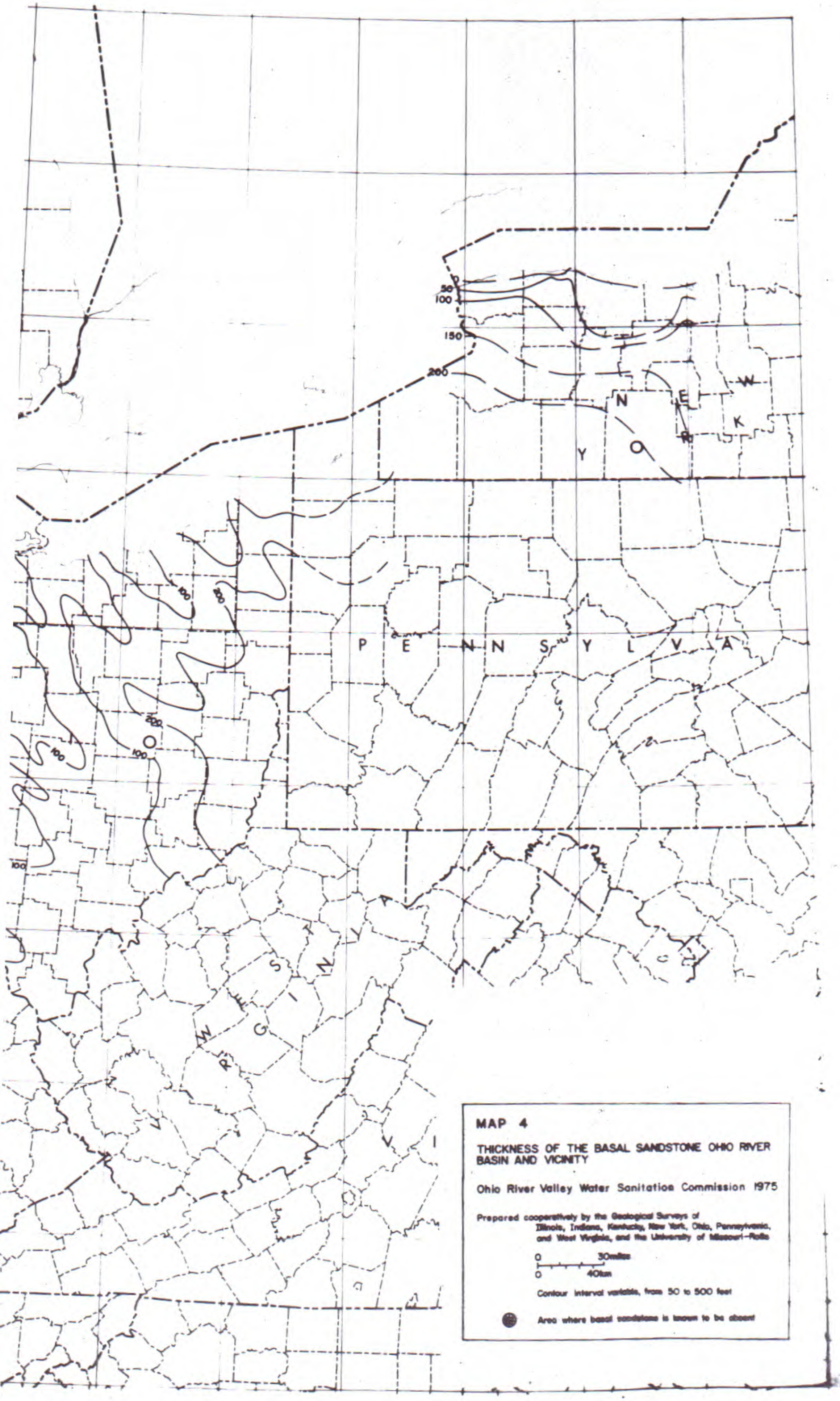


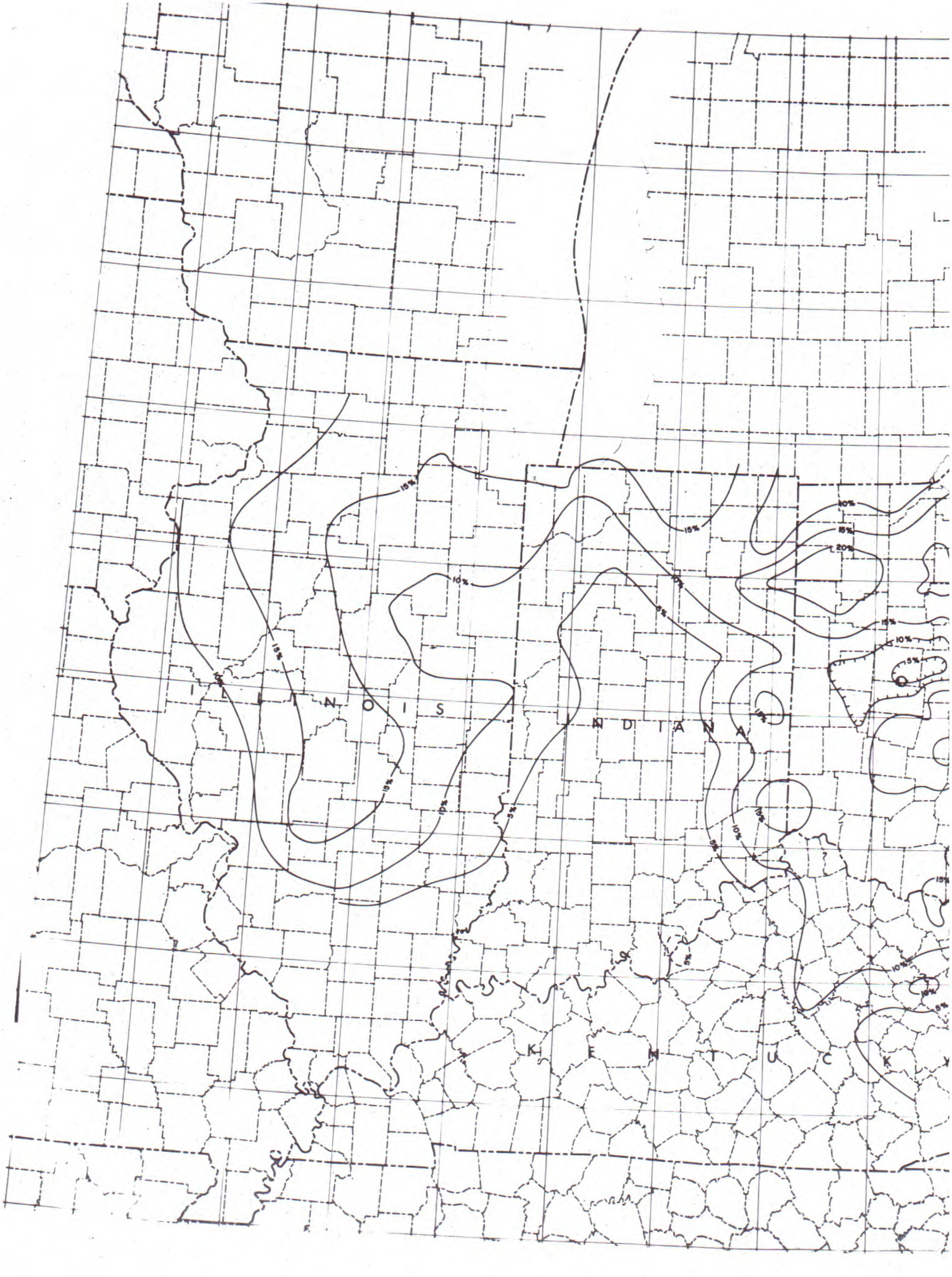
MAP 2
ELEVATION OF THE TOP OF THE PRECAMBRIAN BASEMENT SURFACE, OHIO RIVER BASIN AND VICINITY
Ohio River Valley Water Sanitation Commission 1975
Prepared cooperatively by the Geological Surveys of Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, and West Virginia, and the University of Missouri-Rolla
0 30 miles
0 40 km
Contour interval variable
Datum Sea Level
Fault
NEW YORK
PENNSYLVANIA

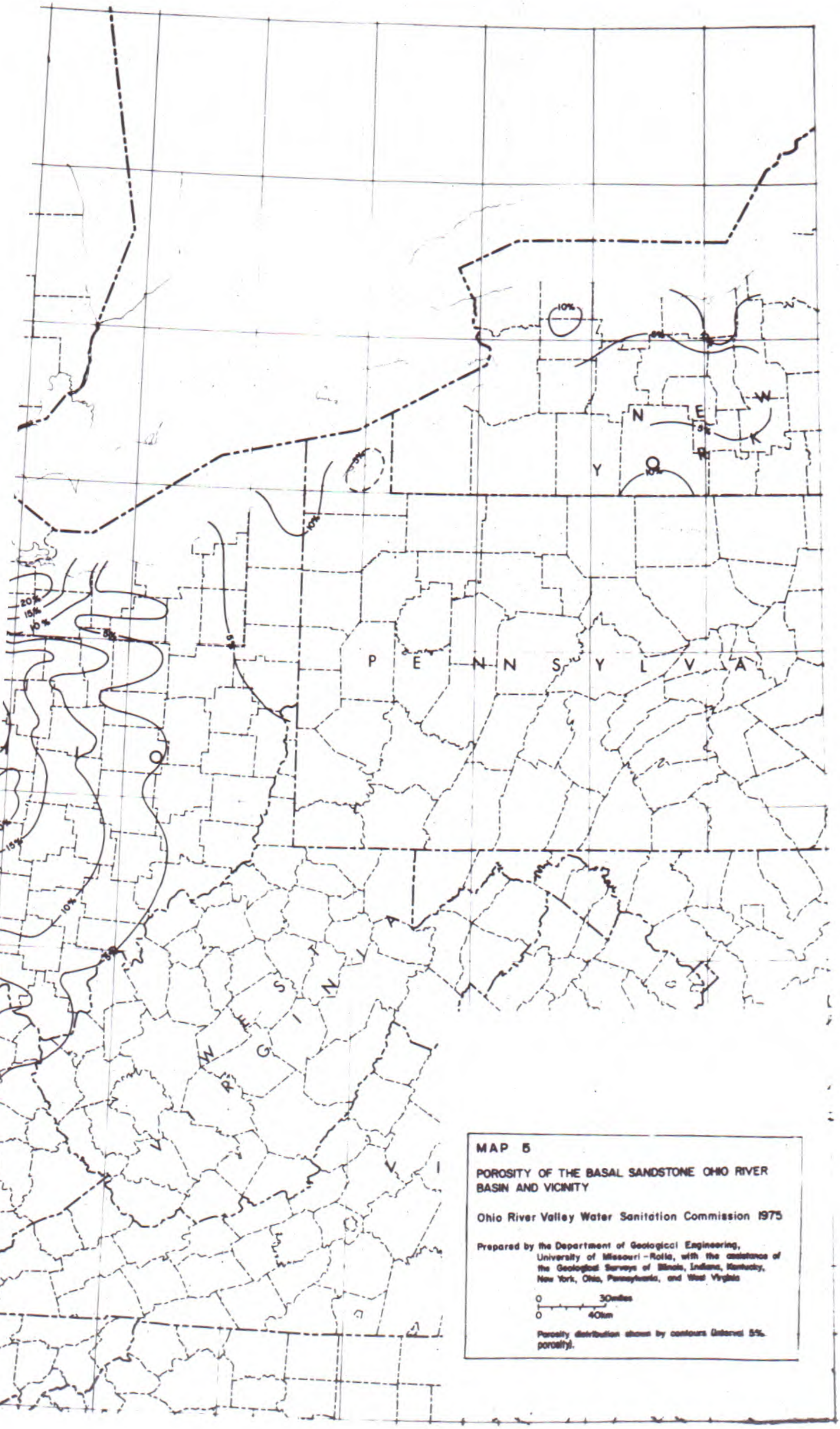

I L L I N O I S
I N D I A N A
K E N T U C K
O
0
-1000
-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10,000
-11,000
-12,000
MINERALIZED AREA

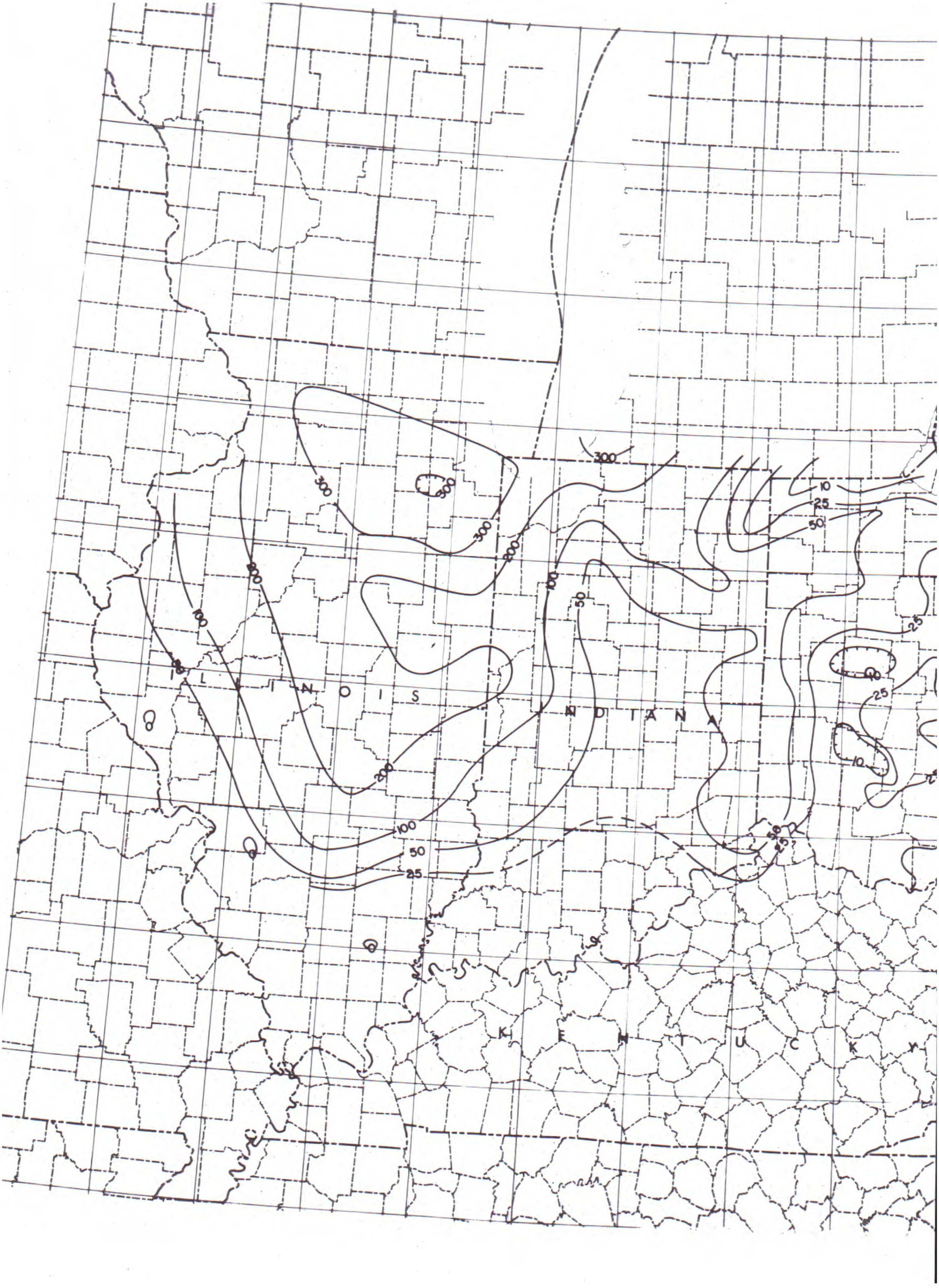

-2000
-3000
-4000
-5000
-6000
-7000
-8000
-9000
-10,000
-11,000
-12,000
P E N N S Y L V A
3000
4000
5000
6000
7000
8000
9000
10000
MAP 3
ELEVATION MAP ON THE TOP OF THE BASAL SANDSTONE OHIO RIVER BASIN AND VICINITY
Ohio River Valley Water Sanitation Commission 1975
Prepared cooperatively by the Geological Surveys of Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, and West Virginia, and the University of Missouri-Rolla
0 30miles
0 40km
Contour interval 1,000 feet
Fault
Area where basal sandstone is known to be absent
Datum: sea level


I L L I N O I S
I N D I A N A
O
K E N T U C K Y
2000
2500
1500
1000
500
250

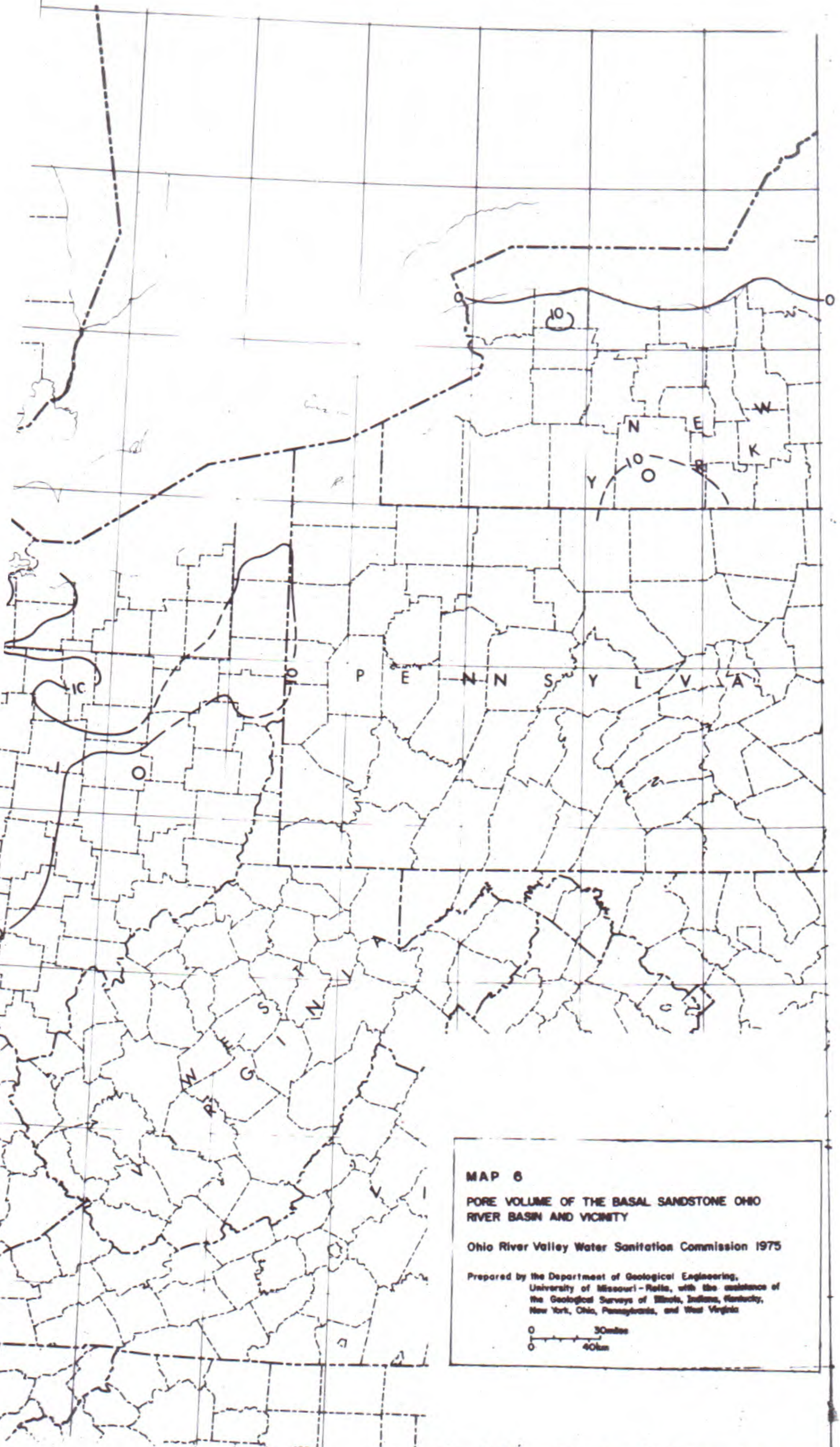

MAP 4
THICKNESS OF THE BASAL SANDSTONE OHIO RIVER BASIN AND VICINITY
Ohio River Valley Water Sanitation Commission 1975
Prepared cooperatively by the Geological Surveys of Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, and West Virginia, and the University of Missouri–Rolla
0 30miles
0 40km
Contour interval variable, from 50 to 500 feet
Area where basal sandstone is known to be absent
N E W
Y O R K
P E N N S Y L V A
O
W E S T V I R G I N I A
50
100
150
200
100
200
100
200
100
100


ILLINOIS
INDIANA
KENTUCKY
5%
10%
15%
20%

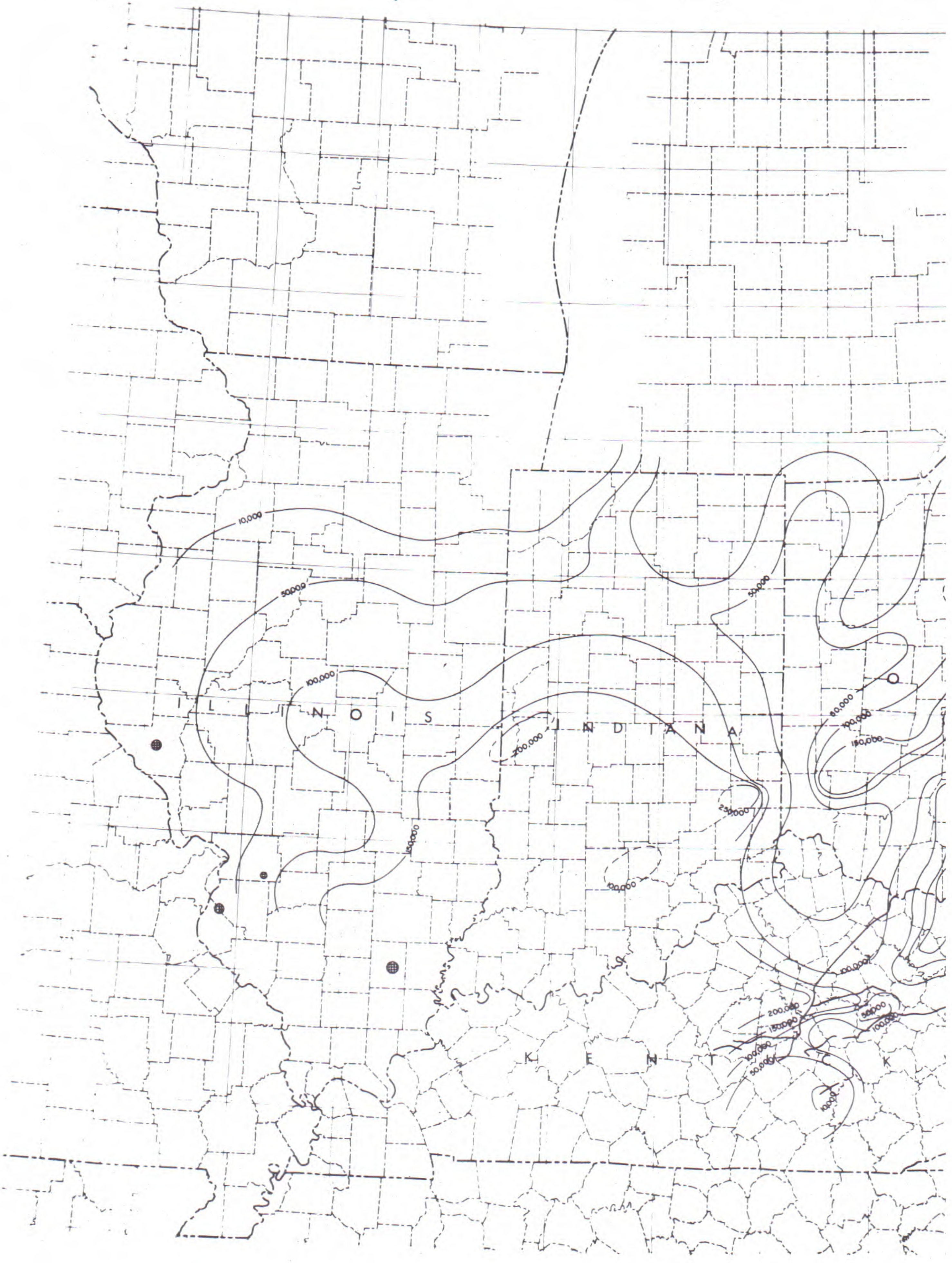

N E W Y O R K
P E N N S Y L V A N I A
W E S T V I R G I N I A
10%
5%
15%
20%
MAP 5
POROSITY OF THE BASAL SANDSTONE OHIO RIVER BASIN AND VICINITY
Ohio River Valley Water Sanitation Commission 1975
Prepared by the Department of Geological Engineering, University of Missouri-Rolla, with the assistance of the Geological Surveys of Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, and West Virginia
0 30miles
0 40km
Porosity distribution shown by contours (interval 5% porosity).

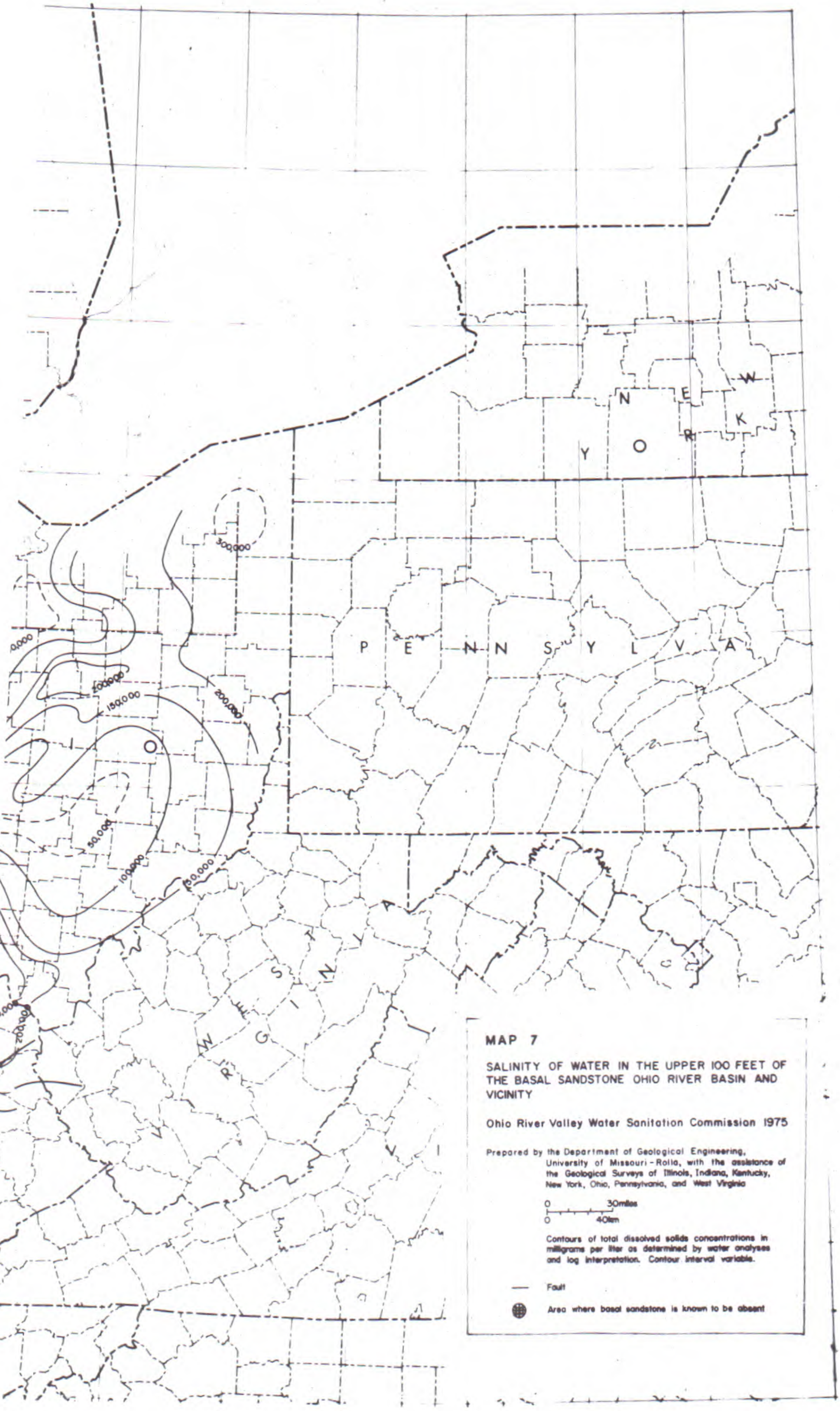


ILLINOIS
INDIANA
KENTUCKY
300
300
300
300
200
200
200
100
100
100
50
50
50
25
25
25
25
10
10
10

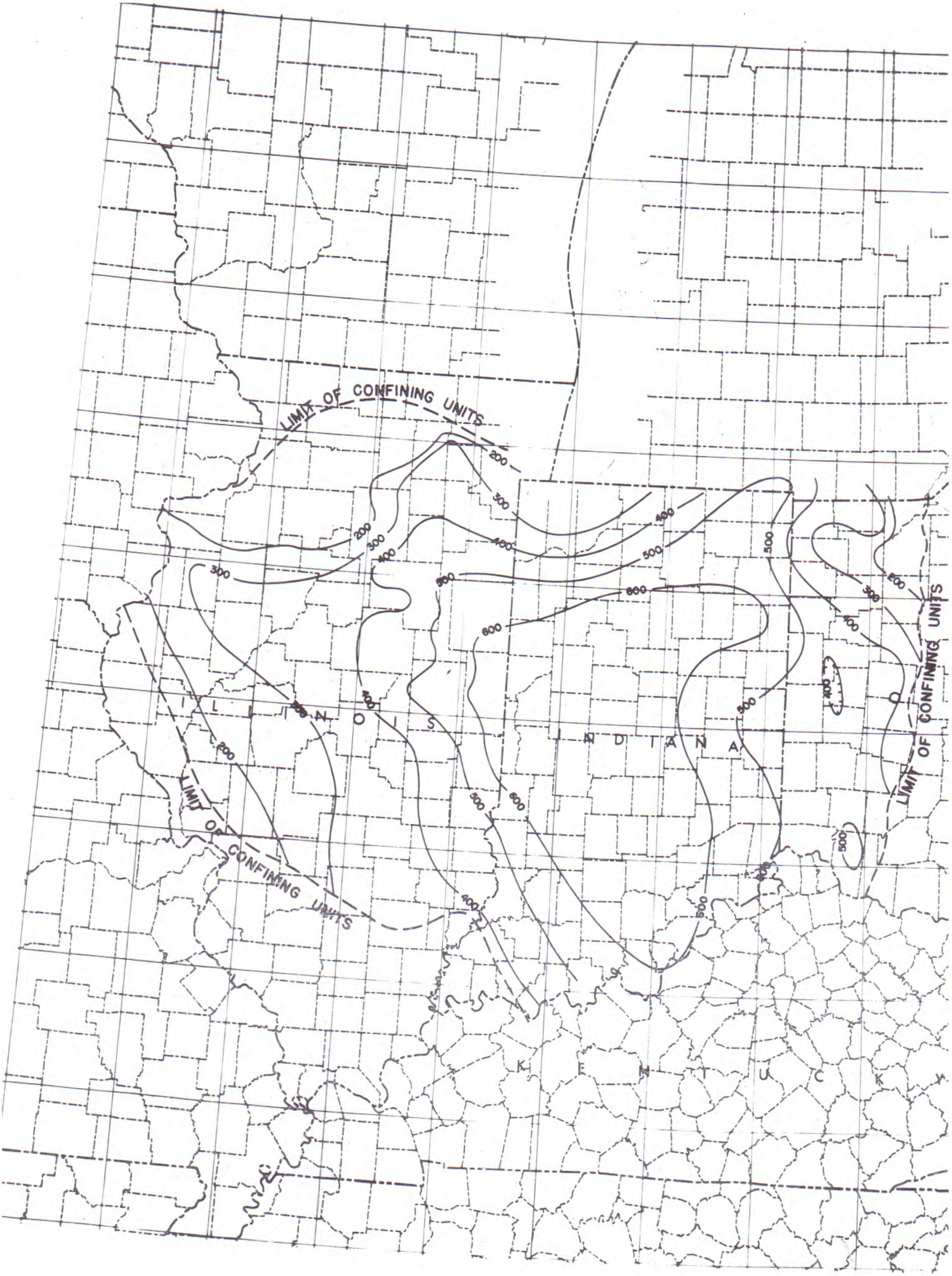


MAP 6
PORE VOLUME OF THE BASAL SANDSTONE OHIO RIVER BASIN AND VICINITY
Ohio River Valley Water Sanitation Commission 1975
Prepared by the Department of Geological Engineering, University of Missouri-Rolla, with the assistance of the Geological Surveys of Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, and West Virginia
0 30miles
0 40km
N E W Y O R K
P E N N S Y L V A N I A
O
W E S T V I R G I N I A
0
10

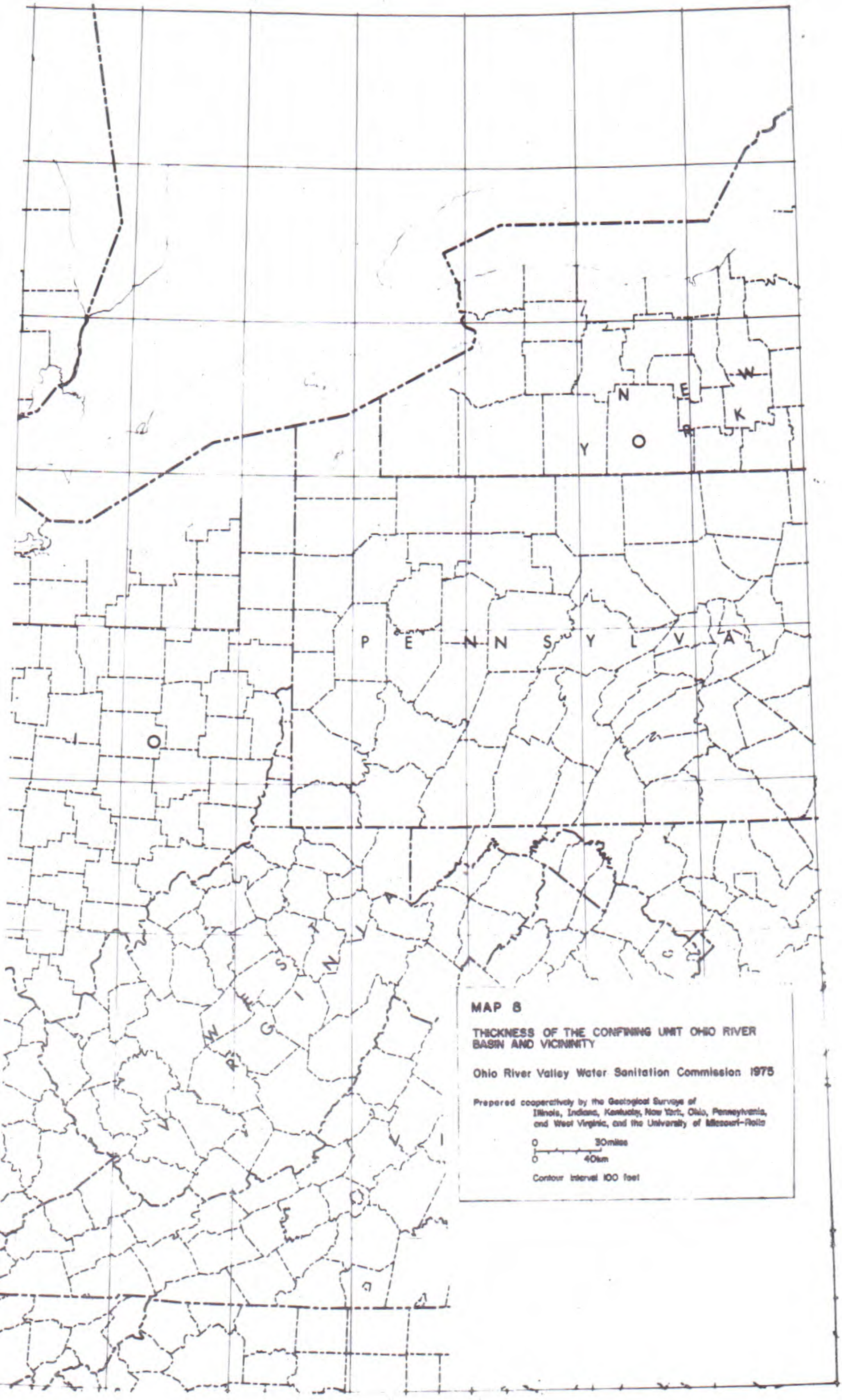

I L L I N O I S
I N D I A N A
K E N T
K
O
10,000
50,000
100,000
150,000
200,000
250,000
60,000

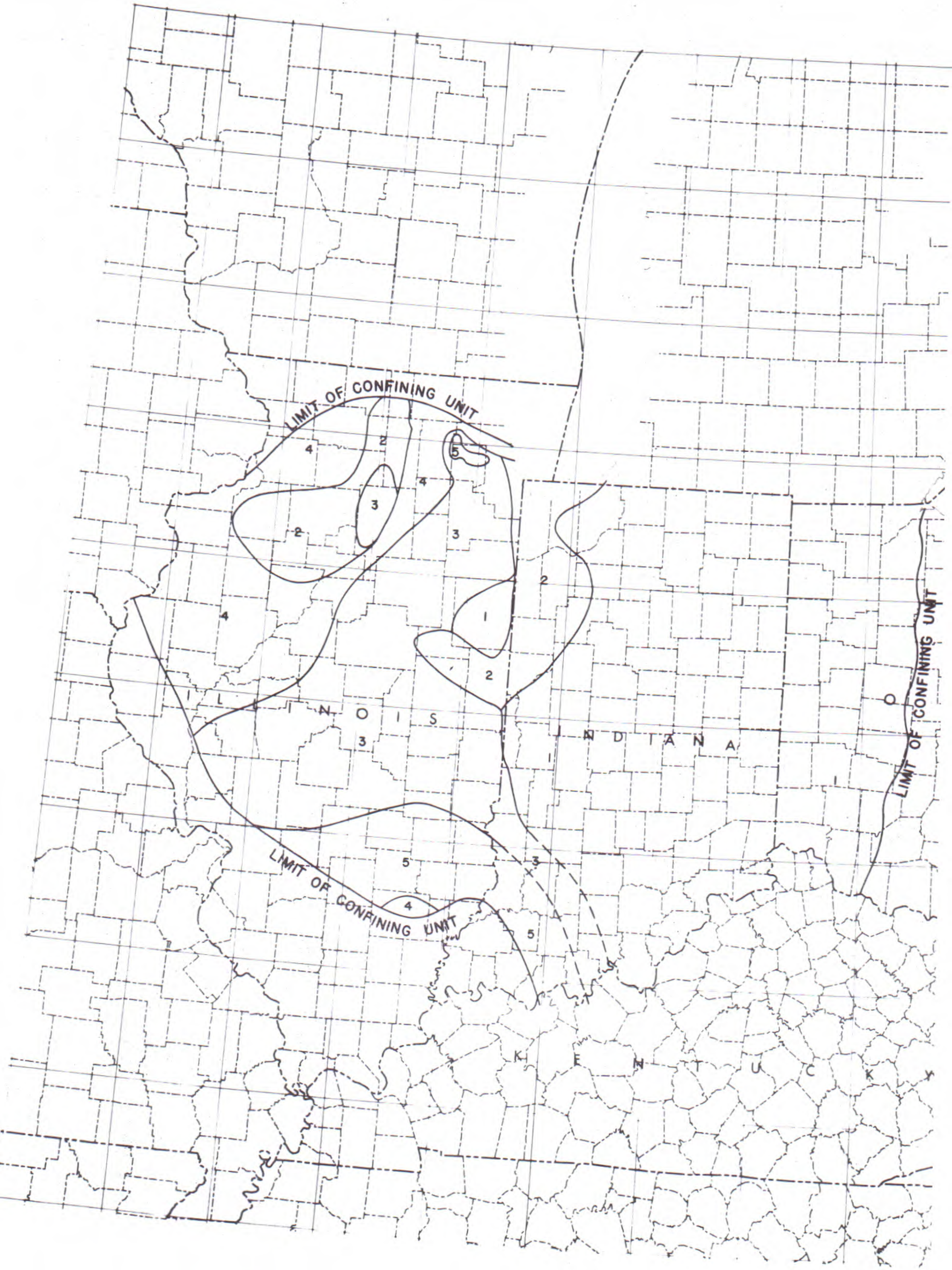


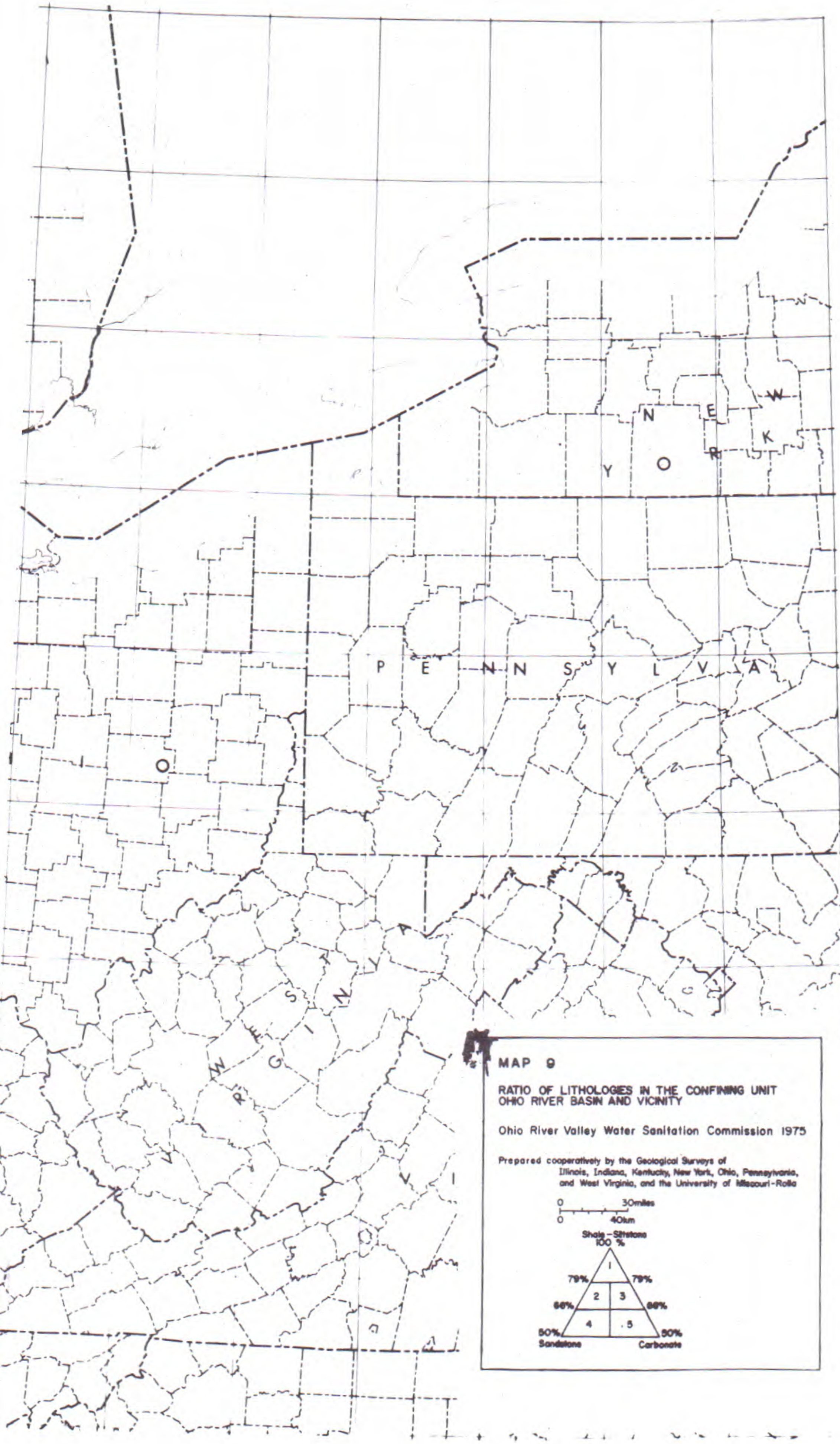
N E W Y O R K
P E N N S Y L V A N I A
W E S T V I R G I N I A
O H I O
300,000
200,000
150,000
100,000
50,000
MAP 7
SALINITY OF WATER IN THE UPPER 100 FEET OF THE BASAL SANDSTONE OHIO RIVER BASIN AND VICINITY
Ohio River Valley Water Sanitation Commission 1975
Prepared by the Department of Geological Engineering, University of Missouri - Rolla, with the assistance of the Geological Surveys of Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, and West Virginia
0 30miles
0 40km
Contours of total dissolved solids concentrations in milligrams per liter as determined by water analyses and log interpretation. Contour interval variable.
Fault
Area where basal sandstone is known to be absent

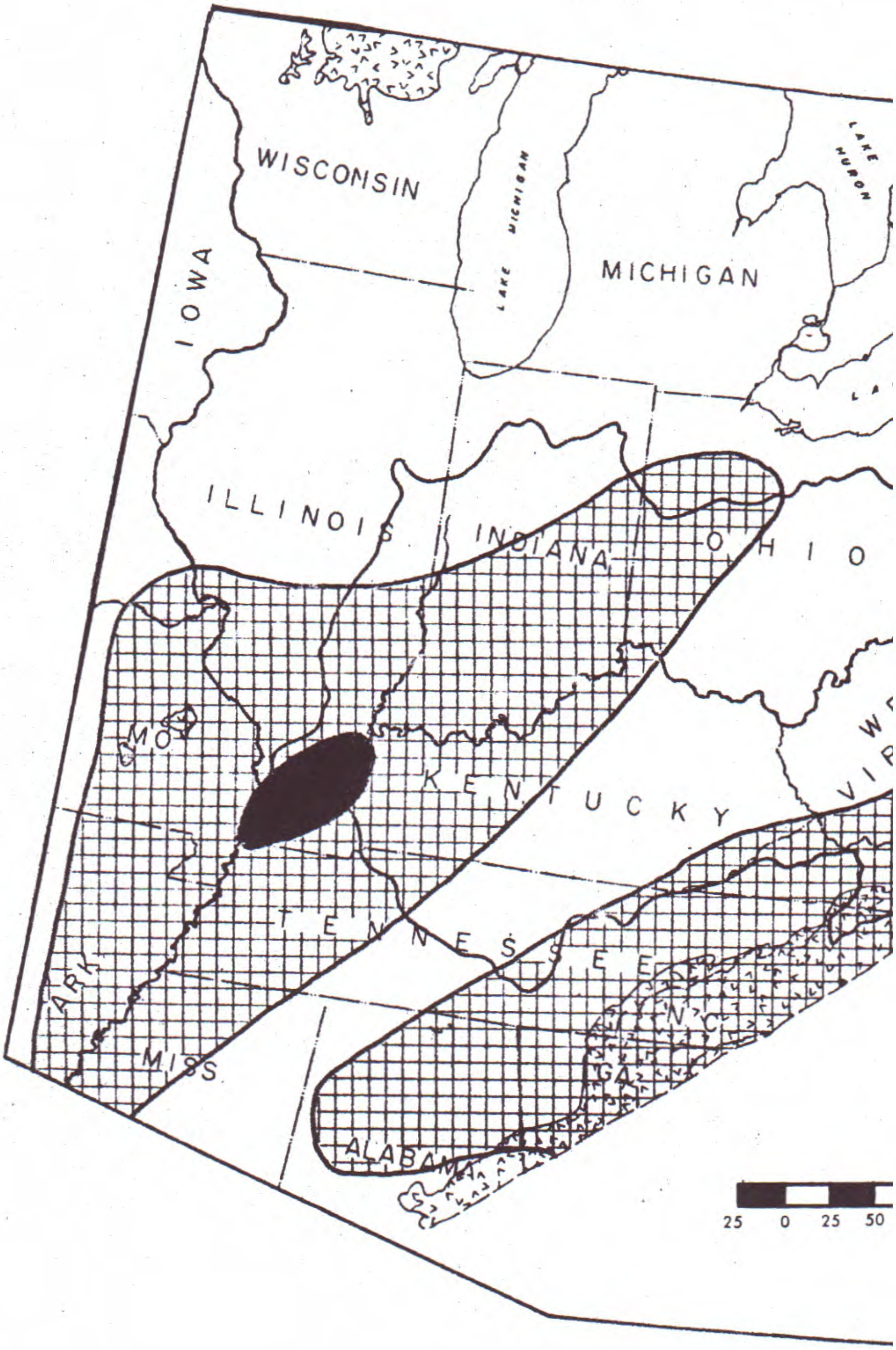


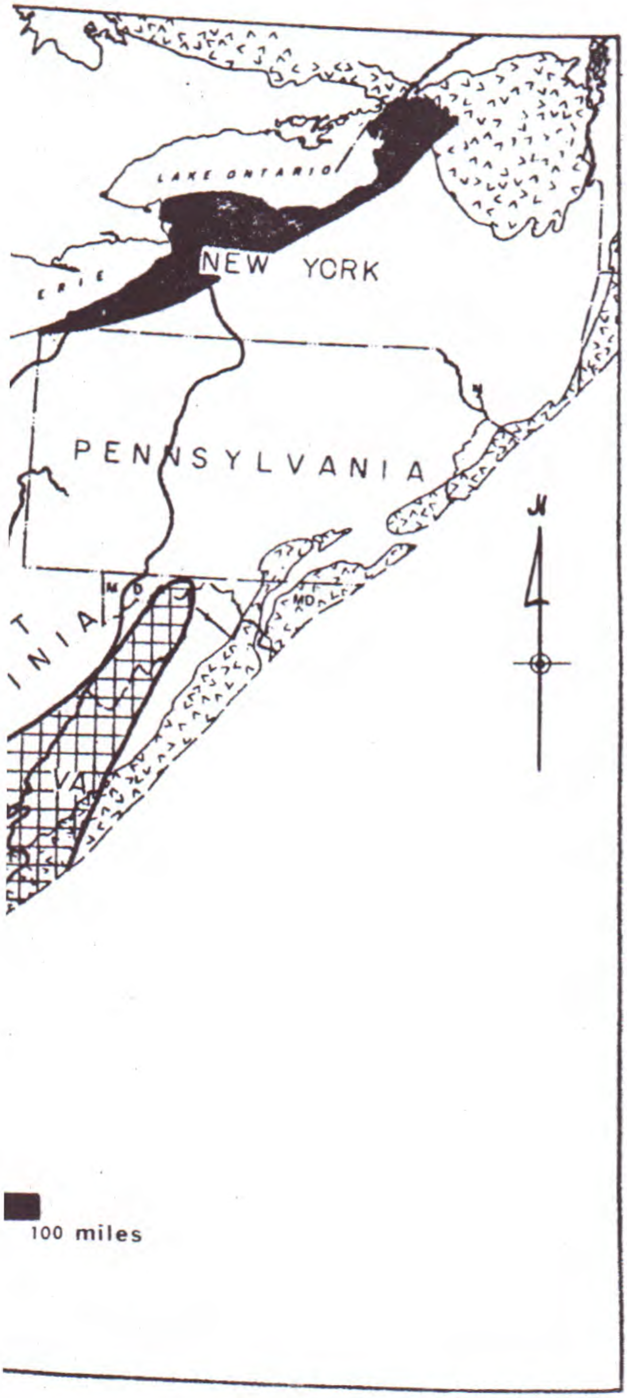
LIMIT OF CONFINING UNITS
LIMIT OF CONFINING UNITS
LIMIT OF CONFINING UNITS
I L L I N O I S
I N D I A N A
K E N T U C K Y
O
200
300
400
500
600


N E W
Y O R K
P E N N S Y L V A
O
MAP 8
THICKNESS OF THE CONFINING UNIT OHIO RIVER BASIN AND VICINITY
Ohio River Valley Water Sanitation Commission 1975
Prepared cooperatively by the Geological Surveys of Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, and West Virginia, and the University of Missouri-Rolla
0 30miles
0 40km
Contour interval 100 feet


LIMIT OF CONFINING UNIT
LIMIT OF CONFINING UNIT
LIMIT OF CONFINING UNIT
I L L I N O I S
I N D I A N A
O H I O
K E N T U C K Y
1
2
3
4
5


NEW YORK
PENNSYLVANIA
O
VIRGINIA
MAP 9
RATIO OF LITHOLOGIES IN THE CONFINING UNIT
OHIO RIVER BASIN AND VICINITY
Ohio River Valley Water Sanitation Commission 1975
Prepared cooperatively by the Geological Surveys of
Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania,
and West Virginia, and the University of Missouri-Rolla
0 30miles
0 40km
Shale-Siltstone
100 %
1
79%
79%
2
3
66%
66%
4
5
50%
50%
Sandstone
Carbonate


WISCONSIN
LAKE MICHIGAN
LAKE HURON
MICHIGAN
IOWA
ILLINOIS
INDIANA
OHIO
MO
KENTUCKY
TENNESSEE
ARK
MISS
ALABAMA
GA
N C
25 0 25 50



MAP 10

The Ohio River basin and vicinity showing the degree of seismic risk as projected from earthquake history and geologic considerations.

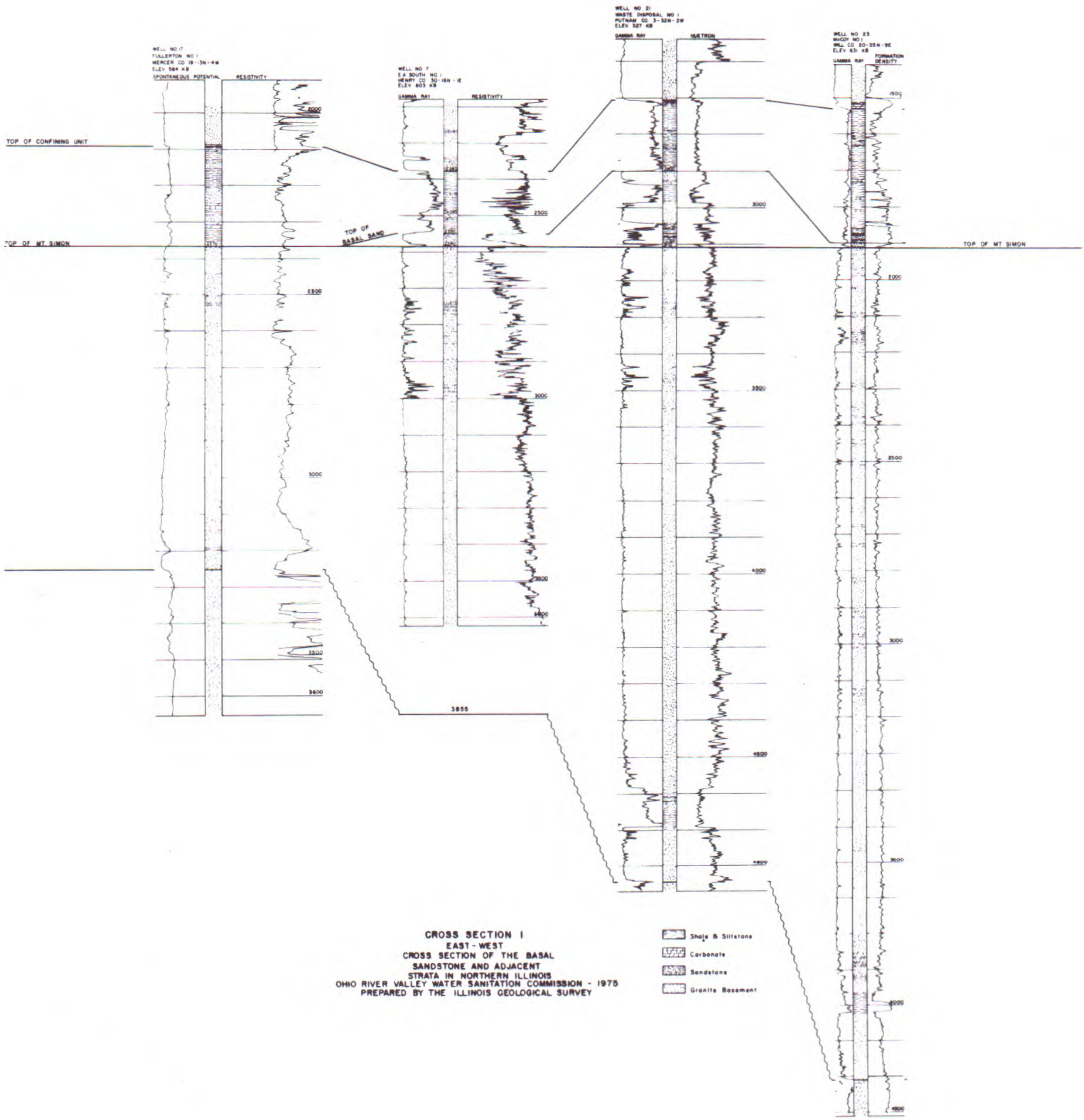
from Algermissen, 1969

LEGEND

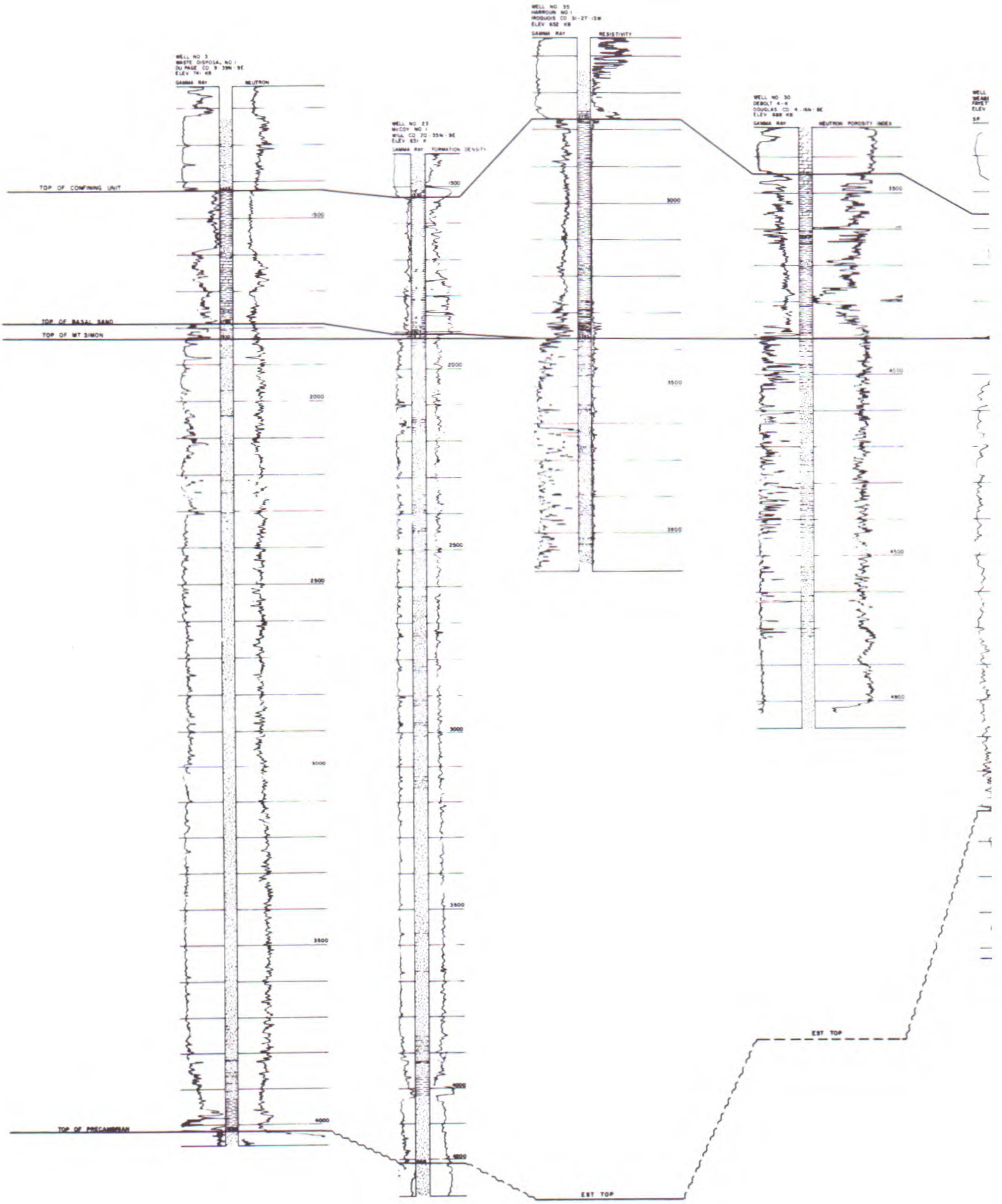
MAJOR DAMAGE FROM EARTHQUAKES MAY OCCUR

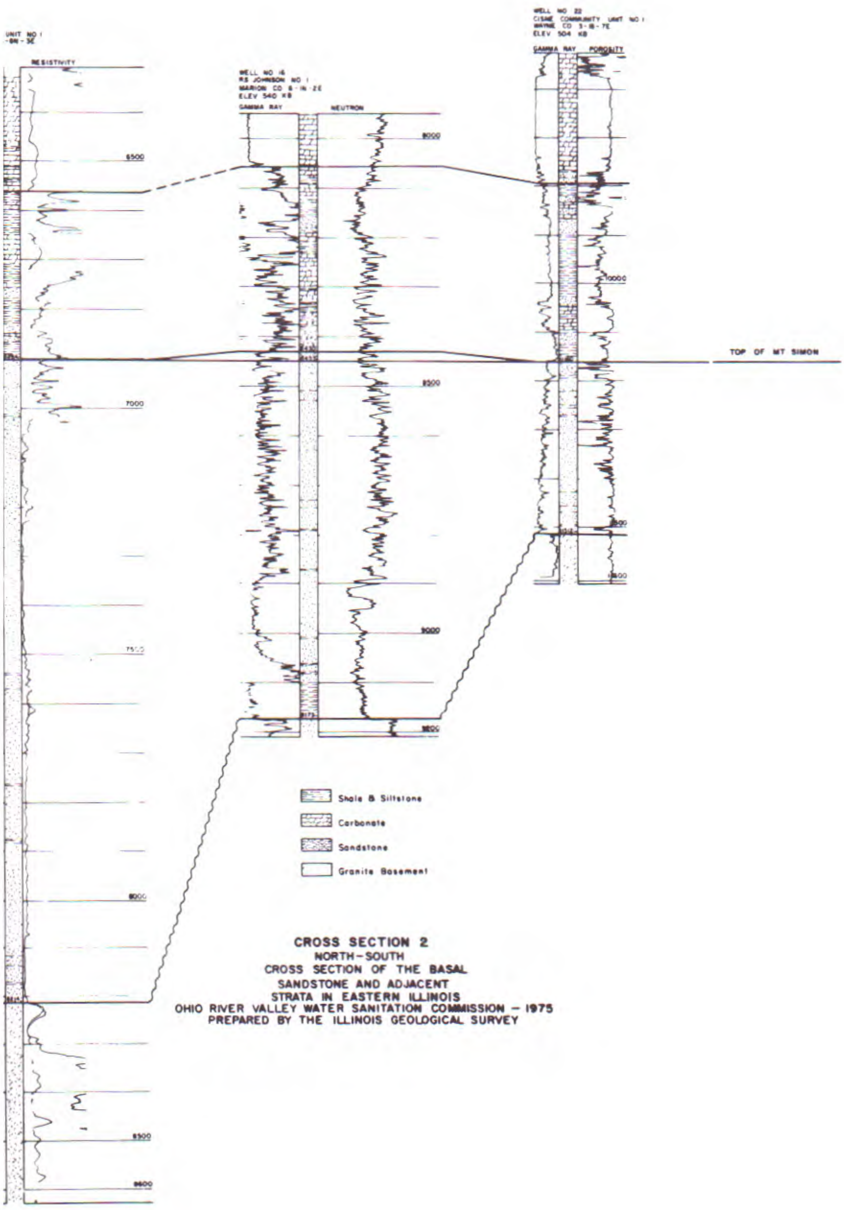
MODERATE DAMAGE FROM EARTHQUAKES MAY OCCUR

MINOR DAMAGE FROM EARTHQUAKES MAY OCCUR

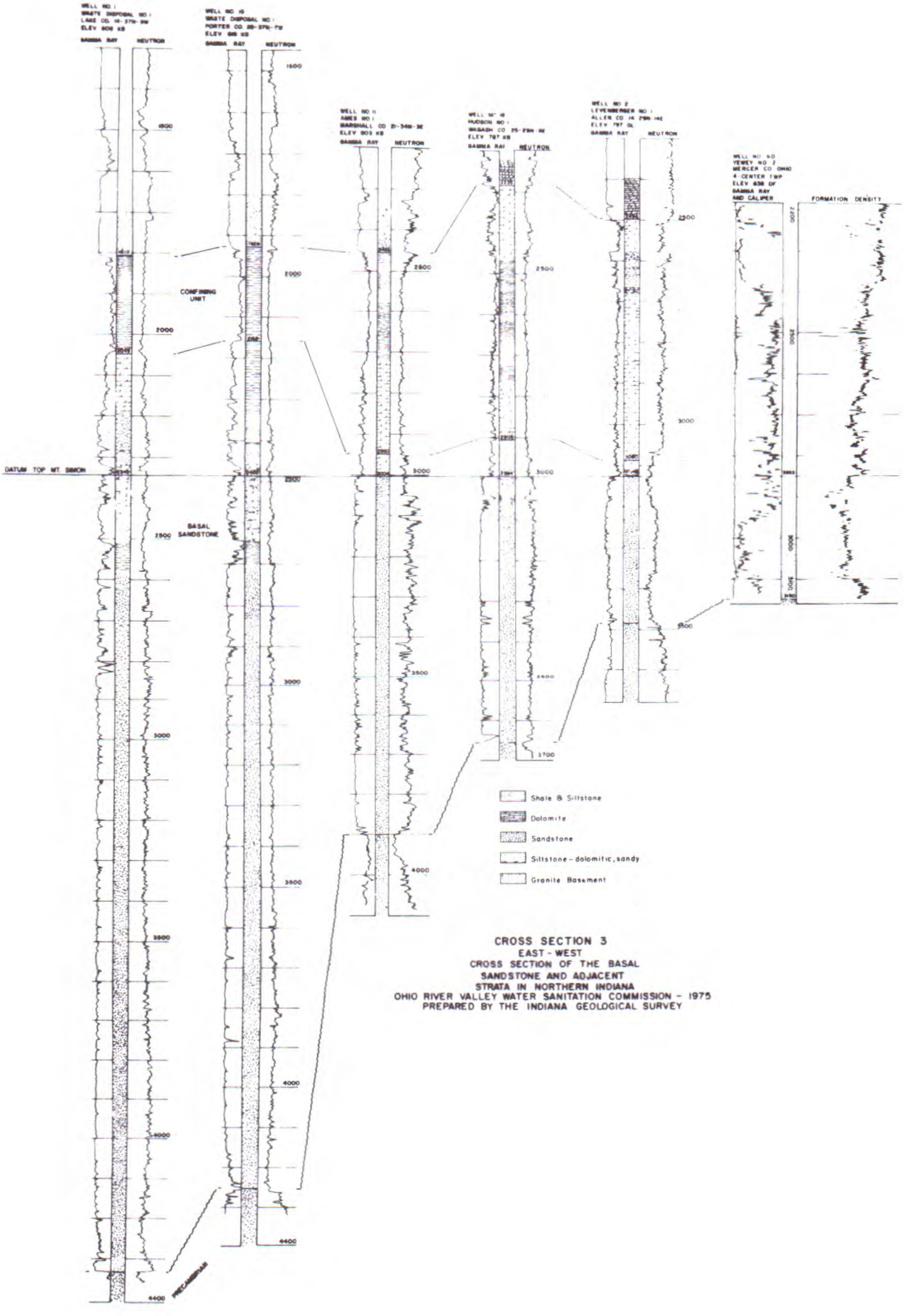


CROSS SECTION I
EAST - WEST
CROSS SECTION OF THE BASAL
SANDSTONE AND ADJACENT
STRATA IN NORTHERN ILLINOIS
OHIO RIVER VALLEY WATER SANITATION COMMISSION - 1975
PREPARED BY THE ILLINOIS GEOLOGICAL SURVEY

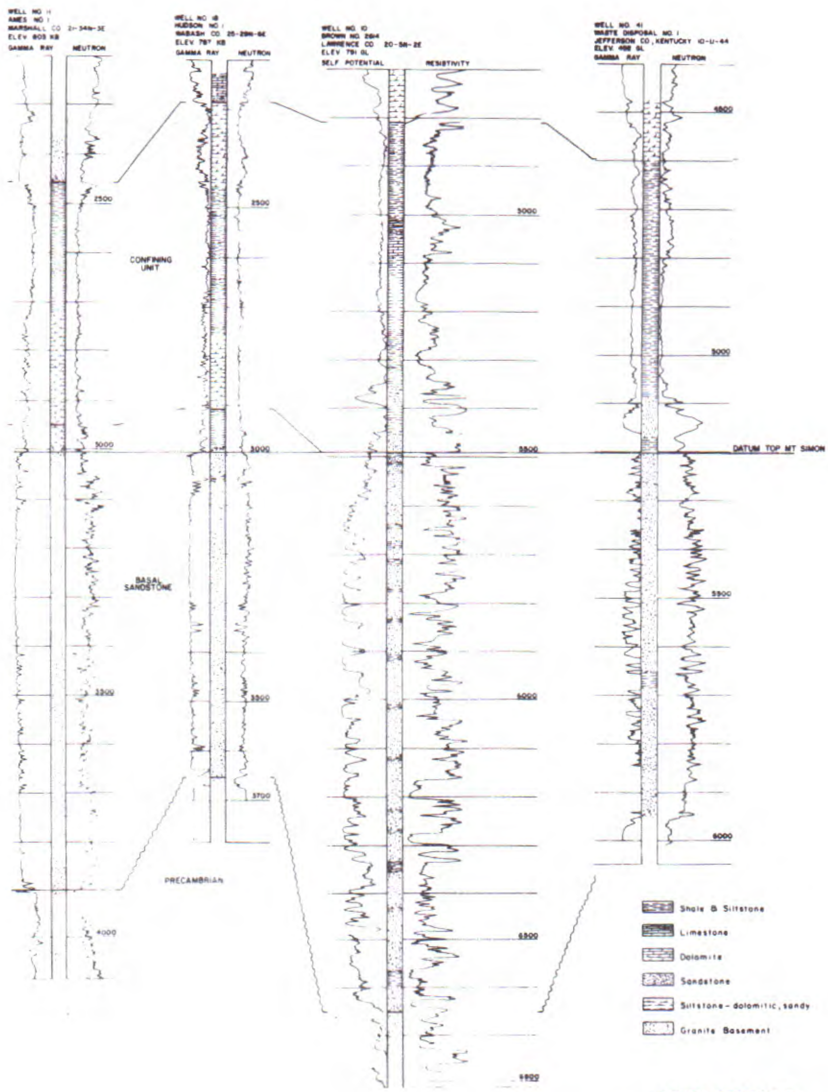

WELL NO 3
WASTE DISPOSAL NO 1
DU PAGE CO 9 39N - 9E
ELEV 741 KB
GAMMA RAY
NEUTRON
WELL NO 23
McCOY NO 1
WILL CO 20 - 35N - 9E
GAMMA RAY
FORMATION DENSITY
WELL NO 35
HARROUN NO 1
IROQUOIS CO 31 - 27 - 13W
ELEV 652 KB
GAMMA RAY
RESISTIVITY
WELL NO 30
DEBOLT 4 - 4
DOUGLAS CO 4 - 16N - 8E
GAMMA RAY
NEUTRON POROSITY INDEX
WELL
ELEV
SP
TOP OF CONFINING UNIT
TOP OF BASAL SAND
TOP OF MT SIMON
TOP OF PRECAMBRIAN
EST TOP
EST TOP
1500
2000
2500
3000
3500
4000
4500



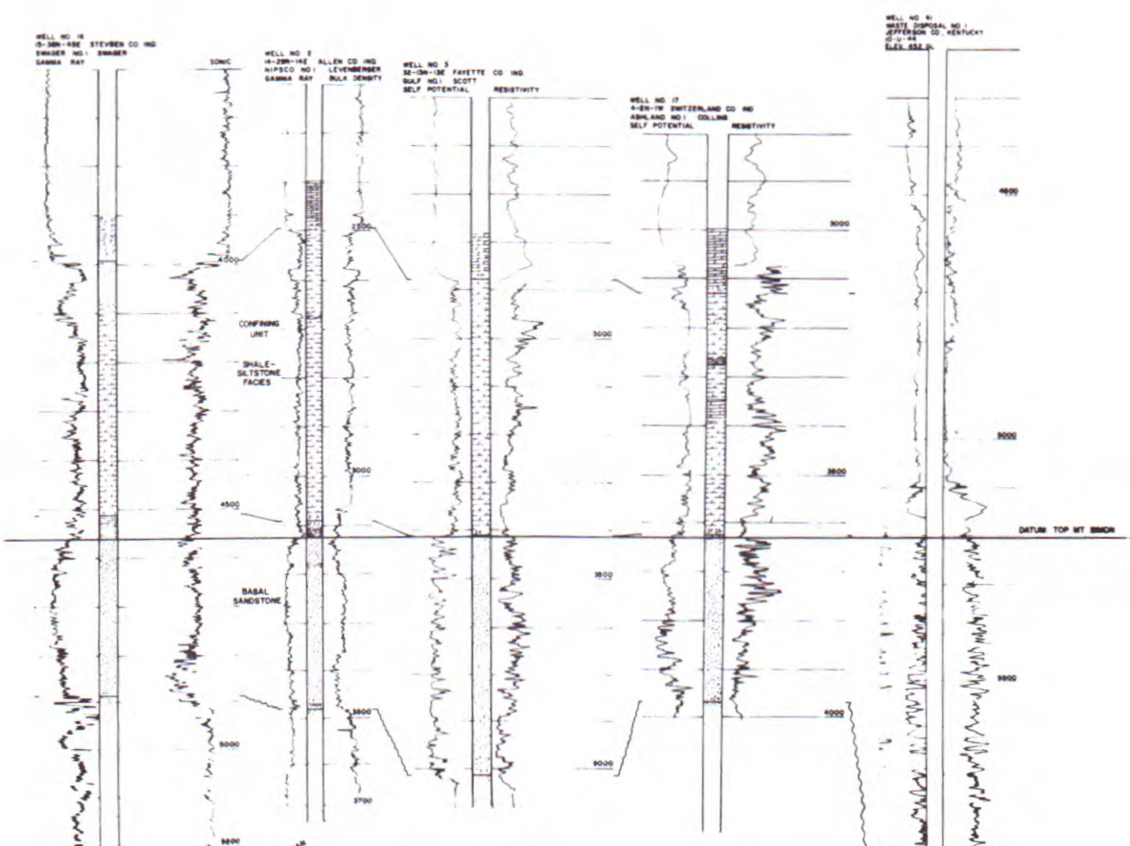
CROSS SECTION 2
NORTH-SOUTH
CROSS SECTION OF THE BASAL
SANDSTONE AND ADJACENT
STRATA IN EASTERN ILLINOIS
OHIO RIVER VALLEY WATER SANITATION COMMISSION — 1975
PREPARED BY THE ILLINOIS GEOLOGICAL SURVEY



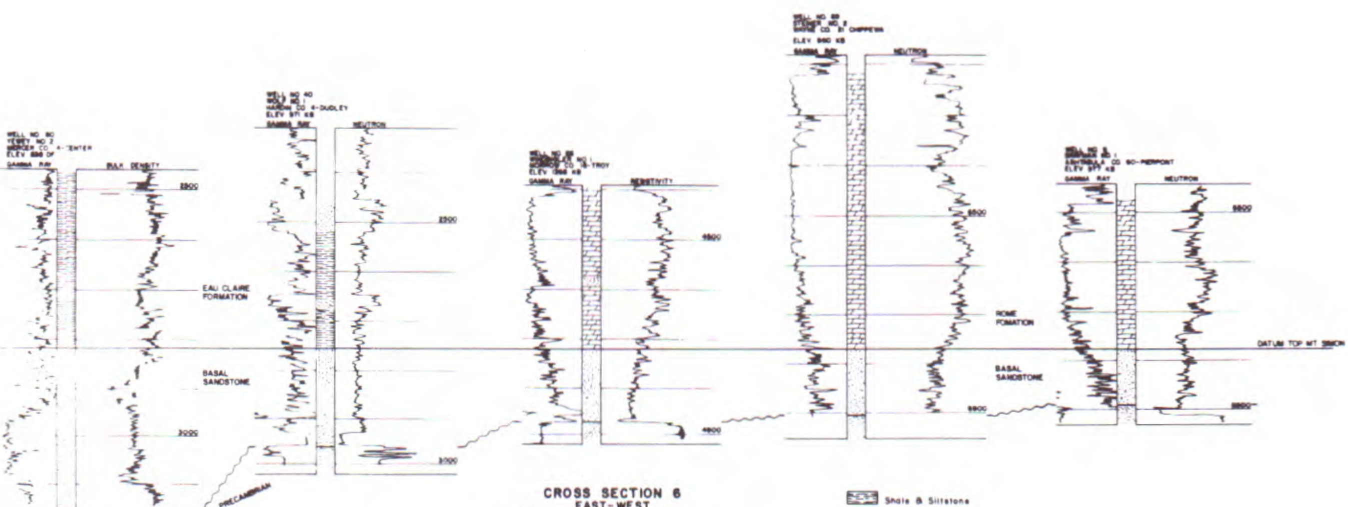
CROSS SECTION 3
EAST - WEST
CROSS SECTION OF THE BASAL
SANDSTONE AND ADJACENT
STRATA IN NORTHERN INDIANA
OHIO RIVER VALLEY WATER SANITATION COMMISSION - 1975
PREPARED BY THE INDIANA GEOLOGICAL SURVEY



CROSS SECTION 4
NORTH - SOUTH
CROSS SECTION OF THE BASAL
SANDSTONE AND ADJACENT
STRATA IN CENTRAL INDIANA
OHIO RIVER VALLEY WATER SANITATION COMMISSION - 1975
PREPARED BY THE INDIANA GEOLOGICAL SURVEY

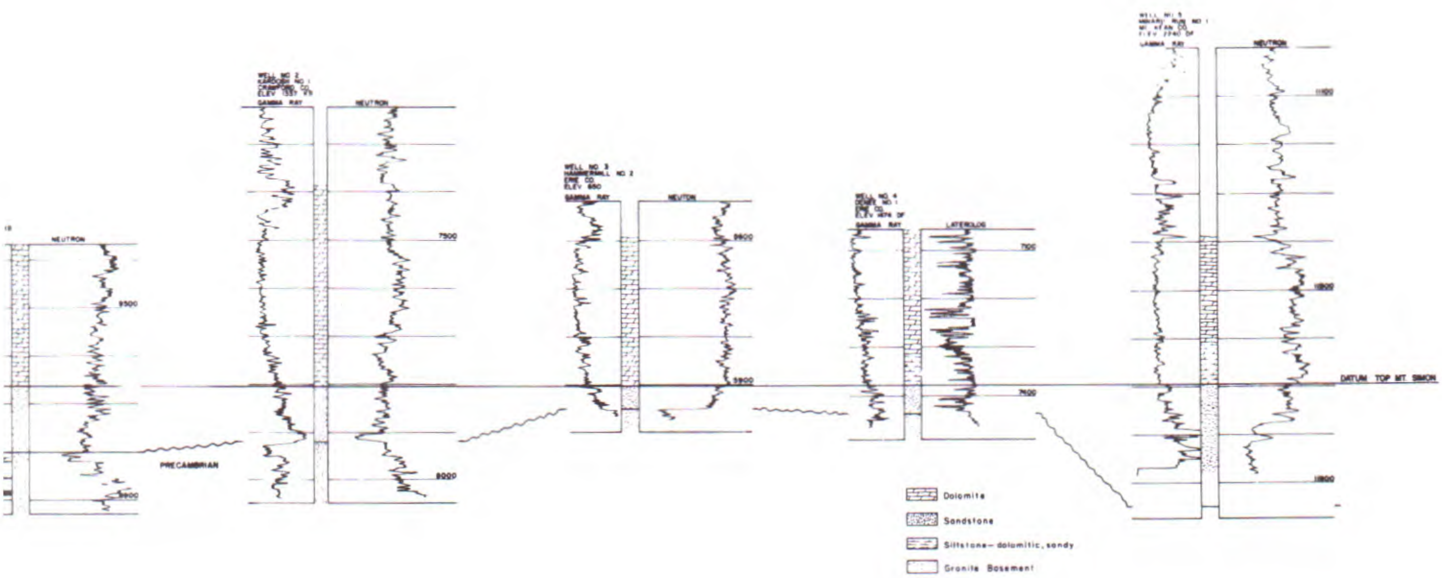


CROSS SECTION 5
NORTH-SOUTH
CROSS SECTION OF THE BASAL
SANDSTONE AND ADJACENT
STRATA IN EASTERN INDIANA
OHIO RIVER VALLEY WATER SANITATION COMMISSION-1975
PREPARED BY THE INDIANA GEOLOGICAL SURVEY



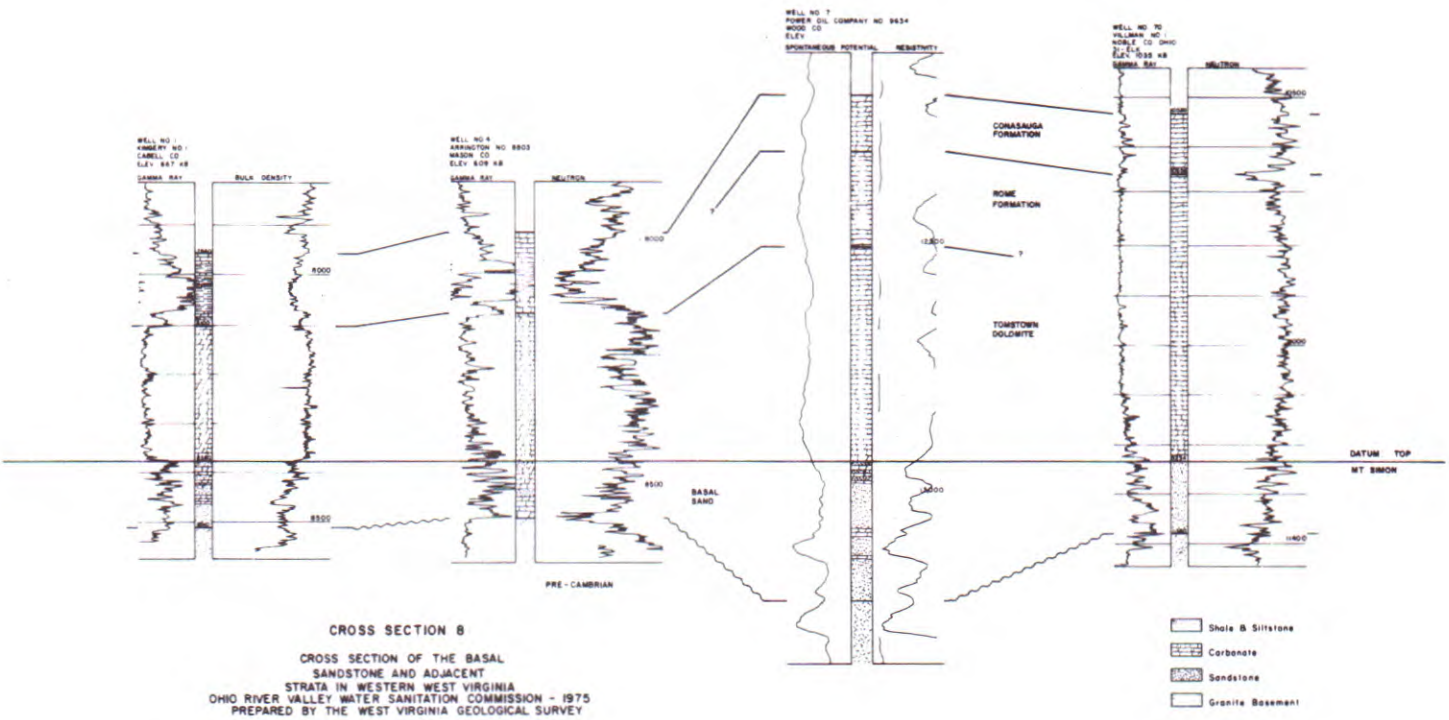
CROSS SECTION 6
EAST-WEST
CROSS SECTION OF THE BASAL
SANDSTONE AND ADJACENT
STRATA IN NORTHERN OHIO
OHIO RIVER VALLEY WATER SANITATION COMMISSION - 1975
PREPARED BY THE OHIO GEOLOGICAL SURVEY

Shale & Siltstone
Dolomite
Sandstone
Granite Basement



CROSS SECTION 7

CROSS SECTION OF THE BASAL
SANDSTONE AND ADJACENT
STRATA IN PENNSYLVANIA
OHIO RIVER VALLEY WATER SANITATION COMMISSION - 1975
PREPARED BY THE PENNSYLVANIA GEOLOGICAL SURVEY



CROSS SECTION 8

CROSS SECTION OF THE BASAL
SANDSTONE AND ADJACENT
STRATA IN WESTERN WEST VIRGINIA
OHIO RIVER VALLEY WATER SANITATION COMMISSION - 1975
PREPARED BY THE WEST VIRGINIA GEOLOGICAL SURVEY

TABLE 1. WELL DATA - Illinois

ILL. WELL NO.	OPERATOR & WELL NAME	YEAR COMP.	COUNTY	LOCATION SEC.	T	R	REFERENCE ELEVATION	T.D.	STATUS	GEOPHYSICAL LOG GR-N	E	SONI
1	- No. 1 E. Taylor		Boone	28	43N	3E	815 TM	2998	O/G ABD	-	-	-
2	- No. 1 P. Shulte		DeKalb	35	41N	5E	910 THL	4484	O/G ABD	-	-	-
3	Amer.Ind.Disp.Sys.No.1 W.D.	1967	DuPage	9	39N	9E	741 KB	4043	DISP. ABD	X	X	X
4	Humble No. 1 Weaber-Horn	1960	Fayette	28	8N	3E	538 KB	8615	O/G ABD	-	X	X
5	Texaco No. 1 E. Cuppy	1965	Hamilton	6	6S	7E	392 KB	13051	O/G ABD	X	X	X
6	- No. 1 Lillard		Henderson	14	9N	5W	625 KB	3180	GAS	-	-	-
7	Ralph Davis No. 1 E.A. South	1961	Henry	30	16N	1E	803 KB	3863	O/G ABD	X	X	X
8	Vickery Drlg. Co. No.1 Mathesius	1958	LaSalle	32	35N	1E	677	3556	GAS STG	X	X	-
9	R.W. Lawinger No.1 A. Miller	1957	LaSalle	1	36N	4E	681 TM	3659	O/G ABD	-	X	-
10	A.C. Otto No. 1 Swenson	1956	LaSalle	1	36N	5E	659 ETM	3725	O/G ABD	X	-	-
11	- No. 1 J. B. McElroy		Lee	30	20N	10E	714	3772	O/G ABD	-	-	-
12	- No. 1 Vedovell		Lee	35	20N	10E	812	3652	O/G ABD	-	-	-
13	- No. S-5 Huldah Baer	1959	Madison	27	3N	6W	516 KB	4868	O/G ABD	-	-	-
14	Ball Assoc. No. S-1 Kircheis	1959	Madison	27	3N	6W	505 KB	5018	O/G ABD	X	X	X
15	Miss.Riv. Trans. No.S-2 Klein	1971	Madison	33	3N	6W	513 KB	5213	O/G ABD	X	X	-
16	Texaco No. 1 R.S. Johnson	1966	Marion	6	1N	2E	540 KB	9210	O/G ABD	X	X	X
17	Harold Kelly No. 1 Fullerton	1958	Mercer	19	13N	4W	584 KB	3716	O/G ABD	-	X	-
18	Miss.Riv.Fuel Co.No.A-15 Theobald	1952	Monroe	35	1S	10W	666 DF	2768	O/G ABD	-	-	-
19	Herndon Drlg.Co.No.1 Campbell	1944	Pike	15	4S	5W	716 DF	3207	O/G ABD	-	X	-
20	Pan.East.P.L.No.1 Mumford	1947	Pike	21	5S	4W	812 DF	2226	O/G ABD	-	X	-
21	Jones & Laughlin No. 1 WD	1966	Putnam	3	32N	2W	527 KB	4868	DISP.	X	X	-
22	Union Oil No. 1 Cisne Comm.	1967	Wayne	3	1S	7E	504 KB	11614	O/G ABD	X	X	-
23	Charles Peed No. 1 McCoy	1963	Will	20	35N	9E	631 KB	4300	O/G ABD	-	X	-
24	- No. 1 Seele		Winnebago	24	44N	2E	870 ETM	3385	O/G ABD	-	-	-
25	People's Gas No. 1 Flessner	1967	Champaign	17	21N	7E	760 KB	4530	GAS STG	X	X	-
26	People's Gas No. 3 Webster	1964	Champaign	17	21N	7E	759 KB	4492	GAS STG	X	X	-
27	Automatic Elec. No. 1 Wtr. Sup.	1958	Cook	31	40N	12E	655	1833	WTR	X	X	-
28	Richardson No. 2 Richardson	1959	Cook	4	39N	12E	632 TM	1960	WTR	-	X	X
29	People's Gas No. 1 Lamb	1963	DeWitt	1	20N	4E	736 KB	4929	O/G ABD	X	X	X
30	Ill. Power Co. No.4-4 DeBolt		Douglas	4	16N	8E	688 KB	4920	GAS STG	-	-	-

TABLE 1. WELL DATA - Illinois

WATER ANALYSES	CORE ANALYSES	CONFINING UNIT SEA LEVEL ELEVATION	CONFINING UNIT THICKNESS	CONFINING UNIT FEET OF SHALE/ SILTSTONE	CONFINING UNIT FEET OF SAND-STONE	CONFINING UNIT FEET OF CARBONATE	BASAL SANDSTONE UNIT SEA LEVEL ELEVATION	BASAL SANDSTONE UNIT THICKNESS	BASAL SANDSTONE UNIT SAND-SHALE RATIO	BASAL SANDSTONE UNIT AVERAGE POROSITY	BASAL SANDSTONE UNIT POROSITY FEET	BASAL SANDSTONE UNIT PERMEABILITY (MD)	BASEMENT SEA LEVEL ELEVATION
-	-	- 100	125	94	31	0	- 255	1885	-	-	-	-	-2110
-	-	- 390	140	70	70	0	- 530	2405	-	-	-	-	-2935
X	-	- 686	363	243	18	102	-1049	2230	~100	.17	375	-	-3279
-	-	- 024	333	166	50	117	-6357	1319	~100	.15	198	-	-7676
X	-	NI	-	-	-	-	NI	-	-	-	-	-	-12622
-	-	-1527	268	147	94	27	-1795	738	-	-	-	-	-2533
X	-	-1575	172	120	43	9	-1747	1305	316	.145	183	-	-3052
X	-	- 313	177	142	35	0	- 493	2338	117	.145	301	150(field ave)	-2831
-	-	+ 7	306	168	77	61	- 299	2489	27	.17	399	-	-2788
X	-	- 79	322	194	64	64	- 401	2640	46	.12	277	-	-3041
-	-	- 916	165	83	82	0	-1081	1965	-	-	-	-	-3046
-	-	- 458	180	120	60	0	- 638	2015	-	-	-	-	-2653
-	-	NI	-	-	-	-	NI	-	-	-	-	-	-4342
X	-	NI	-	-	-	-	-4470	35	8.75	.145	5	-	-4505
-	-	NI	-	-	-	-	-4631	58	-	.04	2	-	-4689
X	-	NI	-	-	-	-	-7890	742	16	.10	68	-	-8632
-	-	-1510	270	149	81	40	-1782	884	~100	-	-	-	-2666
X	-	NI	-	-	-	-	NI	-	-	-	-	-	-2082
-	-	NI	-	-	-	-	-2032	457	45	-	-	-	-2489
X	-	NI	-	-	-	-	NI	-	-	-	-	-	-1409
-	-	-2179	194	145	39	10	-2373	1942	14	.125	202	32.28	-4315
-	-	-10294	359	179	108	72	-10653	357	23	.04	14	-	-11010
-	-	- 899	372	249	37	86	-1271	2308	52	.13	293	-	-3579
-	-	- 23	102	77	25	0	- 125	1661	-	-	-	-	-1786
-	X	-2618	518	363	52	103	-3136	634i	97	.09	53	15(field ave)	NP
-	X	-2577	516	361	52	103	-3093	640i	8	-	-	15(field ave)	NP
-	-	- 825	240	180	12	48	-1065	113i	8.65	-	-	-	NP
-	-	- 918	242	189	12	41	-1160	168i	-	-	-	-	NP
X	-	-3306	482	323	48	111	-3788	405i	46	.11	41	-	NP
-	-	-2758	448	336	22	90	-3206	1026i	-	-	-	-	NP

TABLE 1. WELL DATA - Illinois (con't)

ILL. WELL NO.	OPERATOR & WELL NAME	YEAR COMP.	COUNTY	LOCATION SEC.	T	R	REFERENCE ELEVATION	T.D.	STATUS	GEOPHYSICAL LOGS GR-N	E	SONIC
31	Schneller No.1 Chicago & NW RR	1957	DuPage	10	39N	9E	760 ETM	2082	WTR	-	X	-
32	- No. 11 Wander		DuPage	10	39N	11E	668	1970	WTR	-	-	-
33	Nelson, Erp & Stroh No.1 Erp		Ford	19	24N	7E	828 TM	4250	O/G ABD	-	-	-
34	- No. 68-1 Aux Sable		Grundy	21	34N	8E	525 GL	1901	GAS	-	-	-
35	No. Ill. Gas No. 1 Harroun		Iroquois	31	27N	3W	652 KB	4005	GAS STG	-	-	-
36	- No. 1 Thomas Kerwin		Jersey	2	6N	13W	750 TM	2680	O/G ABD	-	-	-
37	- No. 5 Galena City		JoDaviess	13	28N	1W	840 TM	1600	WTR	-	-	-
38	- No. 12 Aurora		Kane	15	38N	8E	641	2251	WTR	-	-	-
39	- No. 16 Aurora		Kane	34	38W	8E	655 ETM	2139	WTR	-	-	-
40	- No. 3 Batavia		Kane	22	39N	8E	670 TM	2200	WTR	-	-	-
41	- No. 6 St. Charles		Kane	34	40N	8E	750 ETM	2240	WTR	-	-	-
42	- No. 2 Elgin St. Hospital		Kane	23	41N	8E	760 ETM	2000	WTR	-	-	-
43	Nat.Gas Str.of Ill.No.6 Karcher	1954	Kankakee	32	30N	10E	678	2712	GAS STG	-	X	-
44	Nat.Gas Str.of Ill.No.7 Schwark	1957	Kankakee	32	30N	10E	674	5003	GAS STG	-	X	-
45	- No. 1 Percy Cook		Kankakee	3	30N	9E	622 KB	2320	GAS STG	-	-	-
46	- No. 1 Hughes Parish		Kankakee	24	31N	13E	622 ETM	5050	O/G ABD	-	-	-
47	- No. 2 A. D. Lasker		Lake	7	43N	12E	695	2000	WTR	-	-	-
48	No.Ill.Gas Co.No.1 Butler	1968	LaSalle	5	34N	1E	679 KB	1711	GAS STG	X	-	X
49	No.Ill.Gas Co.No.16 Mathesius		LaSalle	32	35N	1E	690 KB	1626	GAS STG	-	-	-
50	Arco No. 77 Lewis	1973	Lawrence	29	4 N	12W	501 KB	9261	O/G ABD	X	X	X
51	No. Ill. Gas Co. No.1A Fehr	1967	Livingston	27	30N	3E	635 KB	2897	GAS STG	X	X	-
52	No. Ill. Gas Co. No.1 Feinhold	1964	Livingston	33	28N	6E	730 KB	3485	GAS STG	X	X	-
53	No. Ill. Gas Co. No.16 Feinhold	1969	Livingston	32	28N	6E	682 KB	3268	GAS STG	X	-	-
54	Cen.Ill.Pub Ser.Co.No.5-34 Hainline	1971	McDonough	31	7N	3W	749 KB	2764	GAS STG	X	-	X
55	- No. 1 Crystal Lake		McHenry	5	43N	8E	915 TM	2000	WTR	-	-	-
56	- No. 1 Dean Milk Company		McHenry	33	46N	5E	870	1783	WTR	-	-	-
57	No. Ill. Gas Co. No.1 Grimes	1969	McLean	1	24N	2E	799 KB	4234	GAS STG	X	-	-
58	No. Ill. Gas Co. No.1 Anderson		McLean	31	26N	3E	731 KB	4062	GAS STG	-	-	-
59	No. Ill. Gas Co. No.2 Furrow	1971	McLean	31	26N	3E	716 KB	4040	GAS STG	X	X	-
60	No. Ill. Gas Co. No. 1 Houck		McLean	19	26N	3E	764 KB	3988	GAS STG	-	-	-

TABLE 1. WELL DATA - Illinois (con't)

WATER ANALYSES	CORE ANALYSES	CONFINING UNIT					BASAL SANDSTONE UNIT						BASEMENT
		SEA LEVEL ELEVATION	THICKNESS	FEET OF SHALE/ SILTSTONE	FEET OF SAND- STONE	FEET OF CARBONATE	SEA LEVEL ELEVATION	THICKNESS	SAND- SHALE RATIO	AVERAGE POROSITY	POROSITY FEET	PERMEABILITY (MD)	SEA LEVEL ELEVATION
-	-	- 700	345	207	17	121	-1045	277i	~100	-	-	-	NP
-	-	- 736	236	142	12	82	- 972	330i	-	-	-	-	NP
X	-	-2977	445i	298	80	67	NP	-	-	-	-	-	NP
-	-	- 935	407	285	20	102	-1342	34i	-	-	-	-	NP
-	-	-2118	591	502	30	59	-2709	644i	-	-	-	-	NP
-	-	NI	-	-	-	-	-1915	15i	-	-	-	-	NP
-	-	NI	-	-	-	-	- 630	130i	-	-	-	-	NP
-	-	- 729	360	252	36	72	-1089	521i	-	-	-	-	NP
-	-	- 725	365	219	91	55	-1090	394i	-	-	-	-	NP
-	-	- 625	365	245	55	65	- 990	540i	-	-	-	-	NP
-	-	- 605	355	177	71	107	- 960	530i	-	-	-	-	NP
-	-	- 512	363	200	54	109	- 875	365i	-	-	-	-	NP
X	X	-1193	539	404	27	108	-1732	302i	~100	.12	13+	185(field ave)	NP
X	-	-1304	542	407	27	108	-1846	2483i	31	.13	309+	185(field ave)	NP
X	X	-1153	438	328	44	66	-1591	107i	-	-	-	82(field ave)	NP
-	-	-1628	450	338	22	90	-2078	2350i	-	-	-	-	NP
-	-	NI	-	-	-	-	- 665	640i	-	-	-	-	NP
-	-	- 319	180	144	36	0	- 499	533i	65	.17	44+	150(field ave)	NP
-	-	- 315	177	142	35	0	- 492	444i	-	-	-	150(field ave)	NP
-	-	-8085	418	209	42	167	-8503	257i	50	.05	12+	-	NP
-	X	-1327	444	333	44	67	-1771	491i	53	.12	38+	100	NP
X	X	-1825	401	269	60	72	-2226	529i	11	.112	42+	26.7	NP
-	X	-1817	388	260	58	70	-2205	381i	8.3	.09	21+	25(field ave)	NP
-	X	-1633	280	140	112	28	-1913	102i	>100	.12	11+	39(field ave)	NP
-	-	NI	-	-	-	-	- 830	255i	-	-	-		NP
-	-	NI	-	-	-	-	- 695	218i	-	-	-		NP
-	X	-2549	412	321	42	49	-2961	474i	16	.113	41+	34.8	NP
X	X	-2403	407	273	61	73	-2810	521i	-	-	-	42	NP
-	X	-2374	410	275	61	74	-2784	540i	12	.125	61+	36	NP
-	-	-2456	404	271	60	73	-2860	364i	-	-	-	48	NP

TABLE 1. WELL DATA - Illinois (con't)

ILL. WELL NO.	OPERATOR & WELL NAME	YEAR COMP.	COUNTY	LOCATION SEC.	T	R	REFERENCE ELEVATION	T.D.	STATUS	GEOPHYSICAL LOGS GR-N	E	SON
61	No. Ill. Gas Co. No.1 Dady	1972	McLean	14	25N	3E	734 KB	4194	GAS STG	X	-	X
62	No. Ill.Gas Co.No.1 Mary Moore	1960	McLean	22	25N	3E	785 KB	4195	GAS STG	X	X	-
63	No. Ill.Gas Co. No.1 Pyne		McLean	14	25N	3E	746 KB	3960	GAS STG	-	-	-
64	Pan.East No. 1-16 Criswell	1965	Morgan	16	13N	8W	672 KB	4253	O/G ABD	X	X	X
65	Harold Sanders No. 1 Harrison	1964	Moultrie	22	15N	5E	686 KB	6525	O/G ABD	-	X	-
66	Nat.Gas P.L. No.2 Keckler	1963	Ogle	35	24N	7E	805 KB	2130	O/G ABD	X	X	-
67	- No. 1 Christensen Bros.		Rock Island	8	17N	1E	620 TM	3270	WTR ABD	-	-	-
68	- No. 1 Prospect Park		Rock Island	8	17N	1W	611	2368	WTR ABD	-	-	-
69	- No. 701 Witte	1971	Stark	11	13N	5E	757 KB	2821	GAS	-	-	-
70	Lohman & Johnson No.1 Allied Chem.	1972	Vermillion	12	19N	11W	741 KB	6675	DISP ABD	X	-	-
71	Ill. Power Co. No. 1 Moberg	1968	Warren	3	12N	1W	743 KB	2640	O/G ABD	X	X	-
72	- No. 1 J.R. McGlashan		Will	25	35N	12E	712 TM	3095	WTR	-	-	-
73	- No. 6 Rockford Unit		Winnebago	31	44N	2E	790	1376	WTR	-	-	-
74	Humble Oil No. 1 Pickel	1967	Union	21	13S	2W	424 KB	8492	O/G ABD	-	X	X
75	People's Gas No. 5 Hunt		Champaign	17	21N	7E	739 GL		GAS STG	-	-	-
76	People's Gas No. 1 Fee		Champaign	9	21S	7E	742 GL		GAS STG	-	-	-
77	Panhandle Estrn. No. 1-4 Bristow	1970	Douglas	4	16N	8E	679 GL	4414	GAS STG	-	X	-
78	No. Ill. Gas		Iroquois	26	27N	13W	654		GAS STG	-	-	-
79	No. Ill. Gas No. 1 Barr		LaSalle	22	30N	2E	671		GAS STG	-	-	-
80	No. Ill. Gas No. 2 Krischel		LaSalle	24	30N	3E	663		GAS STG	-	-	-
81	No. Ill. Gas No. 1 Fordyce		Livingston	33	30N	3E	640		GAS STG	-	-	-
82	No. Ill. Gas No. 1 Schlosser		McLean	32	25N	3E	776		GAS STG	-	-	-
83	No. Ill. Gas No. 1 Smith		McLean	20	25N	4E	746		GAS STG	-	-	-
84	Panhandle Estrn. No. 7-15 Whitlock	1965	Morgan	15	13N	8W	640	2136	GAS STG	-	X	-

TABLE 1. WELL DATA - Illinois (con't)

WATER ANALYSES	CORE ANALYSES	CONFINING UNIT					BASAL SANDSTONE UNIT						BASEMENT
		SEA LEVEL ELEVATION	THICKNESS	SHALE/ SILTSTONE	FEET OF SAND-STONE	FEET OF CARBONATE	SEA LEVEL ELEVATION	THICKNESS	SAND-SHALE RATIO	AVERAGE POROSITY	POROSITY FEET	PERMEABILITY (MD)	SEA LEVEL ELEVATION
		-2504	442	287	66	89	-2946	514i	22	.10	43+	-	NP
X		-2650	449	292	67	90	-3099	311i	23	.11	25+	44.6	NP
		NI	-	-	-	-	NI	-	-	-	-	46.9	NP
X		-3208	240	168	12	60	-3448	133i	7	.11	12+	-	NP
		-5266	340	255	17	68	-5606	233i	10	-	-	-	NP
		- 27	156	78	78	0	- 183	1142i	~ 50	.13	117+	-	NP
		NI	-	-	-	-	-1680	970i	-	-	-	-	NP
		-1479	125	75	25	25	-1604	153i	-	-	-	-	NP
		-1649	204	143	41	20	-1853	211i	-	-	-	-	NP
X		-3689	700	455	175	70	-4389	1545i	15	.10	143+	25	NP
X		-1514	215	118	75	22	-1729	168i	~100	.155	19+	-	NP
		-1106	338	253	17	68	-1444	939i	-	-	-	-	NP
		- 25	105	68	26	11	- 130	456i	-	-	-	-	NP
		NI	-	-	-	-	-7976	92i	~6.0	.075	6+	-	NP
X	-	NI	-	-	-	-	-3150	-	-	-	-	-	?
X	-	NI	-	-	-	-	-3140	-	-	-	-	-	?
X	-	NI	-	-	-	-	-3215	516i	~100	.12	62+	-	NP
X	-	NI	-	-	-	-	-2900	-	-	-	-	-	?
X	X	NI	-	-	-	-	-1570	-	-	-	-	116	?
X	X	NI	-	-	-	-	-1470	-	-	-	-	109	?
X	X	NI	-	-	-	-	-1420	-	-	-	-	63	?
X	X	NI	-	-	-	-	-3170	-	-	-	-	61.1	?
X	X	NI	-	-	-	-	-3100	-	-	-	-	38.3	?
X	-	NI	-	-	-	-	-3448	1952i	-	.13	-	-	NP

TABLE 2. WELL DATA - Indiana

IND. WELL NO.	OPERATOR & WELL NAME	YEAR COMP.	COUNTY	LOCATION			REFERENCE ELEVATION	T.D.	STATUS	GEOPHYSICAL LOGS		
				SEC.	T	R				E	GR-N	SONIC
1	Tecumseh No. 1 Gibson	1947	Allen	33	29N	12E	822	3517	O/G ABD	X	-	-
2	NIPSCO No. 1 Leyenberger	1968	Allen	14	29N	14E	797	3672	O/G ABD	X	X	X
3	Gulf No. 1 Scott	1965	Fayette	32	13N	13E	959 KB	3955	O/G ABD	X	-	X
4	NIPSCO No. 2 Pheil	1967	Fulton	32	29N	1E	750	4056	GAS ST	-	X	-
5	Ohio No. 1 May	1945	Henry	12	16N	11E	1060	3664	O/G ABD	-	-	-
6	Kokomo No. 1 Greentown	1911	Howard	32	24N	5E	821	3996	O/G ABD	-	-	-
7	Petroleum No. 1 Binegar	1940	Jay	29	24N	13E	948	3404	O/G ABD	-	-	-
8	Farm Bureau No. 1 Binegar	1944	Jay	29	24N	13E	949	3395	O/G ABD	-	-	-
9	Inland No. Wd-1 Inland	1967	Lake	14	37N	9W	608 KB	4363	O/D ABD	-	-	-
10	Farm Bureau (Texas-2614) No. 1 Brown	1959	Lawrence	20	5N	2E	800 KB	6806	DISP	X	X	X
11	NIPSCO No. 1 Ames	1969	Marshall	21	34N	3E	789	4082	GAS ST	X	X	X
12	Stoltenberg No. WD-1 Indiana	1969	Porter	16	35N	5W	784 KB	4548	O/D ABD	X	X	X
13	Bethlehem No. WD-1 Bethlehem	1963	Porter	28	37N	6W	625 KB	4304	DISP	-	X	-
14	Bethlehem No. WD-2C Bethlehem	1968	Porter	29	37N	6W	624 KB	4301	DISP	X	X	X
15	Midwest No. WD-1 Midwest	1964	Porter	25	37N	7W	615 KB	4308	DISP	-	X	X
16	Swager No. 1 Swager	1970	Steuben	15	38N	14E	1058 KB	6866	DISP	X	X	X
17	Ashland No. 1 Collins	1965	Switzerland	4	2N	1W	880 KB	4000	O/G ABD	X	X	X
18	Ashland No. 1 Hudson	1965	Wabash	25	29N	6E	787 KB	3685	O/G ABD	X	X	-
19	Gordon No. 1 Doddridge	1950	Wayne	23	15N	13E	957	3907	O/G ABD	X	X	X
20	Parker No. 1 Ashbaugh	1961	Allen	5	31N	11E	851	3501	O/G ABD	-	-	-
21	NIPSCO No. 1 Wakeland	1961	Allen	33	32N	12E	856	3571	O/G ABD	X	X	X
22	Casterline No. 1 Casterline		Blackford	25	24N	10E	885	3505	O/G AB	-	X	-
23	Reed No. 1 Cale	1939	Blackford	20	24N	11E	892	3302	O/G ABD	-	X	-
24	NIPSCO No. 1 Burton	1969	Cass	6	28N	1E	732	3138	O/G ABD	-	-	-
25	NIPSCO No. 1 Conn	1966	Cass	14	28N	1W	746 KB	3010	GAS ST	-	X	-
26	Gulf No. 1 Lamping	1965	Franklin	29	11N	12E	759 KB	3470	GAS ST	X	X	X
27	Gulf No. 1 Lohrey	1965	Franklin	3	11N	13E	717 KB	3336	O/G ABD	X	-	X
28	NIPSCO No. 1 Overmyer	1970	Jasper	16	29N	5W	693	3195	O/G ABD	X	-	X
29	Kankakee No. 1 Bank Rensselaer	1947	Jasper	14	30N	6W	684	3373	O/G AB	-	X	-
30	NIPSCO No. 1 Boezman	1966	Jasper	6	31N	7W	668	3658	O/G ABD	-	-	-

TABLE 2. WELL DATA - Indiana

WATER ANALYSES	CORE ANALYSES	CONFINING UNIT					BASAL SANDSTONE UNIT						BASEMENT
		SEA LEVEL ELEVATION	THICKNESS	FEET OF SHALE/ SILTSTONE	FEET OF SAND- STONE	FEET OF CARBONATE	SEA LEVEL ELEVATION	THICKNESS	SAND- SHALE RATIO	AVERAGE POROSITY	POROSITY FEET	PERMEABILITY (MD)	SEA LEVEL ELEVATION
-	-	-1598	500	460	0	40	-2098	556	9.6	-	-	-	-2654
-	X	-1699	594	511	12	71	-2293	394	0	.22	75	13	-2687
-	-	-1921	532	516	0	16	-2453	502	14	.12	55	-	-2955
-	-	-1420	601	523	48	30	-2021	1141	34.6	.05	55	-	-3162
-	-	-1655	550	484	16	50	-2205	385	-	-	-	-	-2590
-	-	-1524	510	439	0	71	-2034	1070	-	-	-	-	-3104
-	-	-1372	560	-	-	-	-1932	471	-	-	-	-	-2403
-	-	-1343	598	502	6	90	-1941	443	-	-	-	-	-2384
X	X	-1202	239	187	26	26	-1441	2284	58	.15	318	300	-3725
-	-	-4010	681	633	21	27	-4691	1159	6.6	-	-	-	-5850
-	-	-1657	494	405	89	0	-2161	950	10.7	.15	130	-	-3111
X	-	-1393	233	219	12	2	-1626	2119	13.8	.09	150	-	-3745
X	-	-1334	231	159	42	30	-1565	2058	14.6	.13	208	-	-3623
X	-	-1328	234	-	-	-	-1562	2075	10.8	.13	207	-	-3637
X	-	-1313	231	-	-	-	-1544	2093	54	.16	277	45	-3637
-	-	-2938	519	441	31	47	-3457	374	100	.07	23	-	-3831
-	-	-2252	496	466	0	30	-2748	346	7	.115	28	-	-3094
-	-	-1498	630	567	0	63	-2128	739	17.3	.11	68	-	-2867
-	-	-1733	445	432	4	9	-2178	300	-	-	-	-	-2478
-	-	-1815	594	493	89	12	-2409	291i	100	.135	22+	-	NP
-	X	-1850	574	522	52	0	-2424	291i	55.5	.05	111+	48	NP
-	-	-1523	543	-	-	-	-2066	554i	-	-	-	-	NP
-	-	-1398	625	531	25	69	-2023	387i	-	-	-	-	NP
-	-	-1554	597	-	-	-	-2151	255i	-	-	-	-	NP
-	-	-1438	602	-	-	-	-2040	224i	3	.035	5+	-	NP
-	-	-2079	548	510	0	38	-2627	84i	5.3	.135	9+	-	NP
-	-	-1981	539	512	0	27	-2520	99i	4	.15	12+	-	NP
-	-	-1491	556	-	-	-	-2047	455i	66	.085	38+	-	NP
-	-	-1570	564	446	79	39	-2134	555i	-	-	-	-	NP
-	-	-1518	452	321	81	50	-1970	1020i	-	-	-	-	NP

TABLE 2. WELL DATA - Indiana (con't)

IGC WELL NO.	OPERATOR & WELL NAME	YEAR COMP.	COUNTY	LOCATION SEC.	T	R	REFERENCE ELEVATION	T.D.	STATUS	GEOPHYSICAL LOGS E	GR-N	SONIC
31	Continental No. 1 Resur	1960	Jay	31	23N	13E	922	3100	O/G ABD	X	X	X
32	EEL River No. 1 Blocher	1951	Kosciusko	12	30N	6E	855	3295	O/G ABD	-	-	-
33	NIPSCO No. 1 Hayden	1966	Lake	30	32N	8W	640	3052	GAS ST. ABD	X	X	X
34	Dome No. 1 Industrial	1930	Lake	22	36N	9W	623	2458	O/G ABD	-	-	-
35	U.S. Steel No. WD-1 U.S. Steel	1965	Lake	29	37N	8W	600 KB	4303	DISP.	X	X	X
36	NIPSCO No. 1 Hamstra	1965	Newton	3	31N	8W	658	3021	O/G ABD	X	X	-
37	NIPSCO No. 1 Shelhart	1966	Newton	34	32N	8W	642	3021	GAS ST.	X	X	X
38	Comanche No. 1 Pippenger	1965	Noble	15	33N	10E	971 KB	3694	O/G ABD	-	X	-
39	Bethlehem No. WD-1C Bethlehem	1968	Porter	30	37N	6W	624 KB	3945	DISP.	-	X	X
40	NIPSCO No. O-46 Haselby	1972	Pulaski	25	29N	1W	735	3029	SWD	X	-	-
41	NIPSCO No. 1 Hanawalt	1971	Pulaski	16	29N	2W	690	3106	O/G ABD	-	X	-
42	NIPSCO No. 2 Good	1971	Pulaski	26	29N	3W	685	3151	GAS ST.	X	X	X
43	Sanders No. 1 Lowry	1971	Pulaski	15	29N	4W	675	2900	O/G ABD	-	X	-
44	Central No. 16T52 Edward	1966	Randolph	16	19N	13E	1146	3352	O/G ABD	-	X	-
45	Food No. WD-1 Newport	1960	Vermillion	9	16N	9W	650 KB	6160	DISP.	X	X	X
46	Wayne No. 1 Taylor	1943	Wayne	22	13N	1W	1030	3330	O/G ABD	-	-	-
47	NIPSCO No. 0-85 Johnson	1965	Cass	12	28N	1W	751 KB		GAS ST. OBS	X	X	-
48	NIPSCO No. 1 Finnell	1966	Cass	17	28N	1W	711 GL	3077	GAS ST. OBS	X	X	-
49	NIPSCO No. 1 Pfeil	1966	Fulton	30	29N	1E	750 GL	4051	GAS ST.	X	X	X
50	NIPSCO No. 2 Sommers	1968	Fulton	20	29N	1E	740 GL		GAS ST.	X	X	X

TABLE 2. WELL DATA - Indiana (con't)

WATER ANALYSES	CORE ANALYSES	CONFINING UNIT					BASAL SANDSTONE UNIT							BASEMENT
		SEA LEVEL ELEVATION	THICKNESS	FEET OF SHALE/ SILTSTONE	FEET OF SAND-STONE	FEET OF CARBONATE	SEA LEVEL ELEVATION	THICKNESS	SAND-SHALE RATIO	AVERAGE POROSITY	POROSITY FEET	PERMEABILITY (MD)		SEA LEVEL ELEVATION
-	-	-1483	545	485	0	33	-2028	150i	14.3	.17	15+	-		NP
-	-	-1545	475	399	0	19	-2020	420i	-	-	-	-		NP
-	-	-1549	455	-	-	-	-2004	408i	2	.13	20+	-		NP
-	-	-1275	366	-	-	-	-1641	194i	-	-	-	-		NP
X	X	-1238	240	-	-	-	-1478	2225i	25.3	.14	269+	420		NP
-	-	-1520	437	-	-	-	-1957	406i	1.5	-	-	-		NP
-	-	-1521	431	-	-	-	-1952	427i	2.9	.075	14+	-		NP
-	-	-1953	576	409	92	75	-2529	194i	~100	.11	12+	-		NP
-	-	-1322	235	-	-	-	-1557	1764i	-	-	-	-		NP
-	-	-1490	602	-	-	-	-2092	202i	-	-	-	-		NP
-	-	-1378	599	-	-	-	-1977	439i	-	-	-	-		NP
-	-	-1357	608	-	-	-	-1965	501i	4.5	.115	25+	-		NP
-	-	-1465	591	-	-	-	-2056	169i	-	-	-	-		NP
-	-	-1546	453	426	9	18	-1999	207i	6.8	.16	11+	11		NP
X	X	-4175	622	522	44	56	-4797	713i	140	.07	49+	-		NP
-	-	-1650	530	451	0	79	-2180	120i	-	-	-	-		NP
X	-	-1442	596	-	-	-	-2038	251i	-	-	-	-		NP
X	-	-1488	609	-	-	-	-2087	268i	4.6	.035	9+	-		NP
X	-	-1417	599	-	-	-	-2016	282i	34.6	.05	55	-		NP
X	-	-1454	603	-	-	-	-2057	203i	-	-	-	-		NP

TABLE 3. WELL DATA - Kentucky

KEN. WELL NO.	OPERATOR & WELL NAME	YEAR COMP.	COUNTY	LOCATION (CARTER COORDINATES)			REFERENCE ELEVATION	T.D.	STATUS	GEOPHYSICAL LOGS		
										GR-N	E	SONIC
1	Ashland O & R No. 1 Tartar	1965	Adair	24	I	54	858 KB	6677	O/G ABD	X	X	X
2	United Fuel Gas No. 2 Knuckles	1960	Bell	5	C	71	1491 KB	10034	O/G ABD	X	X	-
3	Ford No. 1 Conners	1960	Boone	9	EE	58	908 DF	4090	O/G ABD	-	-	-
4	Cont. Oil No. 1 Snow	1959	Boone	5	DD	58	865 KB	3215	O/G ABD	X	-	X
5	Inland Gas No. 537 Fannin	1969	Boyd	22	W	82	709 KB	7828	GAS	X	X	-
6	Inland Gas No. 533 Fee	1968	Boyd	11	V	81	862 KB	9595	O/G ABD	X	X	-
7	Inland Gas No. 535 McKeand	1968	Boyd	25	W	83	868 KB	9449	O/G ABD	X	X	-
8	Inland Gas No. 551 Smallridge		Boyd	25	W	83	703 GR	8420		-	-	-
9	Inland Gas No. 529 White	1967	Boyd	21	W	82	652 KB	7676	OIL	X	X	-
10	United Fuel Gas No. 8613 Williams	1958	Breathitt	13	M	75	762 KB	11130	O/G ABD	X	X	-
11	Ashland O & R No. 1 Wilson	1966	Campbell	25	DD	62	758 DF	3604	O/G ABD	X	X	-
12	Tri-State Pet. No. 1 Schmidt	1970	Campbell	19	DD	61	695 GR	2977	O/G ABD	-	-	-
13	Inland Gas No. 547 Duncan	1973	Carter	25	W	77	973 GR	5065	O/G ABD	-	-	-
14	Inland Gas No. 538 Fee	1969	Carter	14	V	81	778 GR	7272	O/G ABD	-	-	-
15	Inland Gas No. 546 McDavid	1972	Carter	22	U	79	808 KB	9980	O/G ABD	-	-	-
16	Monitor Pet. No. 1 Robinson	1972	Carter	23	U	79	675 KB	7824	O/G ABD	-	-	-
17	United Fuel Gas No. 8807 Stampner	1959	Carter	3	V	77	857 KB	5085	O/G ABD	X	X	-
18	Cabot Crop.& Ashland No.1 Stapleton	1966	Carter	12	V	77	956 KB	5251	O/G ABD	-	-	-
19	Ashland O & R No. 1 Miller	1967	Clark	16	S	65	949 KB	3425	O/G ABD	X	X	-
20	Widener No. 1 Glover	1972	Clark	18	R	66	907 GR	4690	O/G ABD	-	-	-
21	Texaco No. 1 Williams	1969	Clark	9	Q	64	661 KB	4937	O/G ABD	X	-	X
22	Day & Algonquin No. 1 Hubbard	1965	Clay	22	I	67	1160 GR	6389	OIL	X	X	-
23	Monitor Pet. No. 1 Ison	1970	Elliot	8	T	79	C86 KB	9665	O/G ABD	X	X	X
24	Monitor Pet. No. 2 Ison	1973	Elliot	13	T	79	793 KB	9473	GAS	-	-	-
25	United Fuel Gas No. 1 Litton	1960	Elliot	23	T	76	968 KB	5394	O/G ABD	X	X	-
26	Texaco No. 1 Tipton	1969	Estill	21	O	66	639 GR	6817	O/G ABD	-	X	X
27	Signal O & G No. 1 Hall	1974	Floyd	1	L	81	677 GR	13035	O/G ABD	-	-	-
28	Clinton Oil No. 1-V Hale	1968	Garrard	15	O	61	695 KB	5538	O/G ABD	X	X	-
29	Patrick Pet. No.1 Broadus & Tussey	1969	Garrard	15	N	61	937 GR	5080	O/G ABD	-	X	X
30	Peter Widener No. 1 Burdette	1972	Garrard	7	N	59	817 GR	4465	O/G ABD	-	-	-

TABLE 3. WELL DATA - Kentucky

WATER ANALYSES	CONFINING UNIT		BASAL SANDSTONE UNIT					BASEMENT
	SEA LEVEL ELEVATION	THICKNESS	SEA LEVEL ELEVATION	THICKNESS	SAND-SHALE RATIO	AVERAGE POROSITY	POROSITY FEET	SEA LEVEL ELEVATION
-	-4047	1140	-5187	632i	.21	.07	8+	NP
-	-6957	1375	-8332	211i	-	-	-	NP
-	-1955	562	-2517	293	-	-	-	-2810
-	-2032	318i	NP	-	-	-	-	NP
-	-5408	494	-5902	101	-	-	-	-6003
X	-5642	1142	-6784	863	0.29	.066	13	-7647
-	-6152	1385	-7537	981	0.23	.066	12	-8518
-	-	-	-	-	-	-	-	-
X	-5882	1142i	NP	-	-	-	-	NP
-	-5883	4322	-10205	44	-	-	-	-10249
-	-1850	782	-2632	112	-	-	-	-2744
-	-1817	453	-2270	12i	-	-	-	NP
-	-	-	-	-	-	-	-	-
-	-5237	887	-6124	254	-	-	-	-6378
-	-5500	2384	-7884	934	-	-	-	-8818
-	-5508	1543	-7051	98i	-	-	-	NP
X	-3708	431	-4139	57	1.4	.095	3	-4196
-	-3802	362	-4164	111	-	-	-	-4275
-	-1735	360	-2101	112	3.8	.095	2	-2213
-	-2700	1083i	NP	-	-	-	-	NP
-	-2372	1606	-3978	127	-	-	-	-4105
-	-4626	603i	NP	-	-	-	-	NP
-	-5614	2498	-8112	867i	-	-	-	NP
-	-5529	2918	-8447	233i	-	-	-	NP
-	-3832	380	-4212	10	1.8	.095	3	-4222
-	-3559	2113	-5672	506i	7.8	.04	9+	NP
-	NI	-	-12013	162	-	-	-	-12175
X	-2771	1126	-3897	946i	0.32	.07	16+	NP
-	-2907	1187	-4094	49i	-	-	-	NP
-	-2741	907i	NP	-	-	-	-	NP

TABLE 3. WELL DATA - Kentucky (con't)

KEN. WELL NO.	OPERATOR & WELL NAME	YEAR COMP.	COUNTY	LOCATION (CARTER COORDINATES)			REFERENCE ELEVATION	T.D.	STATUS	GEOPHYSICAL LOGS GR-N	E	SONI
31	L & M Gas No. 1 Causey	1969	Garrard	10	M	61	931 KB	5497	O/G ABD	–	–	–
32	Tartan Oil No. 1 Graham	1970	Garrard	8	O	59	965 KB	4632	O/G ABD	–	–	–
33	Texaco No. 1 Kirby	1968	Garrard	8	O	59	972 KB	5745	O/G ABD	X	X	X
34	Ford No. 1 Delaney	1966	Grant	6	Y	60	867 GR	3557	O/G ABD	–	–	–
35	Texas Gas Trans. No. 1 Shain Drlg.		Grayson	10	L	36	692 GR	D R I L L	I N G	–	–	–
36	Moore Oil No. 1 Perkins	1963	Green	7	I	48	675 GR	5385	O/G ABD	–	–	–
37	Commonwealth Gas No. 1 New Ell	1968	Greenop	7	Z	78	1055 KB	5195	O/G ABD	–	–	–
38	Kin-Ark Oil No. 1 Hager	1965	Jessamine	2	P	60	797 KB	4944	O/G ABD	X	X	–
39	Texaco No. 1 Scherrer	1966	Jessamine	6	P	60	956 KB	5800	O/G ABD	X	X	X
40	Texaco No. 1 Wolfinbarger	1968	Jessamine	1	P	60	966 GR	6072	O/G ABD	X	X	X
41	DuPont No. 1 Fee	1973	Jefferson	10	U	44	465 KB	6008	DISP.	–	–	–
42	Signal O & G No. 1 Elkhorn	1973	Johnson	7	P	82	732 KB	14566	O/G ABD	–	–	–
43	Columbia No. 9784 Evans	1973	Johnson	10	R	79	729 KB	10000	O/G ABD	–	–	–
44	Sober No. 3 Cumberland Mins	1968	Laurel	7	F	63	1160 GR	7343	O/G ABD	X	–	–
45	Inland Gas No. 542 Young	1971	Lawrence	6	U	82	884 KB	12712	O/G ABD	–	–	–
46	United Fuel Gas No. 28 Fordson	1958	Leslie	8	I	73	1191 KB	9432	O/G ABD	–	–	–
47	Ralph Thomas No. 1 Adams	1960	Lewis	13	Y	76	560 KB	4190	O/G ABD	X	X	–
48	United Fuel Gas No. 9060 Shepherd	1961	Lewis	19	W	75	915 KB	4450	O/G ABD	X	X	–
49	Ashland No. 1 Wolfe	1968	Lewis	13	Y	77	1113 KB	5080	O/G ABD	X	–	–
50	Rome O & G No. 1 Foster-Morrow	1970	Lincoln	13	M	58	1032 KB	5781	O/G ABD	X	X	–
51	California Co. No. 1 Spears	1946	Lincoln	13	L	57	1125 GR	6117	O/G ABD	–	X	–
52	Texaco No. 1 Perkins	1969	Madison	11	P	61	951 KB	6420	O/G ABD	X	X	X
53	United Fuel Gas No. 8610 James	1959	Martin	19	Q	84	659 KB	13172	O/G ABD	–	–	–
54	United Fuel Gas No. 9061 Rawlings	1961	Mason	15	Y	71	769 KB	3310	O/G ABD	X	X	–
55	United Fuel Gas No. 9380 Brown	1967	Menifee	21	S	72	989 KB	5858	O/G ABD	X	X	–
56	Benz Oil No. 1 Nunnally	1966	Metcalfe	16	F	46	766 KB	6114	O/G ABD	X	–	–
57	Ferg. & Bros. No. 16-1 Porter	1964	Montgomery	8	R	67	989 KB	5500	O/G ABD	X	X	–
58	Monitor Pet. No. 1 Blanton	1974	Morgan	23	R	73	986 GR	7608	O/G ABD	–	–	–
59	Monitor Pet. No. 1 Ison	1971	Morgan	3	R	78	821 KB	10012	O/G ABD	X	X	X
60	Ashland O & R No. 1 Lee Clay	1969	Morgan	14	S	75	789 KB	5757	O/G ABD	X	X	X

TABLE 3. WELL DATA - Kentucky

WATER ANALYSES	CONFINING UNIT		BASAL SANDSTONE UNIT					BASEMENT
	SEA LEVEL ELEVATION	THICKNESS	SEA LEVEL ELEVATION	THICKNESS	SAND-SHALE RATIO	AVERAGE POROSITY	POROSITY FEET	SEA LEVEL ELEVATION
-	-3266	1300i	NP	-	-	-	-	NP
-	-2718	949i	NP	-	-	-	-	NP
-	-2718	922	-3640	1028	0.42	.06	15	-4668
-	-1998	523	-2521	169i	-	-	-	NP
-	-	-	-	-	-	-	-	-
-	-4585	125i	NP	-	-	-	-	NP
-	-3519	506	-4025	100	-	-	-	-4125
-	-2471	1007	-3478	305	0.69	.11	14	-3783
-	-1934	117	-2051	272	-	-	-	-2323
-	-2542	1022	-3564	1530	0.29	.097	33	-5040
X	-3846	892	-4738	751	-	-	-	-5489
-	-6951	-	-	-	-	-	-	-13563
-	-5663	3408i	NP	-	-	-	-	NP
-	-5505	678i	NP	-	-	-	-	NP
-	-6676	4380	-11056	610	-	-	-	-11666
-	-5996	1961	-7957	264	-	-	-	-8221
-	-3064	486	-3550	48	-	-	-	-3598
-	-3120	465	-3585	35	0.84	.14	2	-3620
-	-3353	484	-3837	74	0.37	.13	3	-3911
-	-3303	1055	-4358	391i	0.47	.07	8	NP
-	-3119	866	-3985	650	-	-	-	-4635
-	-2609	1294	-3903	1516	0.18	.085	20	-5419
-	-7655	4172	-11827	686i	-	-	-	NP
-	-1921	584	-2505	8	3.0	.13	1.0	-2513
-	-3431	850	-4281	530	0.75	.107	24	-4811
-	-4351	700	-5051	67	-	-	-	-5118
-	-2409	965	-3374	27	4.4	.08	2	-3401
-	-	-	-	-	-	-	-	-
-	-5349	3236	-8585	606i	0.5	.05	10	NP
-	-3851	496	-4347	407	0.31	.095	12	-4754

TABLE 3. WELL DATA - Kentucky

KEN. WELL NO.	OPERATOR & WELL NAME	YEAR COMP.	COUNTY	LOCATION (CARTER COORDINATES)			REFERENCE ELEVATION	T.D.	STATUS	GEOPHYSICAL LOGS		
										GR-N	E	SONI
61	Monitor Pet. No. 1 Rice & Trimble	1974	Morgan	4	R	78	873 GR	5200	O/G ABD	-	-	-
62	Monitor Pet. No. 1 Stacy	1974	Morgan	18	Q	74	805 GR	7874	O/G ABD	-	-	-
63	Tenn. Corp. No. BT-3 O'Donovan	1966	Owen	7	Y	55	467 GR	2901	STRAT. TST.	-	-	-
64	Signal O & G No. 1 Stratton	1971	Pike	8	L	85	1199 KB	12471	O/G ABD	-	-	-
65	S. Cent. Pet. No. 1 Hall	1949	Powell	8	P	67	755 GR	6081	O/G ABD	-	-	-
66	Amerada-Hess No. 1 Daulton	1969	Pulaski	14	H	59	1062 KB	6725	O/G ABD	X	X	X
67	Amerada-Hess No. 1 Edwards	1969	Pulaski	24	H	60	968 KB	8868	O/G ABD	X	X	X
68	P. Henderson Oil No. 1 Bailey	1969	Rowan	19	U	72	737 KB	3802	O/G ABD	X	X	-
69	Pennzoil No. 1 Jones	1965	Rowan	4	T	75	1201 KB	4991	O/G ABD	X	X	X
70	Ken. Cent. & Co. No. 1 Perkins	1972	Rowan	21	T	74	1240 KB	4977	O/G ABD	-	-	-

TABLE 3. WELL DATA - Kentucky (con't)

WATER ANALYSES	CONFINING UNIT		BASAL SANDSTONE UNIT					
	SEA LEVEL ELEVATION	THICKNESS	SEA LEVEL ELEVATION	THICKNESS	SAND-SHALE RATIO	AVERAGE POROSITY	POROSITY FEET	SEA LEVEL ELEVATION
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-2319	115i	NP	-	-	-	-	NP
-	-7961	3235	-11196	25	-	-	-	-11221
-	-3295	1852	-5147	179	-	-	-	NP
-	-3906	1403	-5308	300	0.49	.055	5	-5608
-	-4210	2622	-6832	1040	0.23	.065	13	-7872
-	-2613	321	-2934	108	0.91	.09	5	-3042
-	-3324	418	-3742	23	1.09	.08	1.0	-3765
-	-3338	292	-3630	98	-	-	-	-3728

TABLE 4. WELL DATA - New York

NEW YORK WELL NO.	OPERATOR & WELL NAME	YEAR COMP.	COUNTY	LOCATION (TOWNSHIP)	REFERENCE ELEVATION	T.D.	STATUS	GEOPHYSICAL LOGS GR-N	E	SON
1	Pennzoil No. 1 Harrington	1964	Chautauqua	Ellery	1760 GL	7692	O/G ABD	-	-	-
2	Minard Run Oil No. 1 Gage	1964	Chautauqua	Ellery	1524 GL	6292	GAS	-	-	-
3	Humble Oil No. 1 Shadle	1962	Chautauqua	Cherry Creek	1617 DF	6281	O/G ABD	X	-	-
4	- No. 2 Neihaus		Chautauqua		646 GL	4510		-	-	-
5	Iroquois Gas No. 1 Ellis		Cattaraugus	Perrysburg	1328 GL			X	-	-
6	Beth. Steel No. 68-D2 WD	1968	Erie	Hamburg	583 GL	4313	DISP.	-	-	-
7	Hooker Chem. No. 68-D3 WD	1968	Niagara	Niagara Falls	579 DF	3058	DISP.	X	X	-
8	- No. 1 Enterprise Transit		Cattaraugus		2295 KB			-	-	-
9	Parsons Bros. No. 2 Cook	1960	Allegany	Hume	1672 DF	7337	O/G ABD	-	-	-
10	N.Y.S. Nat. Gas No. 1 Wolfer	1963	Allegany	Hume	1572 GL	7560	O/G ABD	X	-	-
11	- No. 1 Wilson		Wyoming		1483 DF	7144	O/G ABD	-	-	-
12	N.Y.S. Nat. Gas No. 1 Veith	1961	Wyoming	Gainesville	1573 KB	7182	O/G ABD	X	-	-
13	N.Y.S. Nat. Gas No. 1 Werner	1964	Wyoming	Orangeville	1609 DF	5722	O/G ABD	-	-	-
14	Flanigan Bros. No. 1 Fisher	1969	Wyoming	Warsaw	1504 DF	5718	O/G ABD	-	-	-
15	N.Y.S. Nat. Gas No. 1 McClurg	1964	Livingston	York	986 DF	5644	O/G ABD	X	X	-
16	N.Y.S. Nat. Gas No. 1 McDonald	1961	Livingston	York	881 GL	5090	O/G ABD	X	-	-
17	N.Y.S. Nat. Gas No. 1 Johnson	1964	Livingston	Caledonia	795 DF	4839	O/G ABD	X	-	-
18	Duchscherer No. 1 Klotzbach	1967	Genesee	Alabama	862 GL	3952	O/G ABD	-	-	-
19	Duchscherer No. 1 Brundage	1967	Genesee	Alabama	733 DF	3600	O/G ABD	X	X	-
20	Blair & Assoc. No. 1 Tyler	1964	Genesee	Byron	712 DF	3998	O/G ABD	X	X	X
21	Ashland O & R No. 1 Naylor	1966	Genesee	Byron	666 GL	3410	O/G ABD	X	X	-
22	Hammerstone No. 1 Wolfe	1965	Niagara	Somerset	329 GL	2159	O/G ABD	-	-	-
23	F.M.C. Corp. No. 68-D1 WD	1968	Niagara	Royalton	549 DF	3192	DISP.	-	-	-
24	Duchscherer No. 1 Weil	1966	Orleans	Yates	319 GL	2041	O/G ABD	-	-	-
25	Duchscherer No. 1 Green	1966	Orleans	Carlton	277 GL	2029	O/G ABD	-	-	-
26	Duchscherer No. 1 Searles	1966	Orleans	Yates	350 GL	2225	O/G ABD	-	-	-
27	Duchscherer No. 1 Morrison	1966	Orleans	Yates	335 DF	2760	O/G ABD	X	X	-
28	Duchscherer No. 1 Helfer	1966	Orleans	Carlton	297 GL	2217	O/G ABD	-	-	-
29	Weaver Expl. No. 1 Brakenbury	1964	Orleans	Carlton	359 GL	2234	O/G ABD	X	-	-
30	Duchscherer No. 1 Woolston	1967	Orleans	Gaines	364 GL	2345	O/G ABD	X	X	-

TABLE 4. WELL DATA - New York

WATER ANALYSES	CORE ANALYSES	BASAL SANDSTONE UNIT SEA LEVEL ELEVATION	THICKNESS	SAND-SHALE RATIO	AVERAGE POROSITY	POROSITY FEET	PERMEABILITY (MD)	BASEMENT SEA LEVEL ELEVATION
–	–	-5840	92i	–	–	–	–	NP
–	–	NP	–	–	–	–	–	NP
–	–	NP	–	–	–	–	–	NP
–	–	NP	–	–	–	–	–	NP
–	–	-4902	220	–	–	–	–	-5122
X	X	-3575	187	1/0	.05	9	113	-3762
X	X	-2321	126	3.6	.075	7	7	-2447
–	–	-8565	215				–	-8760
–	–	NP	–	–	–	–	–	NP
–	–	NP	–	–	–	–	–	NP
–	–	-5487	174i				–	NP
–	–	-5532	75i	–	–	–	–	NP
–	–	NP	–	–	–	–	–	NP
–	–	NP	–	–	–	–	–	NP
–	–	-4459	105	1.8	.045	3	–	-4564
–	–	NP	–	–	–	–	–	NP
–	–	NI	–	–	–	–	–	-3945
–	–	-2948	37				–	-2985
–	–	-2810	57i	6.13	.105	5+	–	NP
–	–	-3031	70	6.00	.077	5	–	-3101
–	–	-2656	88i	3.9	.095	7+	–	NP
–	–	NI	–	–	–	–	–	-1665
–	–	NI	–	–	–	–	–	-2216
–	–	NI	–	–	–	–	–	-1676
–	–	NI	–	–	–	–	–	-1708
–	–	-1827	23				–	-1850
–	–	-1825	25	–	–	–	–	-1850
–	–	NI	–	–	–	–	–	-1788
–	–	NI	–	–	–	–	–	-1834
–	–	-1888	88	4.5	.075	5		-1976

TABLE 4. WELL DATA - New York (con't)

NEW YORK WELL NO.	OPERATOR & WELL NAME	YEAR COMP.	COUNTY	LOCATION (TOWNSHIP)	REFERENCE ELEVATION	T.D.	STATUS	GEOPHYSICAL LOGS GR-N	E	SONIC
31	Duchscherer No. 1 Herman	1966	Orleans	Kendall	316 GL	2559	O/G ABD	X	X	-
32	Duchscherer No. 1 Nowack	1967	Orleans	Kendall	354 GL	2325	O/G ABD	X	X	-
33	Duchscherer No. 1 Malone	1966	Orleans	Gaines	434 GL	2567	O/G ABD	X	-	-
34	Duchscherer No. 1 Thaxter	1967	Orleans	Ridgeway	501 GL	2664	O/G ABD	X	-	-
35	Hammerstone No. 1 Cook	1965	Orleans	Shelby	612 GL	2983	O/G ABD	X	X	-
36	Duchscherer No. 1 Domoy	1967	Orleans	Shelby	630 GL	3152	O/G ABD	X	-	-
37	Humble Oil No. 1 Kelly	1965	Orleans	Barre	658 DF	3044	O/G ABD	-	-	-
38	Weaver Expl. No. 1 Hazen	1964	Monroe	Hamlin	309 GL	2185	O/G ABD	X	-	-
39	Hammerstone No. 1 Yantz	1966	Monroe	Sweeden	644 GL	3274	O/G ABD	-	-	-
40	N.Y.S. Nat. Gas No. 1 Olin	1958	Steuben	Woodhull	1645 DF	13500	O/G ABD	X	X	-
41	Blair & Weaver No. 1 Kennedy	1964	Livingston	Sparta	584 GL	6385	O/G ABD	X	-	-
42	Hoover No. 1 Franklish	1968	Ontario	Gorham	1080 GL	6000	O/G ABD	X	-	-
43	Hammerstone No. 1 Wyman	1966	Ontario	Farmington	597 GL	4305	O/G ABD	-	-	-
44	Strodwick No. 1 Bowerman	1966	Ontario	Farmington	556 GL	4353	O/G ABD	X	-	-
45	Hammerstone No. 1 Smith	1965	Wayne	Macedon	497	3641	O/G ABD	-	-	-
46	Duchscherer No. 1 Hammond	1967	Wayne	Arcadia	587 GL	3750	O/G ABD	X	X	-
47	Duchscherer No. 1 Olson	1967	Wayne	Lyons	487 GL	3740	O/G ABD	X	X	-
48	Union Oil No. 1 Martin	1969	Wayne	Galen	392 GL	4050	O/G ABD	X	X	-
49	Duchscherer No. 1 Reed	1967	Senaca	Junius	401 GL	4152	O/G ABD	-	-	-
50	N.Y.S. Nat. Gas No. 1 Kesselring		Chemung	Van Etten	1081 DF	11145	O/G ABD	-	-	-
51	N.Y.S. Nat. Gas No. 1 Sheperd	1959	Tompkins	Danby	1295 DF	10438	O/G ABD	X	X	-
52	N.Y.S. Nat. Gas No. 1 Fee	1964	Tompkins	Newfield	1051 DF	9390	O/G ABD	-	-	-
53	United Prod. No. 2 Schaffer	1962	Senaca	Fayette	542 DF	5538	O/G ABD	X	-	-
54	Midwest Oil No. 1 Alnutt	1966	Cayoga	Aurelius	515 DF	4853	O/G ABD	-	-	-
55	Duchscherer No. 1 Parker	1967	Cayoga	Brutus	589 DF	4260	O/G ABD	-	-	-
56	Duchscherer No. 1 Ripley	1966	Cayoga	Cato	435 DF	3756	GAS	-	-	-
57	Midas Gas Co. No. 2 Slayton		Cayoga	Conquest	476 GL			-	-	-
58	Duchscherer No. 1 O'Neill	1967	Cayoga	Cato	404 KB	3576	O/G ABD	X	-	-
59	Duchscherer No. 1 Smith	1966	Cayoga	Victory	441	3402	O/G ABD	X	-	-
60	Humble Oil No. 1 Wasielewski	1965	Cayoga	Ira	447 GL	3055	O/G ABD	-	-	-

TABLE 4. WELL DATA - New York (con't)

WATER ANALYSES	CORE ANALYSES	BASAL SANDSTONE UNIT						BASEMENT
		SEA LEVEL ELEVATION	THICKNESS	SAND-SHALE RATIO	AVERAGE POROSITY	POROSITY FEET	PERMEABILITY (MD)	SEA LEVEL ELEVATION
-	-	-1832	42	-	-	-	-	-1874
-	-	-1909	50	2.5	.075	3	-	-1959
-	-	-2001	65	-	-	-	-	-2066
-	-	NP	-	-	-	-	-	NP
-	-	-2263	105	4.8	.063	5	-	-2368
-	-	-2365	100	4.9	.13	11	-	-2465
-	-	-2307	55	-	-	-	-	-2362
-	-	-1839	27	-	-	-	-	-1866
-	-	NI	-	-	-	-	-	NP
-	-	-11230	220i	14.7	.11	22	-	NP
-	-	NI	-	-	-	-	-	NP
-	-	-4880	40i	-	-	-	-	NP
-	-	NI	-	-	-	-	-	NP
-	-	NI	-	-	-	-	-	-3654
-	-	NI	-	-	-	-	-	NP
-	-	-3075	88i	0.52	.10	3+	-	NP
-	-	-3128	78	-	-	-	-	-3206
-	-	-3570	88i	8.8	.11	9+	-	NP
-	-	NI	-	-	-	-	-	NP
-	-	NI	-	-	-	-	-	NP
-	-	-8955	48	2.0	.055	2	-	-9003
-	-	NI	-	-	-	-	-	NP
-	-	-4788	90	-	.039	1	-	-4878
-	-	NI	-	-	-	-	-	NP
-	-	NI	-	-	-	-	-	NP
-	-	NI	-	-	-	-	-	NP
-	-	NI	-	-	-	-	-	-3389
-	-	NI	-	-	-	-	-	-3166
-	-	-2869	90i	1/0	.09	8+	-	NP
-	-	-2501	78	-	-	-	-	.2579

TABLE 4. WELL DATA - New York (con't)

NEW YORK WELL NO.	OPERATOR & WELL NAME	YEAR COMP.	COUNTY	LOCATION	REFERENCE ELEVATION	T.D.	STATUS	GEOPHYSICAL LOGS		
				(TOWNSHIP)				GR-N	E	SONI
61	Duchscherer No. 1 Hall	1966	Oswego	Oswego	318 DF	2559	O/G ABD	X	X	-
62	Tower No. 1 Beckwith		Oswego	Scriba	385 GL			-	-	-
63	Humble Oil No. 1 Heaphy	1962	Oswego	Palermo	465 DF	2592	O/G ABD	X	-	-
64	Humble Oil No. 1 Hoose	1962	Oswego	Hastings	504 DF	2240	O/G ABD	X	-	-
65	Humble Oil No. 1 Kellogg	1962	Oswego	Williams	745 DF	1697	O/G ABD	X	-	-
66	Gulf Oil No. 1 Campbell	1962	Delaware	Hamden	1785 KB	10992	O/G ABD	X	-	-
67	Gulf Oil No. 1 Lanzilotta	1963	Delaware	Roxbury	1830 GL	9070	O/G ABD	-	-	-
68	Gulf Oil No. 1 Leslie	1963	Delaware	Franklin	1486 GL	7950	O/G ABD	-	-	-
69	Bradley Prod. No. 1 Lobdell		Chenango	Columbus	1373 GL		O/G ABD	X	-	-
70	N.Y.S. Nat. Gas No. 1 Danisevich	1960	Madison	Brookfield	1506 GL	4889	O/G ABD	-	-	-
71	N.Y.S. Nat. Gas No. 1 Branagan	1960	Madison	Lebanon	1549 DF	5703	O/G ABD	X	-	-
72	N.Y.S. Nat. Gas No. 1 Letts-Miller	1959	Madison	Brookfield	1255 DF	4170	O/G ABD	-	-	-
73	N.Y.S. Nat. Gas No. 1 Keith	1958	Oneida	Sangerfield	1319 GL	4366	GAS	X	-	-
74	Cady No. 1 Ainsworth		Oneida	Verona	430 GL			-	-	-
75	N.Y.S. Nat. Gas No. 1 Burkard	1965	Ostego	Maryland	1252 GL	5126	O/G ABD	-	-	-
76	N.Y.S. Nat. Gas No. 1 Lum	1961	Ostego	Worchester	1979 GL	5504	O/G ABD	X	-	-
77	Benedum No. 1 Skranko	1960	Herkimer	Warren	1515 GL	3581	O/G ABD	X	-	-
78	Devonian Gas No. 1 Puskeranko	1960	Herkimer	Stark	1590 GL	2716	O/G ABD	-	-	-
79	Cromwells Inc. No. 1 Fee		Orange	Wawayanda	600 GL	6875		-	-	-
80	United Prod. No. 1 Gans	1959	Greene	Wind Ham	1928 GL	7185	O/G ABD	-	-	-
81	Humble Oil No. 1 Gould	1961	Lewis	Highmarket	1788 DF	1788	O/G ABD	X	-	-

TABLE 4. WELL DATA - New York (con't)

WATER ANALYSES	CORE ANALYSES	BASEMENT SANDSTONE UNIT						BASEMENT
		SEA LEVEL ELEVATION	THICKNESS	SAND-SHALE RATIO	AVERAGE POROSITY	POROSITY FEET	PERMEABILITY (MD)	SEA LEVEL ELEVATION
-	-	-2143	44	4.5	.11	4	-	-2187
-	-	-1912	20	-	-	-	-	-1932
-	-	NI	-	-	-	-	-	-2095
-	-	NI	-	-	-	-	-	-1692
-	-	NI	-	-	-	-	-	- 915
-	-	-9065	115	-	-	-	-	-9180
-	-	NI	-	-	-	-	-	-7090
-	-	-6349	43	-	-	-	-	-6392
-	-	-4103	64	-	-	-	-	-4167
-	-	NI	-	-	-	-	-	NP
-	-	-4086	18	-	-	-	-	-4104
-	-	NI	-	-	-	-	-	-2907
-	-	-2990	19	-	-	-	-	-3009
-	-	-1940	33	-	-	-	-	-1973
-	-	NI	-	-	-	-	-	NP
-	-	-3316	60	1/0	.032	3	-	-3376
-	-	NI	-	-	-	-	-	NP
-	-	NI	-	-	-	-	-	NP
-	-	NI	-	-	-	-	-	NP
-	-	NI	-	-	-	-	-	NP
-	-	NI	-	-	-	-	-	+ 22

TABLE 5. WELL DATA - Ohio

OHIO WELL NO.	OPERATOR & WELL NAME	YEAR COMP.	COUNTY	LOCATION (TOWNSHIP)	REFERENCE ELEVATION	T.D.	STATUS	GEOPHYSICAL LOG GR-N	GR-D	E
1	Cabot No. 1-A Bailey	1964	Adams	Jefferson	714 KB	3790	O/G ABD	X	X	X
2	Commonwealth No. 1 Covert	1965	Adams	Jefferson	624 KB	3829	O/G ABD	X	X	X
3	Vistron No. 1 Sohio	1968	Allen	Shawnee	872 KB	3133	DISP.	-	X	X
4	Vistron No. 2 Sohio	1969	Allen	Shawnee	854 KB	3170	DISP.	-	X	-
5	Vistron No. 3 Sohio	1972	Allen	Shawnee	856 KB	3170	O/G ABD	-	X	-
6	Ohio Oil No. 1 Krause	1945	Ashland	Ruggles	1114 G	5251	O/G ABD	-	-	-
7	U.S. Oil No. 1 Roultstone	1970	Ashtabula	Morgan	861 KB	6659	O/G ABD	X	X	-
8	East Ohio No. 1 Brayman	1965	Ashtabula	Pierpoint	977 KB	6907	O/G ABD	X	X	-
9	Horizon No. 1 Rhoa	1965	Ashtabula	Trumbull	983 KB	6750	O/G ABD	X	X	-
10	West Ohio No. 1 Hoelscher	1970	Auglaize	St. Marys	896 KB	3067	DISP.	X	X	X
11	Armco No. 1 Armco	1967	Butler	Lemon	667 KB	3296	DISP.	X	X	X
12	Armco No. 2 Armco	1968	Butler	Lemon	671 KB	3285	O/G ABD	-	X	-
13	Hodges No. 1 Elcamere Farms	1964	Clark	Harmony	1167 KB	3570	O/G ABD	X	-	-
14	Edmund No. 1 Brown	1962	Clark	Pleasant	1249 KB	3644	O/G ABD	-	-	X
15	Continental No. 1 Wikoff	1960	Clermont	Stonelick	817 KB	3435	O/G ABD	X	-	-
16	Kewanee No. 1 McVey	1960	Clinton	Wayne	1087 KB	3465	O/G ABD	-	-	X
17	Kewanee No. 1 Adams	1958	Clinton	Wayne	1080 KB	3457	O/G ABD	-	-	X
18	Kewanee No. 1 Van Pelt	1959	Clinton	Wayne	1092 KB	3259	O/G ABD	-	-	X
19	Mngmnt. Contr. No. 3 Murray	1970	Columbiana	Hanover	1194 KB	10242	O/G ABD	X	X	-
20	Tatum No. 1 Lee	1971	Coshocton	Jefferson	1040 KB	6970	O/G ABD	X	X	X
21	Hawkins No. 1 Leonhardt	1965	Crawford	Chatfield	1008 KB	3774	O/G ABD	X	X	X
22	Brown No. 1 Haver	1962	Defiance	Mark	702 KB	3606	O/G ABD	X	X	-
23	McClure No. 1 Smith	1965	Delaware	Brown	992 KB	4035	O/G ABD	X	-	-
24	Minnesota-Ohio No. 1 Lindsey	1965	Delaware	Genoa	919 KB	4071	O/G ABD	X	-	-
25	Wise No. 1 Vance	1937	Delaware	Orange	920 G	4291	O/G ABD	-	-	-
26	Wehmeyer No. 1 Sprain	1962	Delaware	Oxford	996 KB	4035	O/G ABD	-	X	X
27	Minnesota-Ohio No. 1 Gregory	1965	Delaware	Porter	1205 KB	4685	O/G ABD	X	-	-
28	So. Triangle No. 1 Jones	1964	Delaware	Radnor	945 KB	3426	O/G ABD	X	-	X
29	Ohio Fuel No. 1 Jones	1964	Erie	Florence	819 DF	4434	O/G ABD	X	-	-
30	Sun No. 1 Krysik-Wakefield	1966	Erie	Florence	828 KB	4463	O/G ABD	X	X	X

TABLE 5. WELL DATA - Ohio

WATER ANALYSES	CORE ANALYSES	CONFINING UNIT		BASAL SANDSTONE UNIT						BASEMENT
		SEA LEVEL ELEVATION	THICKNESS	SEA LEVEL ELEVATION	THICKNESS	SAND-SHALE RATIO	AVERAGE POROSITY	POROSITY FEET	PERMEABILITY (MD)	SEA LEVEL ELEVATION
-	-		ND	ND	ND	6	.15	9	-	-3055
-	-		ND	ND	ND	~100	.11	5	-	-3148
X	X	-1548	401	-1949	329	-	-	-	80	-2278
-	-	-1536	410	-1946	343	-	-	-	-	-2289
-	-	-1544	380	-1924	368	-	-	-	-	-2292
-	-			-4001	136i	-	-	-	-	-
-	-			-5645	100	-	-	-	-	-5745
-	-			-5801	114	-	.11	~10	-	-5915
-	-			-5637	120	-	.07	~ 8	-	-5757
-	-	-1444	373	-1817	327	-	-	-	44	-2144
X	X		ND	ND	ND	45	.125	40	25.1	-2569
-	-		ND	ND	ND	-	-	-	-	-2562
-	-	-1773	360	-2133	250	41	.185	45	-	-2383
-	-	-1561	380	-1941	430	42	.145	42	-	-2371
-	-	-1767	541	-2308	220	4.5	.10	17	-	-2528
-	-		ND	-2053	320	37	.17	25	-	-2373
-	-		ND	-1980	330	-	.115	~38	-	-2310
-	-		ND	ND	ND	~100	.02	1.0	-	-2126
-	-			-8831	175	~100	.06	13	-	-9006?
-	-			-5820	104	~100	.075	8	-	-5924
-	-			-2642	140	~100	.10	11	-	-2782 (est)
-	-	-2126	314	-2440	464i	8	.13	25	-	-
-	-			-2808	191	2.4	.18	24	-	-2999
-	-			-3076	58	~100	.19	11	-	-3134
-	-			-2790	135	-	-	-	-	-2925
-	-			-2854	150	9	.15	19	-	-3004
-	-			-3355	125	~100	.14	18	-	-3480
-	-			-2330	145	~100	.17	25	-	-2475
-	-			-3491	90	-	-	-	-	-3581
-	-			-3532	95	~100	.16	14	-	-3627

TABLE 5. WELL DATA - Ohio (con't)

OHIO WELL NO.	OPERATOR & WELL NAME	YEAR COMP.	COUNTY	LOCATION (TOWNSHIP)	REFERENCE ELEVATION	T.D.	STATUS	GEOPHYSICAL LOG GR-N	GR-N	E
31	Kewanee No. 1 Wilson	1957	Fayette	Concord	1017 DF	3494	O/G ABD	X	-	X
32	Kewanee No. 1 Barnes	1958	Fayette	Jasper	1044 DF	3410	O/G ABD	X	-	-
33	Kewanee No. 1 Hopkins	1957	Fayette	Union	965 DF	4708	O/G ABD	X	-	X
34	Marble Cliff No. 1 Fee	1965	Franklin	Franklin	697 KB	3623	O/G ABD	X	X	X
35	Liberty No. 1 Storeholder	1970	Fulton	Swancreek	690 KB	3700	O/G ABD	X	X	-
36	Lakeshore No. 1 Marshall	1961	Guernsey	Adams	1007 KB	8622	O/G ABD	X	-	-
37	Cowen No. 1 Harris	1964	Hancock	Amanda	833 KB	2797	O/G ABD	X	-	-
38	Kin-Ark No. 1 Drummelsmith	1966	Hancock	Jackson	809 KB	2805	O/G ABD	X	-	X
39	Dever No. 1 Frazier	1964	Hancock	Union	824 DF	3017	O/G ABD	X	-	X
40	McMahon-Bullinton No. 1 Wolf	1964	Hardin	Dudley	971 KB	3002	O/G ABD	X	-	X
41	Edmund No. 1 Jones	1962	Hardin	Jackson	941 KB	2834	O/G ABD	-	-	X
42	Ohio Valley No. 1 Courtney	1972	Highland	Fairfield	957 DF	3610	O/G ABD	X	X	-
43	Kewanee No. 1 Pavey	1959	Highland	Fairfield	1043 KB	3512	O/G ABD	-	-	X
44	Dunigan No. 1 Hockman	1966	Hocking	Starr	970 KB	6495	O/G ABD	X	X	X
45	Halbert No. 1 Wood	1964	Jackson	Franklin	816 KB	6320	O/G ABD	X	X	X
46	Kin-Ark No. 1 Huffman	1964	Knox	Hilliar	1183 KB	407	O/G ABD	-	-	-
47	Ohio Fuel No. 1 Larimore	1963	Knox	Milford	1204 KB	5376	O/G ABD	X	-	-
48	Cantway No. 1 Cunningham	1961	Knox	Pike	1253 KB	5745	O/G ABD	-	-	X
49	Calhio No. 1 Calhio	1971	Lake	Perry	701 KB	6072	DISP.	X	X	X
50	Atha No. 1 Roberts	1964	Licking	Hartford	1179 KB	4952	O/G ABD	X	X	X
51	Ashland No. 1 Schmelzer	1965	Licking	Lima	1068 KB	4802	O/G ABD	X	X	X
52	Lakeshore No. 1 Crowley	1961	Licking	Mary Ann	1060 KB	5991	O/G ABD	X	-	-
53	Ohio Oil No. 1 Johns	1947	Logan	McArthur	1190 DF	3361	O/G ABD	-	-	X
54	East Ohio No. 1 Born	1960	Lorain	Henrietta	850 DF	4590	O/G ABD	X	-	-
55	Liberty No. 1 Ketrin	1972	Lucas	Harding	675 DF	3915	O/G ABD	X	X	-
56	Amerada No. 1 Hume	1965	Madison	Fairfield	995 KB	3631	O/G ABD	X	-	X
57	United No. 1 Mitchell	1962	Marion	Claridon	1001 KB	3672	O/G ABD	X	-	X
58	Ohio Fuel No. 1 Warner	1959	Medina	Granger	1117 KB	6731	O/G ABD	X	X	-
59	Wiser No. 1-A Smith	1959	Medina	Hinckley	1200 KB	7040	O/G ABD	X	-	-
60	Harner Union No. 2 Yewey	1971	Mercer	Center	838 DF	3215	O/G ABD	X	X	X

TABLE 5. WELL DATA - Ohio (con't)

WATER ANALYSES	CORE ANALYSES	CONFINING UNIT		BASAL SANDSTONE UNIT						BASEMENT
		SEA LEVEL ELEVATION	THICKNESS	SEA LEVEL ELEVATION	THICKNESS	SAND-SHALE RATIO	AVERAGE POROSITY	POROSITY FEET	PERMEABILITY (MD)	SEA LEVEL ELEVATION
-	-		ND	-2011	312	-	-	-	-	-2323
-	-		ND	ND	ND	4	.055	9	-	-2288
-	-		ND	-2255	325	9	.18	36	-	2580
-	-			-2778	131	~100	.225	29	-	-2909
-	-	-2350	300	-2650	220	14	.095	17	-	-2870
-	-			-7238	86	-	.04	3	-	-7324
-	-		ND	ND	ND	-	.15	36	-	-1962
-	-		240	-1641	345	~100	.185	45	-	-1986
-	-		ND	ND	ND	-	.17	52	-	-2184
-	-		ND	ND	ND	5	.18	35	-	-1987
-	-	-1411	220	-1499	400	~100	.18	45	-	-1899
-	-		ND	ND	ND	-	-	-	-	-2616
-	-		ND	-2237	235	3	.24	40	-	-2472
-	-			-5430	70	9	.08	5	-	-5500
-	-			-5334	80	7	.09	6	-	-5414
-	-			-3477	113	~ 50	.09	10	-	-3590
-	-			-3986	174	4	.13	18	-	-4160
-	-			-	80i	-	-	-	-	-
-	X			-5227	137	-	.084	-	11.6	-5364
-	-			-3586	149	24	.15	21	-	-3735
-	-			-3721	119	9	.16	17	-	-3721
-	-			-4810	108	8	.09	9	-	-4918
-	-	-1325	420	-1745	317	25	-	-	-	-2062
-	-			-3630	93	11	.05	4	-	-3723
-	-	-2427	198	-2625	323	-	-	-	-	-2948
-	-			-2415	207	13	.16	31	-	-2622
-	-			-2599	65	-	.18	12	-	-2664
-	-			-5423	122	9	.07	8	-	-5545
-	-			-5320	60	1	.045	1	-	-5380
-	-	-1527	440	-1967	345	-	-	-	-	-2312

TABLE 5. WELL DATA - Ohio (con't)

OHIO WELL NO.	OPERATOR & WELL NAME	YEAR COMP.	COUNTY	LOCATION (TOWNSHIP)	REFERENCE ELEVATION	T.D.	STATUS	GEOPHYSICAL LOGS GR-N	GR-D	E	S
61	National No. 1 Walker	1958	Miami	Lost Creek	1035 KB	3513	O/G ABD	X	-	--	-
62	Sun No. 1 Levering	1955	Miami	Washington	995 DF	3411	O/G ABD	X	-	-	-
63	Wray No. 1 McBee	1964	Morrow	Bennington	1140 KB	4450	O/G ABD	X	-	X	X
64	Otter Creek No. 1 Irey	1965	Morrow	Canaan	1004 KB	3876	O/C ABD	-	-	-	-
65	United No. 3 Myers	1961	Morrow	Canaan	1016 KB	4100	O/G ABD	X	-	X	X
66	Comanche No. 1-C Bush	1964	Morrow	Cardington	998 KB	3866	O/G ABD	X	-	X	-
67	Kin-Ark No. 5 Shaver-Neff	1964	Morrow	Peru	1007 KB	4215	O/G ABD	X	-	X	-
68	Pan American No. 1 Windbigler	1962	Morrow	Troy	1398 KB	4890	O/G ABD	X	X	X	X
69	Wehmeyer No. 1 Henry	1962	Morrow	Westfield	995 KB	4048	O/G ABD	-	X	X	X
70	Amerada No. 1 Ullman	1967	Noble	Elk	1035 KB	11442	O/G ABD	X	X	X	-
71	McMahon-Bullington No. 1 Croman	1963	Pickaway	Jackson	797 KB	3731	O/G ABD	X	-	-	-
72	Kewanee No. 1 Long	1959	Pickaway	Monroe	856 DF	3257	O/G ABD	-	-	X	-
73	Midwest No. 1 Miller	1964	Pickaway	Pickaway	693 DF	4179	O/G ABD	X	-	-	-
74	Ohio Oil No. 1 Barlage	1944	Putnam	Liberty	740 G	3377	O/G ABD	-	-	-	-
75	Empire Reeves No. 1 Fee	1967	Richland	Madison	1176 KB	5085	DISP.ABD	X	X	-	-
76	Tri-State No. 2 Scott	1966	Richland	Washington	1458 KB	5503	O/G ABD	X	-	-	X
77	Crest No. 1 Clark	1964	Ross	Concord	1035 KB	3863	O/G ABD	X	X	X	-
78	Ohio Liquid Disposal No. 1 Fee	1972	Sandusky	Riley	620 KB	2932	DISP.	-	X	X	-
79	East Ohio No. 1 Haff	1960	Sandusky	Townsend	644 DF	3123	O/G ABD	X	X	-	-
80	Dunigan No. 1 Avers	1964	Sandusky	Washington	633 KB	2721	O/G ABD	X	X	X	-
81	Ohio Oil No. 1 Bruns		Sandusky	Woodville	650 G	2822	O/G ABD	-	-	-	-
82	Maguire No. 1 Kerbel	1965	Sandusky	Woodville	647 KB	2782	O/G ABD	X	X	-	-
83	U.S.S. Chemicals No. 1 Fee	1968	Scioto	Green	557 KB	5617	DISP.	X	X	X	-
84	Ashland No. 1 Stigamire	1965	Seneca	Adams	796 KB	3175	O/G ABD	X	X	X	-
85	Sun No. 1 Nelson	1955	Shelby	Perry	1050 DF	3276	O/G ABD	X	-	-	-
86	Gump No. 1 Fogt	1956	Shelby	Salem	1037 G	3360	O/G ABD	-	-	-	-
87	H. & R. No. 1 Zenith	1961	Union	Union	1001 KB	3352	O/G ABD	X	-	X	-
88	West Ohio No. 5 Miller	1973	Van Wert	Jennings	820 KB	3242	O/G ABD	X	X	X	X
89	East Ohio No. 2 Steiner	1961	Wayne	Chippewa	960 KB	6919	O/G ABD	X	-	-	-
90	Great Lakes No. 1 Drake	1965	Wayne	Green	1151 KB	6897	O/G ABD	X	X	X	-

TABLE 5. WELL DATA - Ohio (con't)

WATER ANALYSES	CORE ANALYSES	CONFINING UNIT		BASAL SANDSTONE UNIT						BASEMENT
		SEA LEVEL ELEVATION	THICKNESS	SEA LEVEL ELEVATION	THICKNESS	SAND-SHALE RATIO	POROSITY	POROSITY FEET	PEMEABILITY (MD)	SEA LEVEL ELEVATION
-	-		ND	ND	ND	~100	.09	14	-	-2215
-	-	-1509	385	-1894	391	-	-	-	-	-2285
-	-			-3230	75	-	-	-	-	-3305
-	-			-2756	115	-	-	-	-	-2871
-	-			-2849	137	-	-	-	-	-2986
-	-			-2743	124i	13	.15	17	-	-
-	-			-3036	152	37	.17	25	-	-3188
-	-			-3352	120	12	.10	12	-	-3472
-	-			-2870	144	13	.15	20	-	-3014
-	-			-10,200	175	7	.03	5	-	-10,375
-	-		ND	ND	ND	-	-	-	-	-2943
-	-	-1994	150	-2144	185	-	-	-	-	-2329
-	-			-3256	199	9	.14	25	-	-3455
-	-	-1860	300	-2160	350	-	-	-	-	-2510
X	X			-3817	68	~100	.14	10	9	-3885
-	-			-3947	92	-	.08	7	-	-4039
-	-			-2625	185	10	.16	27	-	-2810
-	X			-2190	122	-	.155	-	30	-2312
-	-			-2314	134	~100	.20	27	-	-2448
-	-			-1887	186	~100	.175	33	-	-2073
-	-			-1827	190	-	-	-	-	-2017
-	-			-1883	230	~ 20	.16	37	-	-2113
X	X			-4957	66	~ 50	.12	8	27	-5023
-	-			-2244	100	~100	.22	22	-	-2344
-	-	-1444	402	-1816	274	7	.07	9	-	-2090
-	-		ND	ND	ND	-	-	-	-	-2245
-	-	-1724	345	-2069	280	~100	.15	26	-	-2349
-	-	-1580	400	-1980	414	-	-	-	-	-2394
-	-			-5810	134	~ 50	.05	7	-	-5944
-	-			-5435	142	-	-	-	-	-5577

TABLE 5. WELL DATA - Ohio (con't)

OHIO WELL NO.	OPERATOR & WELL NAME	YEAR COMP.	COUNTY	LOCATION (TOWNSHIP)	REFERENCE ELEVATION	T.D.	STATUS	GEOPHYSICAL LOGS GR-N	GR-D	E	S
91	Columbia No. 1 Cook	1971	Williams	Bridgewater	914 KB	4497	O/G ABD	X	X	-	X
92	Beglinger No. 1 Kennerk	1963	Williams	St. Joseph	842 DF	4172	O/G ABD	X	-	-	-
93	Kin-Ark No. 1 Carter	1965	Wood	Center	672 KB	2827	O/G ABD	X	-	X	-
94	Southern Triangle No. 1 Kan.	1964	Wood	Center	694 KB	2764	O/G ABD	-	-	X	-
95	Brailey No. 1 Killian	1937	Wood	Liberty	688 G	2927	O/G ABD	-	-	-	-
96	J.R.S. No. 1 Asmus	1965	Wood	Middleton	670 KB	2825	O/G ABD	X	-	-	-
97	Kin-Ark No. 1 Smith	1965	Wood	Plain	677 KB	2786	O/G ABD	X	-	-	-
98	Ohio Oil No. 1 Heck	1942	Wyandot	Crawford	860 G	2801	O/G ABD	-	-	-	-
99	Minnesota-Ohio No. 1 Eyestn.	1965	Wyandot	Eden	942 KB	3260	O/G ABD	X	-	-	-
100	Texaco No. 1 Bowen	1964	Wyandot	Mifflin	846 KB	2902	O/G ABD	X	-	X	-
101	Comanche No. 1 Frey	1964	Wyandot	Salem	868 DF	2875	O/G ABD	X	-	-	-
102	Kin-Ark Oil Co. No. 1 Gray	1965	Huron	Fitchville	1021 KB	4097	O/G ABD	X	X	X	-
103	Halbert No. 1 Slavens	1964	Jackson	Hamilton	665 KB	5681	O/G ABD	-	X	X	-

TABLE 5. WELL DATA - Ohio (con't)

WATER ANALYSES	CORE ANALYSES	CONFINING UNIT		BASAL SANDSTONE UNIT						BASEMENT
		SEA LEVEL ELEVATION	THICKNESS	SEA LEVEL ELEVATION	THICKNESS	SAND-SHALE RATIO	AVERAGE POROSITY	POROSITY FEET	PERMEABILITY (MD)	SEA LEVEL ELEVATION
-	-	-2826	400	-3226	357i	5	.05	10	-	-
-	-	-2336	322	-2658	422	-	-	-	-	-3080
-	-	-1578	250	-1828	325	8	.17	42	-	-2153
-	-	-1451	275	-1726	300	-	-	-	-	-2026
-	-		ND	ND	ND	-	-	-	-	-2196
-	-	-1600	180	-1780	355	13	.175	50	-	-2135
-	-	-1543	170	-1713	380	-	.105	30	-	-2093
-	-			-1698	242	-	-	-	-	-1940
-	-			-2113	195	23	.15	28	-	-2308
-	-			-1789	225	7	.17	33	-	-2014
-	-			-1817	175	-	.175	31	-	-1992
-	-		ND	-2983	93	~50	.055	5	-	ND
-	-			-4820	105	~50	.06	6	-	-4925

TABLE 6. WELL DATA - Pennsylvania

PENN. WELL NO.	OPERATOR & WELL NAME	YEAR COMP.	COUNTY	LOCATION	REFERENCE ELEVATION	T.D.	STATUS	GEOPHYSICAL LOGS		
				(TOWNSHIP)				GR-N	E	SONIC
1	People's Nat. Gas No. 1 Temple	1965	Mercer	Stoneboro	1344 KB	9919	O/G ABD	X	X	-
2	Benedum & Arkla Gas No. 1 Kardosh	1958	Crawford	Linesville	1337 KB	8031	O/G ABD	X	X	-
3	Hammermill Paper No. 2 Hammermill	1964	Erie	Erie	650 GL	5972	DISP. ABD	X	X	-
4	Consol Gas Supply No. 1 Denee	1965	Erie	Venango	1474 KB	7465	O/G ABD	X	X	-
5	Minard Run Oil No. 1 Minard Run	1962	McKean	Bradford	2240 KB	11878	O/G ABD	X	-	-

TABLE 6. WELL DATA - Pennsylvania

WATER ANALYSES	CORE ANALYSES	BASAL SANDSTONE UNIT						BASEMENT
		SEA LEVEL ELEVATION	THICKNESS	SAND-SHALE RATIO	AVERAGE POROSITY	POROSITY FEET	PERMEABILITY (MD)	SEA LEVEL ELEVATION
-	-	-8326	132	6.3	.065	7.4	-	-8458
-	-	-6473	110	3.23	.07	5.8	-	-6583
-	X	-5254	48	2.07	.04	1.2	230	-5302
-	-	-5906	55	2.67	.06	2.4	-	-5961
-	-	-9455	183	-	-	-	-	-9638

TABLE 7. WELL DATA - West Virginia

WEST VIR. WELL NO.	OPERATOR & WELL NAME	YEAR COMP.	COUNTY	LOCATION	REFERENCE ELEVATION	T.D.	STATUS	GEOPHYSICAL LOGS		
				(DISTRICT)				GR-N	E	SONIC
1	Cycops Corp. No. 1 Kingery	1971	Cabell	Union	652	8552	O/G ABD	X	X	-
2	Exxon No. 1 Hathaway	1974	Calhoon	Center	1206	20222	O/G ABD			
3	Exxon No. 1 McCormick	1974	Lincoln	DuVal	737	19154	O/G ABD			
4	United Fuel Gas No. 1 Arrington	1959	Mason	Clendenin	597	8635	O/G ABD	X	X	X
5	Columbia Gas Trans. No. 1 C.G.T.	1973	Mingo	Harvey	935	19537	O/G ABD			
6	Exxon No. 1 Smith	1974	Wayne	Butler	594	14625	O/G ABD			
7	Hope Nat. Gas No. 1 Power Oil	1955	Wood	Walker	1039	13331	O/G ABD	X	X	-
8	Exxon No. 1 McCoy	1975	Jackson	Washington	910	17625	GAS			

TABLE 7. WELL DATA - West Virginia

WATER ANALYSES	CORE ANALYSES	BASAL SANDSTONE UNIT						BASEMENT
		SEA LEVEL ELEVATION	THICKNESS	SAND-SHALE RATIO	AVERAGE POROSITY	POROSITY FEET	PERMEABILITY (MD)	SEA LEVEL ELEVATION
-	-	-7758	80	-	-	-	-	-7838
		-	TIGHT HOLE		-	-	-	~19000
		-	TIGHT HOLE		-	-	-	~18000
-	-	-7546	415	-	-	-	-	-7961
		-	TIGHT HOLE		-	-	-	~18000
		-	TIGHT HOLE		-	-	-	~14000
-	-	-11951	282	-	-	-	-	-12233
		-	TIGHT HOLE	-	-	-	-	~16700

TABLE 8

SALINITY (TOTAL DISSOLVED SOLIDS) AND DENSITY OF WATERS FROM THE BASAL SANDSTONE UNIT IN THE OHIO VALLEY AREA

Illinois Well No.	Depth of Observation	Sea Level Elevation of Observation	Total Dissolved Solids	Fluid Density	Method of Interpretation
75	3889	-3150	90,000		
	3942	-3203	90,000	1.059	Water Analysis
76	3882	-3140	82,600		
	3931-4010	-3189	82,600	1.016	Water Analysis
29	4550	-3818	107,100		
	4570	-3834	107,100	1.074	Water Analysis
77	3894	-3215	113,000		
	3995	-3316	113,000	1.081	Water Analysis
	4000	-3321	50,000		Log Analysis
	4265	-3586	100,000		Log Analysis
3	1818	-1084	< 10,000		Log Analysis
	2200	-1466	2,000	1.000	Water Analysis
	2213	-1479	10,000		Log Analysis
	2500	-1766	7,000	1.003	Water Analysis
	2793	-2059	50,000		Log Analysis
	3000	-2266	28,500	1.020	Water Analysis
	3643	-2909	100,000		Log Analysis
	3900	-3166	93,000	1.070	Water Analysis
4	6895	-6357	~ 80,000		Log Analysis
	7115	-6577	46,000		Log Analysis
	7245	-6707	67,000		Log Analysis
	7900	-7362	24,000		Log Analysis
	8112	-7574	58,000		Log Analysis

TABLE 8 (con't)

Salinity (total dissolved solids) and Density of Waters from the Basal Sandstone Unit in the Ohio Valley Area

Illinois Well No.	Depth of Observation	Sea Level Elevation of Observation	Total Dissolved Solids	Fluid Density	Method of Interpretation
33	4220	-3392	57,600	1.039	Water Analysis
5	11793	-11400	212,179	1.128	Water Analysis
7	2540	-1747	5,900		
	2636	-1843	5,900	1.004	Water Analysis
78	3400	-2746	86,600	1.061	Water Analysis
	3554	-2900	90,000		Log Analysis
	3580	-2924	96,200	1.068	Water Analysis
45	2204	-1582	9,300	1.004	Water Analysis
	2213	-1591	9,300		
43	2410	-1732	∿ 6,000		Log Analysis
	2436	-1758	10,000		Log Analysis
	2439	-1761	13,400	1.013	Water Analysis
	2501	-1823	25,000		Log Analysis
44	2544	-1870	∿ 9,000		Log Analysis
	2700	-2026	10,000		Log Analysis
	3650	-2976	25,000		Log Analysis
10	3464-3470	-2805	67,000	1.047	Water Analysis
79	2241	-1570	12,200		
	2370	-1699	12,200	1.006	Water Analysis
8	1176	- 493	2,300		
	1421	- 738	2,300	1.000	Water Analysis

TABLE 8 (con't)

Salinity (total dissolved solids) and Density of Waters from the Basal Sandstone Unit in the Ohio Valley Area

Illinois Well No.	Depth of Observation	Sea Level Elevation of Observation	Total Dissolved Solids	Fluid Density	Method of Interpretation
80	2133	-1470	12,200		Log Analysis
	2508	-1845	13,400	1.011	Water Analysis
81	2060	-1420	17,900		
	2178	-1538	17,900	1.011	Water Analysis
52	2958	-2226	50,800		
	3008	-2276	50,800	1.034	Water Analysis
14	4940	-4436	98,500	1.070	Water Analysis
	4974	-4470	98,500		
16	8400	-7859	50,000		Log Analysis
	8430	-7889	175,000		Log Analysis
	8612	-8071	100,000		Log Analysis
	8826	-8285	150,000		Log Analysis
	8892	-8351	262,000	1.165	Water Analysis
	9040	-8499	200,000		Log Analysis
82	3946	-3170	74,400		
	3956	-3180	74,400	1.053	Water Analysis
58	3537	-2810	59,600		
	3608	-2881	59,600	1.045	Water Analysis
83	3846	-3100	64,400		
	3857-3943	-3111	64,400	1.051	Water Analysis
62	3896	-3115	68,400		
	3908-3994	-3127	68,400	1.050	Water Analysis

TABLE 8 (con't)

Salinity (total dissolved solids) and Density of Waters from the Basal Sandstone Unit in the Ohio Valley Area

Illinois Well No.	Depth of Observation	Sea Level Elevation of Observation	Total Dissolved Solids	Fluid Density	Method of Interpretation
64	4120	-3448	∿ 80,000		Log Analysis
	4215	-3543	28,000		Log Analysis
84	4088	-3448	51,400		
	4100	-3460	51,400	1.035	Water Analysis
18	2750	-2084	20,000	1.013	Water Analysis
21	2898	-2371	20,000		Log Analysis
	3109	-2582	61,600	1.041	Water Analysis
71	2466	-1729	4,100	1.005	Water Analysis
70	6660	NI	214,000		Water Analysis

TABLE 9

SALINITY (TOTAL DISSOLVED SOLIDS) AND DENSITY OF WATERS FROM THE BASAL SANDSTONE UNIT IN THE OHIO VALLEY AREA

Indiana Well No.	Depth of Observation	Sea Level Elevation of Observation	Total Dissolved Solids	Fluid Density	Method of Interpretation
2	3090	-2293	∿ 15,000		
	3142	-2345	15,000		Log Analysis
	3275	-2478	25,000		Log Analysis
	3440	-2643	18,000		Log Analysis
20	3132	-2268	∿100,000		
	3360	-2496	109,000		Log Analysis
47	2789	-2038			
	2904	-2167		1.064	Water Analysis
25	2780	-2048	38,000		Log Analysis
	2786	-2054	∿ 38,000		
	2836	-2104	50,000		Log Analysis
	2906	-2174	∿ 90,000	1.062	Water Analysis
	2946	-2214	100,000		Log Analysis
	2966	-2234	112,000		Log Analysis
48	2822	-2111	78,000		
	2828	-2117	78,000		Log Analysis
	2910	-2199	100,000		Log Analysis
	2958?	-2209?	∿ 90,000	1.062	Water Analysis
	3010	-2299	148,000		Log Analysis
3	3412	-2453	73,000		Log Analysis
	3550	-2591	74,000		Log Analysis
	3770	-2811	104,000		Log Analysis
	3890	-2931	121,000		Log Analysis

TABLE 9 (con't)

Salinity (total dissolved solids) and Density of Waters from the
Basal Sandstone Unit in the Ohio Valley Area

Indiana Well No.	Depth of Observation	Sea Level Elevation of Observation	Total Dissolved Solids	Fluid Density	Method of Interpretation
26	3386	-2627	∿250,000		
	3396	-2637	250,000		Log Analysis
27	3237	-2520	∿250,000		
	3244	-2527	250,000		Log Analysis
49	2721	-1971	∿ 27,000		
	2760	-2010	25,000		Log Analysis
	2770	-2020	68,000	1.045	Water Analysis
	2862	-2112	104,400	1.074	Water Analysis
	3100	-2350	50,000		Log Analysis
	3770	-3020	100,000		Log Analysis
	3874	-3124	108,000		Log Analysis
	3991	-3241	124,200	1.090	Water Analysis
50	2784-2823	-2044		1.065	Water Analysis
	2797	-2057			
	2880-2913	-2140		1.075	Water Analysis
30	2635	-1967	15,500		Log Analysis
	2638	-1970	∿ 16,500		
	3610	-2942	49,000		Log Analysis
31	2950	-2023	∿ 50,000		
	3020	-2093	52,000		Log Analysis
9	2049	-1441	∿ 2,000		
	2410	-1802	10,000		Log Analysis
	2582-2600	-1974	20,100	1.016	Water Analysis
	2970	-2362	50,000		Log Analysis
	3590	-2982	100,000		Log Analysis
	[illegible]				

TABLE 9 (con't)

Salinity (total dissolved solids) and Density of Waters from the Basal Sandstone Unit in the Ohio Valley Area

Indiana Well No.	Depth of Observation	Sea Level Elevation of Observation	Total Dissolved Solids	Fluid Density	Method of Interpretation
35	2048	-1478	∿ 4,500		
	2360	-1760	10,000		Log Analysis
	2469-2491	-1869	13,700	1.010	Water Analysis
	3035	-2435	50,000		Log Analysis
	3316-3333	-2716	101,600	1.071	Water Analysis
	3430	-2830	100,000		Log Analysis
	3560	-2960	150,000		Log Analysis
	3793-3813	-3193	131,100	1.092	Water Analysis
	3880	-3280	200,000		Log Analysis
	4030	-3430	250,000		Log Analysis
10	5491	-4700	∿65,000		
	5738	-4947	79,000		Log Analysis
	6024	-5233	100,000		Log Analysis
11	2825	-2022	∿45,000		
	2982	-2179	∿34,000	1.100	Water Analysis
	3026	-2223	50,000		Log Analysis
	3780	-2977	100,000		Log Analysis
	3820	-3017	150,000		Log Analysis
	3860	-3057	200,000		Log Analysis
	3900	-3097	250,000		Log Analysis
15	2159	-1544	∿ 5,000		
	2160-4259	-1545	57,300	1.040	Water Analysis
	2432	-1817	6,000		Log Analysis
	2578	-1963	10,000		Log Analysis
	2950	-2335	28,000		Log Analysis
	3500	-2885	50,000		Log Analysis
	4100	-3485	72,000		Log Analysis

TABLE 9 (con't)

Salinity (total dissolved solids) and Density of Waters from the Basal Sandstone Unit in the Ohio Valley Area

Indiana Well No.	Depth of Observation	Sea Level Elevation of Observation	Total Dissolved Solids	Fluid Density	Method of Interpretation
13	1865-2918	-1252 to -2305	1,280		Water Analysis
	2181	-1568	~ 6,500		
	2222-4263	-1609 to -3650	68,100	1.048	Water Analysis
	2520	-1907	10,000		Log Analysis
	2820	-2207	50,000		Log Analysis
	3175	-2562	100,000		Log Analysis
	3535	-2922	150,000		Log Analysis
	3895	-3282	200,000		Log Analysis
42	2561	-1881	~ 3,900		
	2630	-1950	5,000		Log Analysis
	2873	-2193	10,000		Log Analysis
	3166	-2486	25,000		Log Analysis
16	4515	-3457	~ 100,000		
	4575	-3517	100,000		Log Analysis
	4715	-3657	150,000		Log Analysis
	4850	-3792	200,000		Log Analysis
17	3628	-2748	~50,000		
	3678	-2798	50,000		Log Analysis
	3738	-2858	100,000		Log Analysis
	3800	-2920	150,000		Log Analysis
	3865	-2985	200,000		Log Analysis
45	5447	-4797	~200,000		
	5450-6160	-4800 to -5510	204,400	1.148	Water Analysis
18	2900	-2113	100,000		Log Analysis
	2915	-2128	~100,000		
	3360	-2573	150,000		Log Analysis
	3465	-2678	200,000		Log Analysis
	3574	-2787	250,000		Log Analysis

TABLE 10

SALINITY (TOTAL DISSOLVED SOLIDS) AND DENSITY OF WATERS FROM THE BASAL SANDSTONE UNIT IN THE OHIO VALLEY AREA

Kentucky Well No.	Depth of Observation	Sea Level Elevation of Observation	Total Dissolved Solids	Fluid Density	Method of Interpretation
1	6045	-5187	30,000		Log Analysis
	6115	-5257	30,000		Log Analysis
	6208	-5350	12,000		Log Analysis
	6555	-5617	25,000		Log Analysis
6	7674	-6812	200,000		Log Analysis
	7956	-7094	200,000		Log Analysis
	8112	-7250	300,000		Log Analysis
	8348	-7486	175,000		Log Analysis
9	7516	-6864	170,000		Water Analysis
		REPORTED AS N. P. - D. S. T. DATA REFUTES THIS			
7	8405	-7597	170,000		Log Analysis
	8557	-7749	175,000		Log Analysis
	8733	-7925	200,000		Log Analysis
	8928	-8120	300,000		Log Analysis
	9303	-8495	300,000		Log Analysis
11	3390	-2632	16,000		Log Analysis
17	4996	-4132	250,000		Water Analysis
	5020	-4163	250,000		Water Analysis
19	3050	-2101	100,000		Log Analysis
25	6311	-5664	40,000		Log Analysis

TABLE 10 (con't)

Salinity (total dissolved solids) and Density of Waters from the Basal Sandstone Unit in the Ohio Valley Area

Kentucky Well No.	Depth of Observation	Sea Level Elevation of Observation	Total Dissolved Solids	Fluid Density	Method of Interpretation
27	4592	-3897	80,000		Log Analysis
	4632	-3937	80,000		Log Analysis
	4980	-4285	270,000		Water Analysis
	5344	-4649	250,000		Log Analysis
28	5031	-4082	158,000		Water Analysis
32	4612	-3640	160,000		Log Analysis
	4666	-3694	170,000		Log Analysis
	4869	-3897	200,000		Log Analysis
	5205	-4233	250,000		Log Analysis
37	4275	-3478	190,000		Log Analysis
	4390	-3593	155,000		Log Analysis
	4466	-3669	175,000		Log Analysis
	4506	-3709	280,000		Log Analysis
	4540	-3743	130,000		Log Analysis
39	4530	-3558	150,000		Log Analysis
	4825	-3853	200,000		Log Analysis
	5251	-4279	200,000		Log Analysis
	5452	-4480	300,000		Log Analysis
	5700	-4728	275,000		Log Analysis
48	5390	-4358	130,000		Log Analysis
	5500	-4468	269,000		Water Analysis
	5604	-4572	180,000		Log Analysis

TABLE 10 (con't)

Salinity (total dissolved solids) and Density of Waters from the Basal Sandstone Unit in the Ohio Valley Area

Kentucky Well No.	Depth of Observation	Sea Level Elevation of Observation	Total Dissolved Solids	Fluid Density	Method of Interpretation
50	4854	-3903	175,000		Log Analysis
	4884	-3933	>300,000		Log Analysis
	5062	-4111	150,000		Log Analysis
	5100	-4149	110,000		Log Analysis
	5244	-4293	190,000		Log Analysis
	5426	-4475	150,000		Log Analysis
	5742	-4791	200,000		Log Analysis
	6126	-5175	300,000		Log Analysis
52	3274	-2505	140,000		Log Analysis
53	5270	-4281	170,000		Log Analysis
	5454	-4465	195,000		Log Analysis
	5602	-4613	250,000		Log Analysis
	5778	-4789	250,000		Log Analysis
57	9406	-8585	180,000		Log Analysis
	9476	-8655	180,000		Log Analysis
	9704	-8883	80,000		Log Analysis
	9986	-9165	130,000		Log Analysis
58	5136	-4347	160,000		Log Analysis
	5348	-4559	200,000		Log Analysis
	5474	-4685	200,000		Log Analysis
64	6370	-5308	15,000		Log Analysis
	6468	-5406	25,000		Log Analysis
	6614	-5552	13,000		Log Analysis
	6646	-5584	90,000		Log Analysis

TABLE 10 (con't)

Salinity (total dissolved solids) and Density of Waters from the Basal Sandstone Unit in the Ohio Valley Area

Kentucky Well No.	Depth of Observation	Sea Level Elevation of Observation	Total Dissolved Solids	Fluid Density	Method of Interpretation
65	7800	-6832	4,700		Log Analysis
	8704	-7736	13,000		Log Analysis
67	4943	-3744	250,000		Log Analysis
66	3671	-2934	300,000		Log Analysis
	3755	-3018	300,000		Log Analysis

TABLE 11

SALINITY (TOTAL DISSOLVED SOLIDS) AND DENSITY OF WATERS FROM THE BASAL SANDSTONE UNIT IN THE OHIO VALLEY AREA

Ohio Well No.	Depth of Observation	Elevation Observation	Total Dissolved Solids	Fluid Density	Method of Interpretation
2	3728	-3104	300,000		Log Analysis
1	3701	-2987	192,000		Log Analysis
3	2780	-1908	58,950		Water Analysis
11	2975	-2316	122,000		Log Analysis
	3200	-2541	112,500		Water Analysis
14	3320	-2071	122,000		Log Analysis
13	3300	-2133	129,000		Log Analysis
16	3310	-2223	82,000		Log Analysis
20	6860	-5820	100,000		Log Analysis
28	3360	-2415	114,000		Log Analysis
26	3860	-2864	150,000		Log Analysis
30	4360	-3532	153,000		Log Analysis
34	3585	-2888	66,000		Log Analysis
41	2660	-1719	76,000		Log Analysis
44	6400	-5430	67,000		Log Analysis

TABLE 11 (con't)

Salinity (total dissolved solids) and Density of Waters from the Basal Sandstone Unit in the Ohio Valley Area

Ohio Well No.	Depth of Observation	Sea Level Elevation Observation	Total Dissolved Solids	Fluid Density	Method of Interpretation
102	4004	-2983	52,000		Log Analysis
45	6174	-5306	126,000		Log Analysis
103	5485	-4820	197,000		Log Analysis
46	4660	-3477	108,000		Log Analysis
51	4753	-3685	140,000		Log Analysis
49	5930	-5229	315,000		Water Analysis
56	3462	-2467	153,000		Log Analysis
69	3900	-2905	129,000		Log Analysis
70	11382	-10347	132,000		Log Analysis
75	5000	-3824	183,000		Water Analysis
77	3702	-2669	157,000		Log Analysis
80	2610	-1977	80,000		Log Analysis
83	5517	-4960	200,140		Water Analysis
84	3080	-2284	56,000		Log Analysis
87	3180	-2179	106,000		Log Analysis

TABLE 12

SALINITY (TOTAL DISSOLVED SOLIDS) AND DENSITY OF WATERS FROM THE BASAL SANDSTONE UNIT IN THE OHIO VALLEY AREA

New York Well No.	Depth of Observation	Sea Level Elevation of Observation	Total Dissolved Solids	Fluid Density	Method of Interpretation
19	3543	-2809	20,000		Log Analysis
20	3743	-3027	25,000		Log Analysis
21	3322	-2657	68,000		Log Analysis
15	5458	-4456	230,000		Log Analysis
	5506	-4504	225,000		Log Analysis
30	2252	-1881	24,000		Log Analysis
6	4113	-3575	321,000	1.22	Water Analysis
7	2900	-2321	270,000	1.2	Water Analysis

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State of Illinois
2200 Churchill Road
Springfield, Illinois 62706
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INDIANA
Indiana Stream Pollution Control Board
1330 West Michigan Street
Indianapolis, Indiana 46206
(317) 633-4420

KENTUCKY
Department of Natural Resources
Capital Plaza Tower
Frankfort, Kentucky 40601
(502) 564-3410

NEW YORK
Environmental Health Services
NYS Department of Environmental Conservation
50 Wolf Road
Albany, New York 12201
(518) 457-7362

OHIO
Ohio Environmental Protection Agency
P.O. Box 1049
Columbus, Ohio 43216
(614) 466-2390

PENNSYLVANIA
Department of Environmental Resources
P.O. Box 2351
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VIRGINIA
State Water Control Board
P.O. Box 11143
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WEST VIRGINIA
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