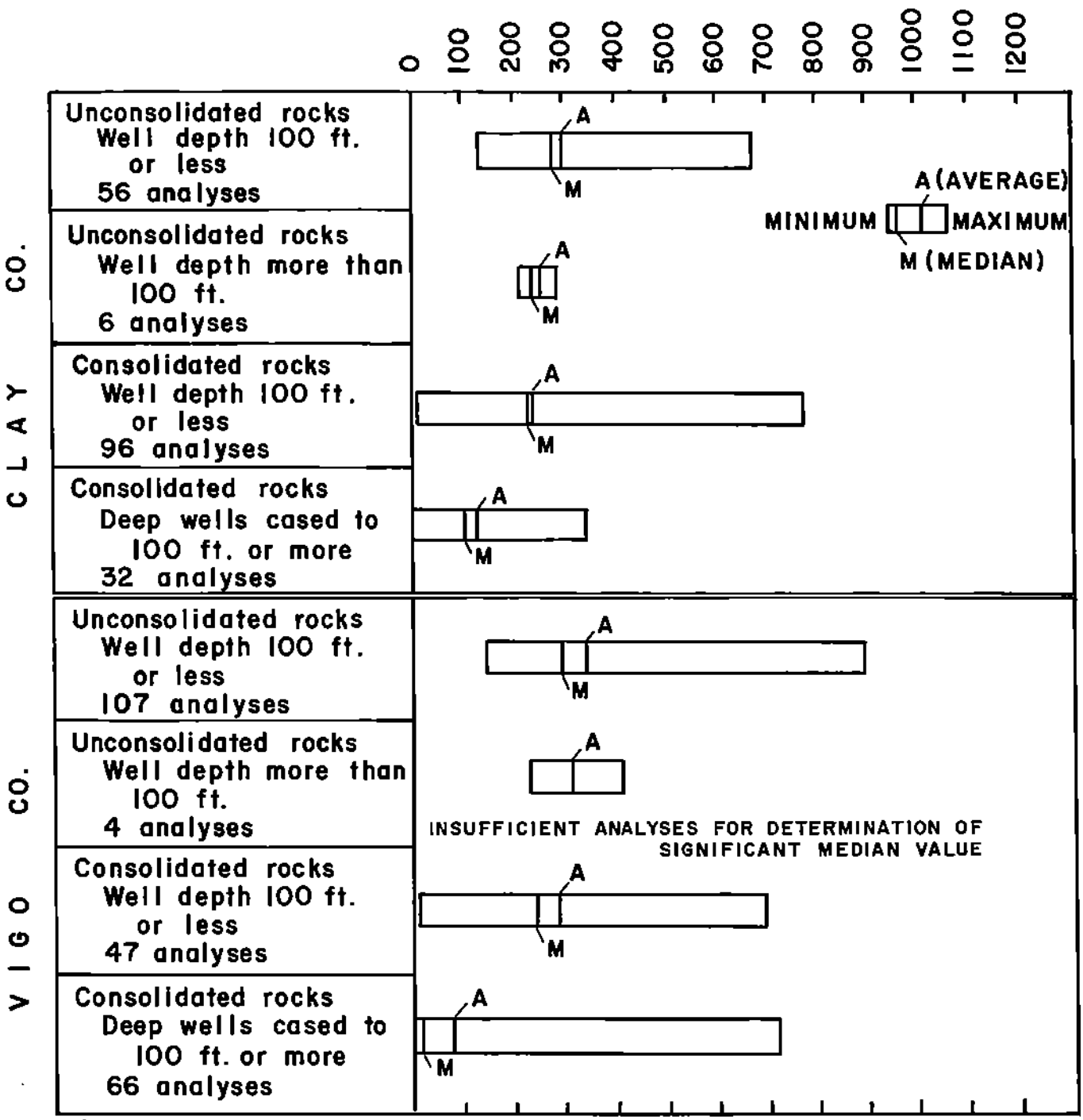

FIGURE 13.-- Hardness concentrations in the consolidated and unconsolidated rocks of Vigo and Clay Counties.

BICARBONATE CONCENTRATION
(PARTS PER MILLION)

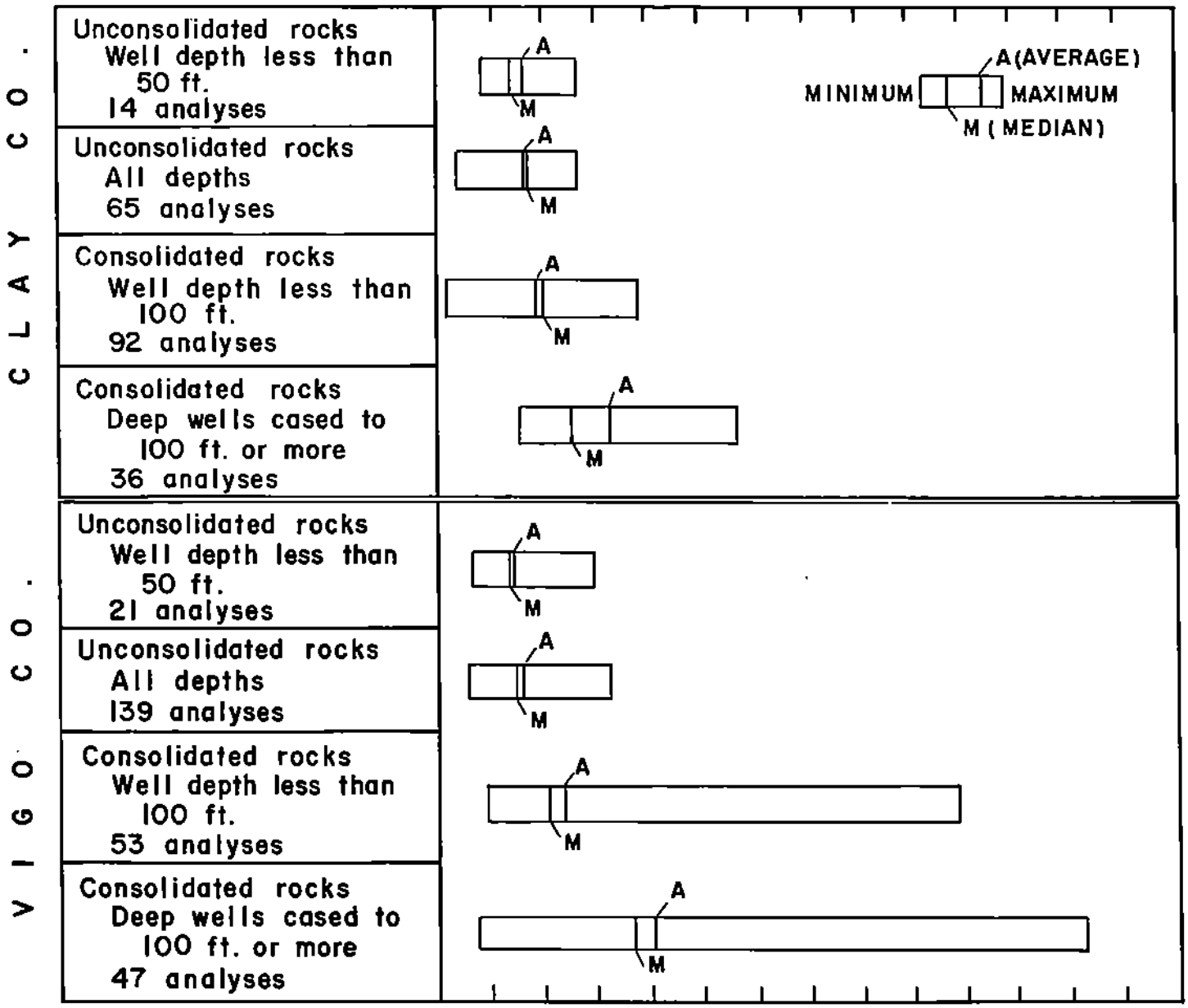

FIGURE 14.-- Bicarbonate concentrations in the consolidated and unconsolidated rocks of Vigo and Clay Counties.

Sulfate

Much of the sulfate in ground water is derived from the oxidation of sulfide minerals in the rocks. Coal-mining operations frequently produce large quantities of sulfuric acid by exposing pyrite-bearing rocks to air in the presence of water. The acid mine-drainage is ultimately neutralized by chemical reaction with rock material and bicarbonate water, producing metallic sulfates in solution. Some of the smaller streams in the area contain sulfate concentrations at low flow that exceed 1,000 parts per million. As there is an interchange of water between valley alluvium and streams, it would be expected that the median sulfate concentration of water from the unconsolidated rocks would be higher than in the case of the consolidated rocks. (See fig. 15). The few bedrock wells which yield excessive sulfate can be explained by the oxidation of sulfide minerals in the vicinity of the well bore and are not, therefore, necessarily attributable to mining.

Fluoride

Fluoride concentrations in water from consolidated and unconsolidated rocks of the Vigo-Clay County area are shown in figure 16. Water produced from the consolidated rocks shows a definite relationship between hardness and fluoride concentration--the hard waters having a deficiency and the soft waters having an excess. This phenomenon can be readily explained if it is assumed that most of the fluoride is derived from calcium and magnesium fluoride minerals disseminated throughout the rocks. If a water poor in calcium and magnesium ions, but rich in sodium and potassium ions, is in contact with these minerals, the minerals will tend to be dissolved. In the section on hardness it was shown that hardness decreases with depth in the consolidated rocks and that deep wells in Middle and Upper Pennsylvanian aquifers of Vigo County generally yield softer water than those in Lower Pennsylvanian aquifers in Clay County. The latter condition would explain the higher fluoride concentrations for Vigo County.

Chloride

Chloride concentrations in water from wells in the Vigo-Clay County area range from near zero to several hundred ppm. The upward migration of sodium chloride waters from deep brine-bearing rocks is the most probable cause of the higher concentrations. In some instances, migration has been intensified by the drilling of oil and gas wells, affording an easy path for upward movement. In wells bottomed in the bedrock beneath the Wabash River, salty water can probably be encountered at depths of slightly over 100 feet. In the upstream portions of tributaries the depth to salt water beneath stream level is usually in the 150- to 350-foot range.

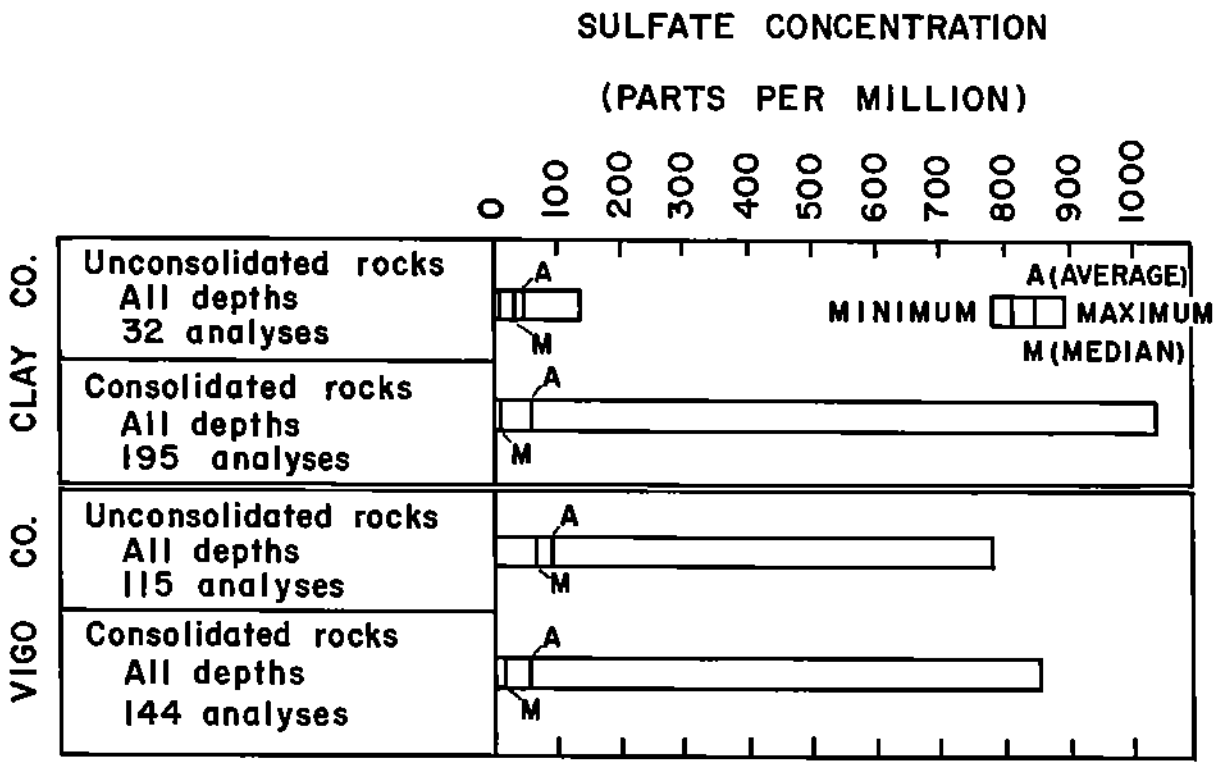

FIGURE 15.-- Sulfate concentrations in the consolidated and unconsolidated rocks of Vigo and Clay Counties.

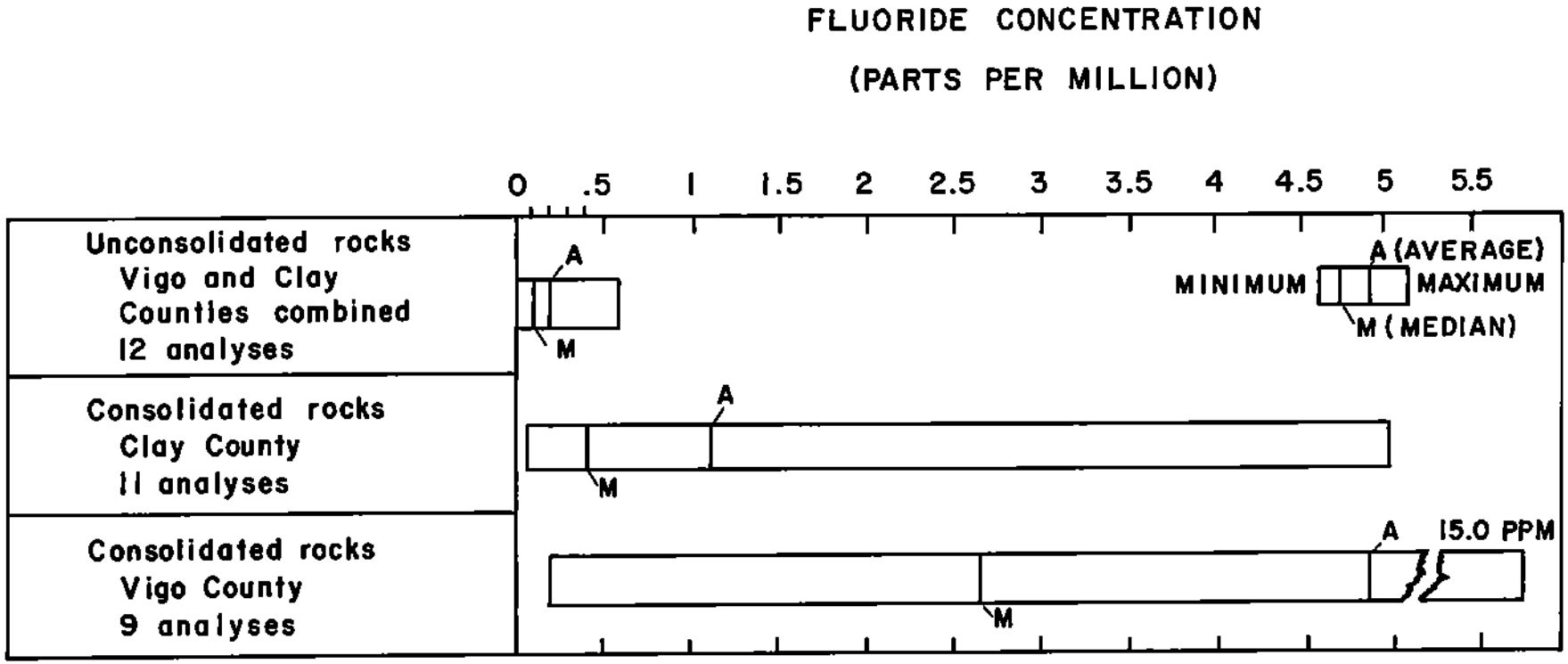

FIGURE 16.--Fluoride concentration in the consolidated and unconsolidated rocks of Vigo and Clay Counties.

Most of the natural seepage of salt water is discharged at the bedrock surface in valleys where it is diluted rapidly to less than the recommended maximum concentration. In the "Maryland Heights" area south of Terre Haute, excessive chloride has been noted in alluvial wells having depths of 48 to 76 feet. This occurrence appears to be due to contamination from nearby oil fields.

SUMMARY AND CONCLUSIONS

Vigo and Clay Counties lie principally in the Wabash Lowland physiographic province of west-central Indiana. Consolidated and unconsolidated rocks of Mississippian, Pennsylvanian and Quaternary ages immediately underlie the area.

The Pennsylvanian rocks of the Vigo-Clay County area contain six sandstone bodies which are extensive enough to be considered important aquifers. These aquifers are designated units 1 through 6 in accordance with their stratigraphic position and occur at regular intervals throughout the Pennsylvanian rocks. Yields from wells in these aquifers average 6.6 gpm and rarely exceed 20 gpm. Due to wide local variation in thickness, no regional value for transmissibility is given, however, this value may be calculated locally. The total amount of water in storage in the mapped areas of all bedrock aquifers in the area is approximately 523 million gallons, and the estimated potential recharge is 7 mgd. The total estimated current withdrawal is 1.8 mgd.

Aquifers in the consolidated rocks are generally thin and of relatively small permeability. Yields from wells in these aquifers are, therefore, correspondingly low. The amount of water normally produced from these wells is adequate for farm, domestic, small industrial, and, in some cases, small municipal supplies. Any attempt to obtain the production necessary to supply large industries or large municipalities would seem to be highly impractical. The importance of the consolidated rock aquifers, however, lies in the fact that over much of the two-county area they constitute the sole source of potable ground water.

The unconsolidated deposits in the Vigo-Clay area are mostly Pleistocene in age and yield water chiefly from coarse-textured sand and gravel deposits. These sand and gravel aquifers occur almost exclusively as glacial outwash deposited in the Wabash and Eel River valleys. The Wabash River valley aquifer is the best and most extensive aquifer of the entire two-county area. A detailed analysis of the Eel River valley aquifer is not possible due to insufficient data.

The Wabash River valley aquifer forms a single complex hydrologic system which may be subdivided into two major areas--an unconfined area adjacent to the river and a confined area beneath the till to the east. Yields from wells in the unconfined area average 660 gpm with yields as high as 2,700 gpm reported. The estimated regional value of transmissibility is 72,000 gpd per foot. Wells in the confined area yield an average of 25 gpm with maximum yields of 40 to 45 gpm noted. The regional

value of transmissibility is estimated to be 5,100 gpd per foot. The total amount of water in storage in this aquifer in the Vigo-Clay area is approximately 367,800 million gallons and the estimated potential recharge is 68 mgd. The estimated current withdrawal is 22.2 mgd.

The unconfined area of the Wabash River valley sand and gravel aquifer is the most productive of the entire two-county area. However, due to its relatively limited lateral extent, the tremendous amount of potable water stored in this aquifer is available to only a small part of the area and only a fraction of its potential is now being developed. Its potential is considered sufficient as an available source of supply to satisfy the demands of large industries and large municipalities. The potential of the confined area of this aquifer is substantially less than that of the unconfined area but considerably greater than that of the consolidated rock aquifers. Therefore, production from available sources is considered adequate for the requirements of moderate-sized industries and municipalities.

The water from the unconsolidated rocks and shallow consolidated rocks is usually a calcium bicarbonate water, whereas the water from deep wells in the consolidated rocks is a sodium bicarbonate water. The mineral content of water in the consolidated rocks generally increases with depth. At depths from about 100 to 350 feet below stream level, water containing excessive chloride is frequently encountered. Excessive fluoride concentrations are common in wells which yield very soft water.

GLOSSARY

Hydraulic Coefficients (after Ferris and others, 1962)

Permeability, Field Coefficient of.--Measure of a material's capacity to transmit water; expressed as rate of flow of water in gallons per day through a cross-sectional area of 1 square foot under a hydraulic gradient of 1 foot per foot at the prevailing water temperature.

Storage, Coefficient of.--Volume of water released from or taken into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface.

Transmissibility, Coefficient of.--Rate of flow of water, at the prevailing water temperature, in gallons per day, through a vertical strip of the aquifer 1 foot wide extending the full saturated height of the aquifer under a hydraulic gradient of 1 foot per foot.

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DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER

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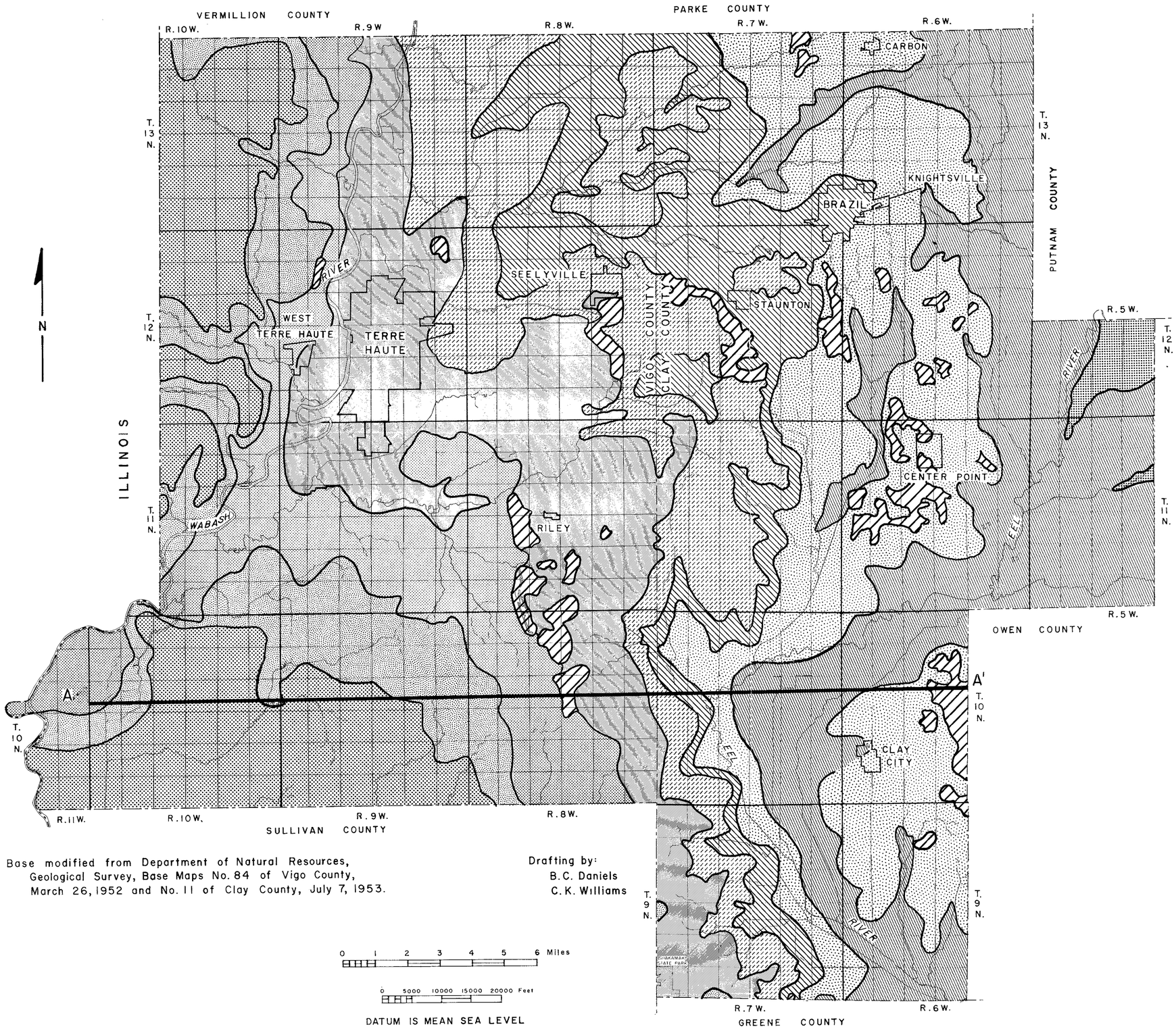
BULLETIN 34 PLATE I

BEDROCK GEOLOGIC MAP OF VIGO AND CLAY COUNTIES, INDIANA



N

Base modified from Department of Natural Resources, Geological Survey, Base Maps No. 84 of Vigo County, March 26, 1952 and No. 11 of Clay County, July 7, 1953.

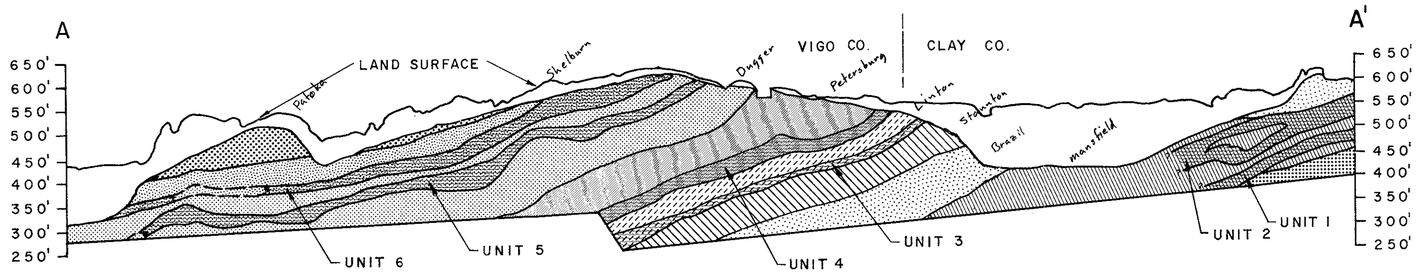
Drafting by:
B.C. Daniels
C.K. Williams

0 1 2 3 4 5 6 Miles

0 5000 10000 15000 20000 Feet

DATUM IS MEAN SEA LEVEL
by L. W. Cable

Geology in part after Friedman, 1961; Frielinghausen, 1950; Hutchison, 1956, 1958, 1960; Kottlowski, 1959; Waddell, 1952; Wier, 1950, 1952; and Wier and Gray, 1961.



GENERALIZED GEOLOGIC SECTION

EXPLANATION

PLEISTOCENE AND RECENT — QUATERNARY

Unconsolidated rocks

UPPER PENNSYLVANIAN

Patoka Fm.
Coal, underclay, gray shale, black shale, sandy shale, sandstone, and limestone

Shelburn Fm.
Coal, underclay, gray shale, black shale, red shale, sandy shale, sandstone, and limestone

MIDDLE PENNSYLVANIAN

Dugger Fm.
Coal, underclay, gray shale, black shale, sandy shale, sandstone, and limestone

Petersburg Fm.
Coal, underclay, gray shale, black shale, sandy shale, and sandstone

Linton Fm.
Coal, underclay, gray shale, black shale, sandy shale, and sandstone

Staunton Fm.
Coal, underclay, gray shale, black shale, sandy shale, and sandstone

Brazil Fm.
Coal, underclay, gray shale, black shale, sandy shale, sandstone, and limestone

PENNSYLVANIAN

LOWER PENNSYLVANIAN

Mansfield Fm.
Coal, underclay, gray shale, black shale, sandy shale, sandstone, and limestone

CHESTER (?) — MISSISSIPPIAN

Aquifer
(Shown on cross section only)

Strip Mine

Approximate boundary of geologic formations

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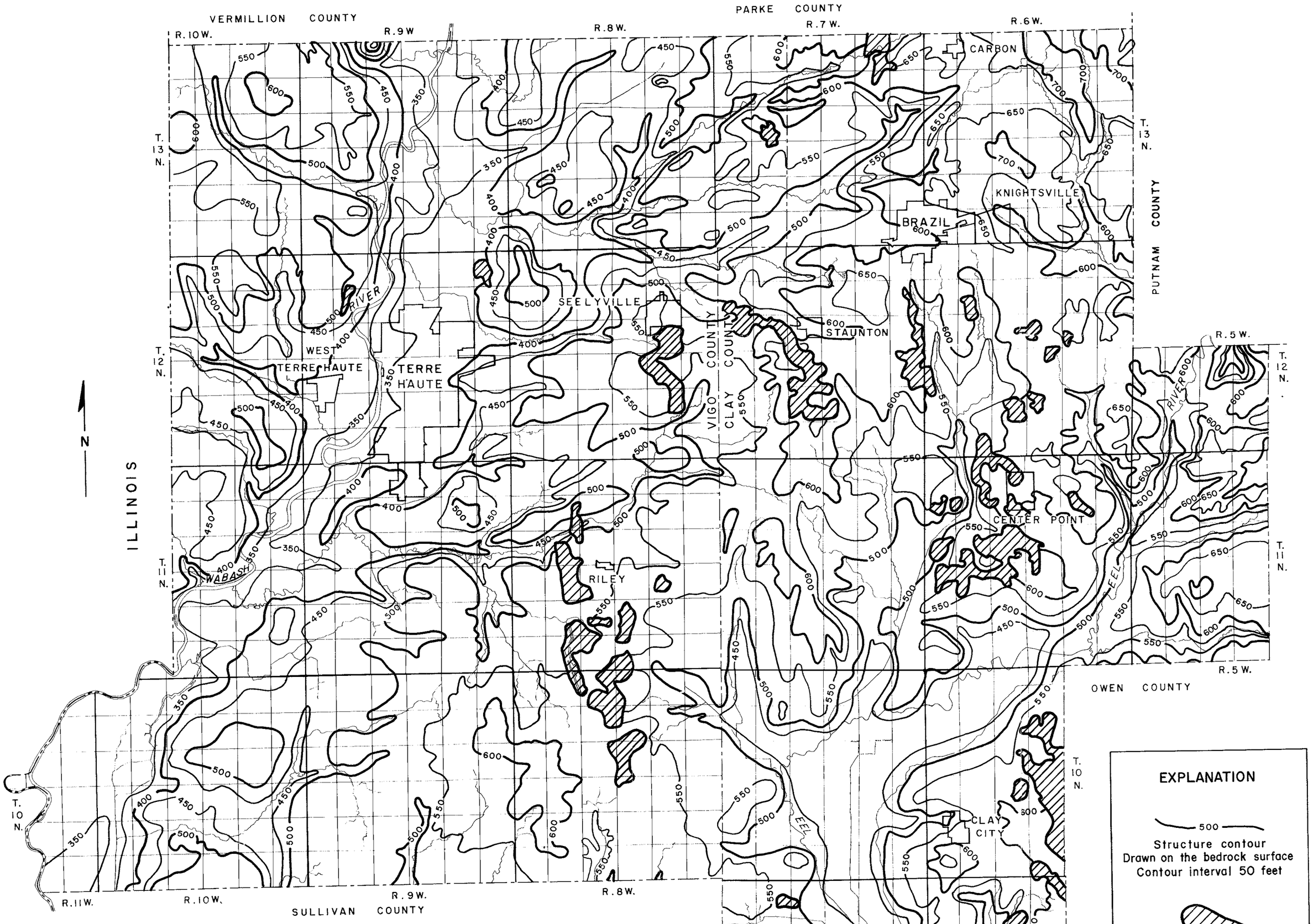

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Drafting by:
B.C. Daniels
D. Maddox

DATUM IS MEAN SEA LEVEL

by L. W. Cable

EXPLANATION

500

Structure contour
Drawn on the bedrock surface
Contour interval 50 feet

Strip Mine

MAP OF VIGO AND CLAY COUNTIES, INDIANA SHOWING TOPOGRAPHY OF BEDROCK SURFACE

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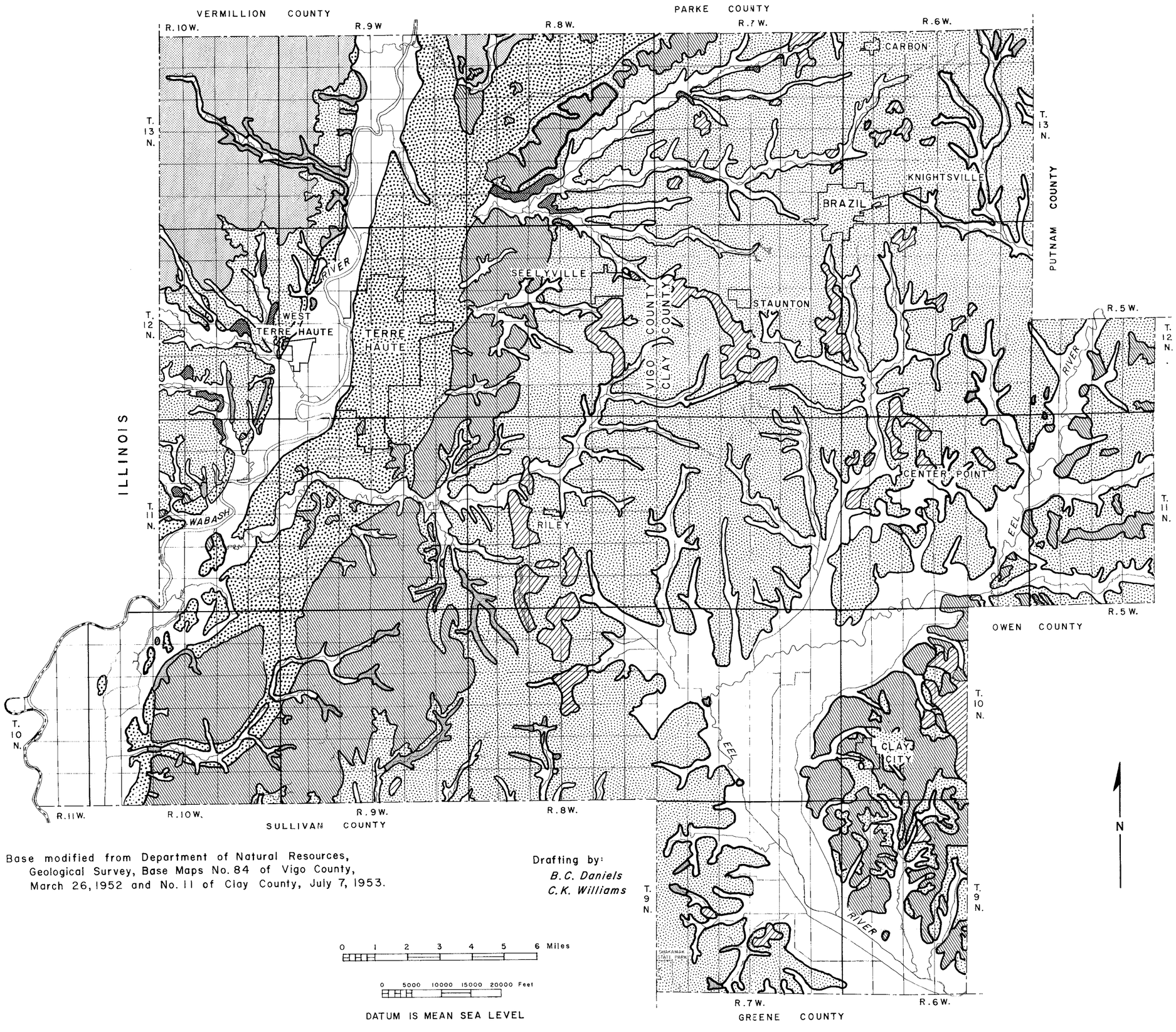
BULLETIN 34 PLATE 3



EXPLANATION

QUATERNARY

Pleistocene and Recent

- Alluvium
- Lacustrine Deposits silt and clay
- Eolian Deposits sand, silt, and clay
- Outwash Deposits sand and gravel

Pleistocene

- Till — Wisconsin Glaciation
- Till — Illinoian Glaciation

Pre—Pleistocene

- Bedrock

Strip Mines

N

Base modified from Department of Natural Resources, Geological Survey, Base Maps No. 84 of Vigo County, March 26, 1952 and No. 11 of Clay County, July 7, 1953.

Drafting by:
B.C. Daniels
C.K. Williams

0 1 2 3 4 5 6 Miles

0 5000 10000 15000 20000 Feet

DATUM IS MEAN SEA LEVEL

by D. G. Jordan and L. W. Cable

Geology in part after Friedman, 1961; Frielinghausen, 1950; Hutchison, 1958, 1960; Kottlowski, 1959; Waddell, 1952; Wayne, 1958; and Wier, 1950.

SURFICIAL GEOLOGIC MAP OF VIGO AND CLAY COUNTIES, INDIANA.

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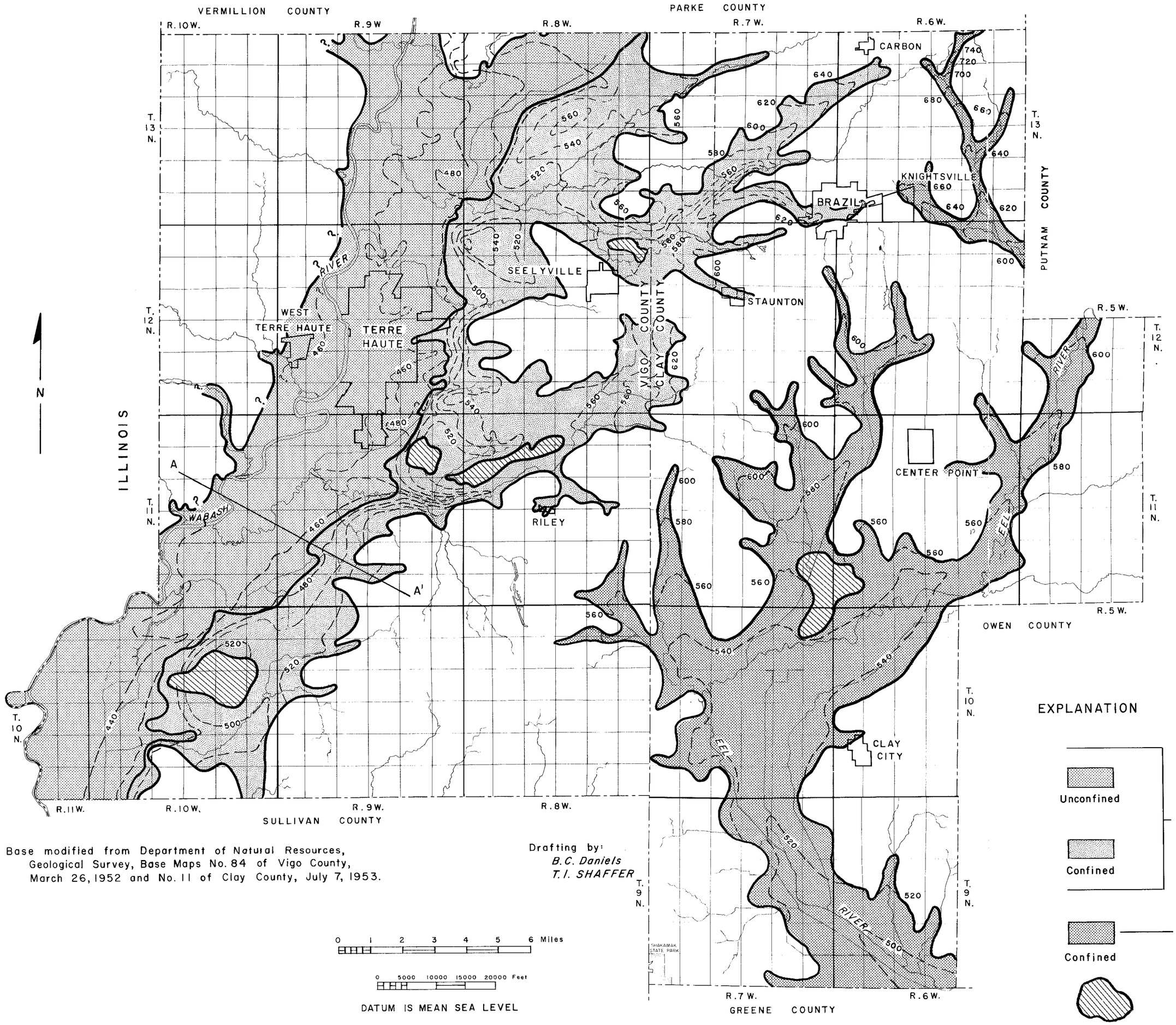
BULLETIN 34 PLATE 4



Base modified from Department of Natural Resources, Geological Survey, Base Maps No. 84 of Vigo County, March 26, 1952 and No. 11 of Clay County, July 7, 1953.

Drafting by:
B.C. Daniels
T.I. SHAFFER

0 1 2 3 4 5 6 Miles

0 5000 10000 15000 20000 Feet

DATUM IS MEAN SEA LEVEL

by F. A. Watkins, Jr.

EXPLANATION

Unconfined
Confined
Wabash River valley aquifer

Confined
Eel River valley aquifer

Bedrock high; aquifer absent

—— 550 ——
Piezometric contour

Contour interval 20 feet

Boundary of unconsolidated aquifers

A ——— A'
See figure 11

MAP OF VIGO AND CLAY COUNTIES, INDIANA SHOWING PRINCIPAL UNCONSOLIDATED ROCK AQUIFERS AND THEIR PIEZOMETRIC SURFACES