IRRIGABLE LANDS INVENTORY--
PHASE I GROUNDWATER AND RELATED INFORMATION

by
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Wisconsin Geological and Natural History Survey
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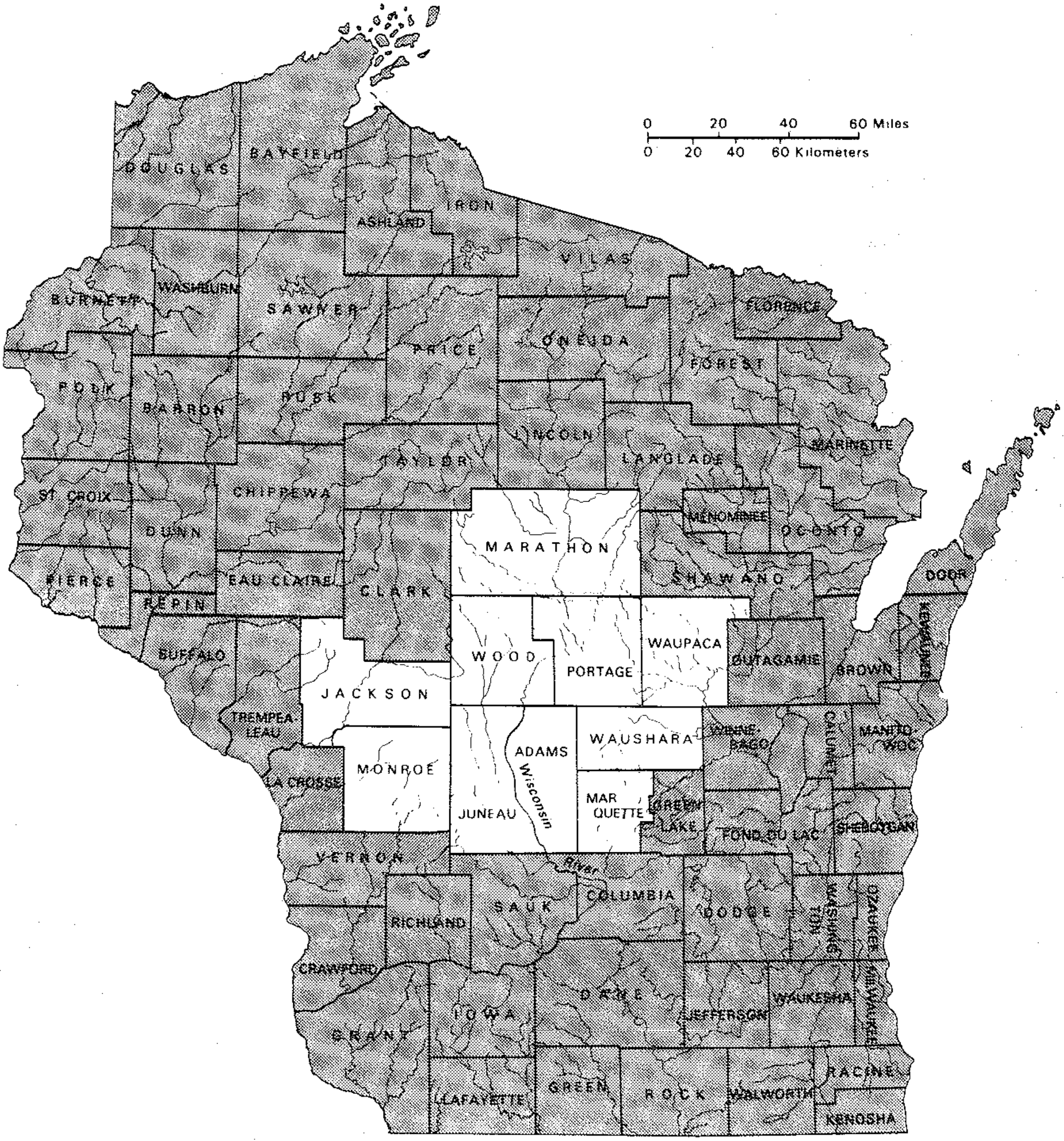

Figure 1. Map of Wisconsin, showing location of the Golden Sands R.C.&D. Area.

INTRODUCTION

The location of the Golden Sands Resource Conservation and Development (RC&D) Area of central Wisconsin, which is the area covered in this study, is shown in Figure 1. It is comprised of all of the following counties: Adams, Jackson, Juneau, Marathon, Marquette, Monroe, Portage, Waupaca, Waushara, and Wood.

This report consists of ten water-table elevation maps (Maps 1 to 10), eleven aquifer-potential maps (Maps 11 to 21), and a narrative which is intended to aid users in understanding these maps.

Ground water is an important and valuable resource: one which is having ever increasing demands placed on it. In addition to private and municipal water supplies, ground water is extensively used for irrigation. Because ground water contributes significant volumes of water to many lakes and streams, it is also vital to many recreational activities, such as trout fishing, boating, swimming, and canoeing.

Irrigation in the central sand plain area of Wisconsin has increased dramatically over the last few decades, and due to continuing demands for food for our expanding population, further expansion is likely to occur. Any such expansion should take into careful account the other users or potential users of the water resources in question.

Purpose of Project

The purpose of this project was to compile and interpret hydrogeologic information in the ten county Golden Sands RC&D Area, and to present this information in a form which can assist soil- and water-resource planners and land-use planners in making environmentally and economically sound decisions.

Funding

This project was funded by the Upper Great Lakes Regional Commission, (technical assistance project number 10020489; University of Wisconsin-Madison account number 144-Q393) through the sponsorship of the Golden Sands Resource Conservation and Development Area. Additional funding was provided by the Wisconsin Geological and Natural Survey (WG&NHS).

Previous Studies

In the past, various studies were made of parts of the Golden Sands RC&D Area. Some of these, such as the U.S. Geological Survey Water Supply Papers 1669-U, 1796, 1809-B, and 2022, were fairly detailed and involved extensive field work. Others, such as the U.S. Geological Survey Hydrologic Investigations Atlases HA-321, HA-367, HA-474, and HA-479, scale 1:1,000,000, were much broader. A more complete listing of previous studies is given in the Selected References section of this report. The present study is the first to produce hydrologic maps of the Golden Sands RC&D Area at a uniform and reasonably detailed scale.

Scope and Limitations

It was the intent of this study to produce a preliminary interpretation of the water-table elevation, and the aquifer-potential of the Golden Sands RC&D Area. It was beyond the scope of this project to field check the published and unpublished data (such as the locations and water levels given on the well constructor's reports) which were utilized in making the maps. Therefore this report should be considered neither final, nor definitive for site specific applications.

It was not practical to show the location of the data points on the maps themselves. These data were compiled on U.S. Geological Survey topographic quadrangle maps and are on open file (Golden Sands Resourse Maps) at the WG&NHS. The accuracy of the interpretation varies throughout the study area, increasing with greater data density, and decreasing with greater hydrogeologic complexity. The level of confidence in the interpretation of a given area is indicated on the maps, and is discussed in the Interpretation section of this report. The maps prepared in this study delineate those areas where further information is most urgently required, and provide a starting point for future investigations.

Acknowledgements

Special acknowledgement is made to the sponsors of the Golden Sands Resource Conservation and Development (RC&D) Area, who provided continuous support and encouragement throughout the project. The Board of Directors of the Golden Sands RC&D Area requested a steering committee to develop the original proposal for the project, and it was the Golden Sands RC&D Area which solicited the funds for this project from the Upper Great Lakes Regional Commission (UGLRC). Special thanks also go to Janet Hodge of the UGLRC for her assistance and enthusiasm.

This project would not have been possible without the well constructor's reports provided by the Department of Natural Resources (DNR), Bureau of Water Supply, Private Water Supply

Section. Sincere thanks are extended to Kevin Kessler, Thomas Riewe, Peter Overton, and Stephanie Howard of the DNR for their cooperation and assistance.

Thanks are also extended to the well drillers of Wisconsin, who gathered, and then submitted, the subsurface and water information to the DNR.

The authors also wish to thank, and acknowledge the contribution of, the workers who assisted with various aspects of this project: Andrea Sutherland, Susan Pickard, Marten Cieslik, and Carol Ptacek for sorting and plotting of well logs; Paul Putzier and Daniel Maschoff for sorting; Sara Sauers for compilation of public ownership data; and Deborah Patterson and Susan Fell for preparation of base maps.

Cartographic production was by M. L. Czechanski; maps and figures were drafted by Deborah Patterson and Judith Lee. The authors greatly appreciate and acknowledge their many hours of diligent work.

GROUND WATER IN GENERAL

Ground water in the Golden Sands RC&D Area plays an active role in a continuing water recycling process called the water cycle.

Gravity and solar energy drive the water cycle. Water falling on land flows downhill as runoff, evaporates, transpires through plants, or infiltrates into the ground. As this infiltrating water seeps downward by gravity through rock or soil, it travels through pore spaces and open cracks or fractures in the subsurface material. The porous and/or fractured rock or soil can be viewed as a "sponge like" container. The level to which the void spaces in the container are filled is called the water table. The water present in the saturated zone below the water table is called ground water. Eventually the ground water will discharge to a land or water surface where solar energy evaporates it into the atmosphere to continue the water cycle.

An aquifer is defined as a rock or soil formation that can yield fresh water economically. The nature of the porosity of a soil or rock formation determines how well it will be able to transmit water. Large pores or fractures can hold more water than small ones, but in order for water to flow, these pores or fractures must be interconnected. Water-bearing cracks, fractures, and pore spaces are not present everywhere throughout the crust of the earth. They usually extend downward for only a few hundreds or thousands of feet, and usually decrease in size and density with depth, depending on the local geology.

Sandy soils may have relatively large pore spaces that are well connected with each other, allowing water to seep more rapidly than clayey soils with poorly connected pores. Some rocks such as limestone (dolomite in Wisconsin) are usually highly fractured. The usually extensive system of interconnecting cracks may allow water to flow quickly. Other rocks such as crystalline granite usually have small (less than ¼ inch) closed or intermittent fractures and do not transmit water easily. In the crystalline rocks of Marathon County, for example, the fractures that store and transmit water are spaced many feet apart, so the amount of water available to a well can vary from zero to more than ten gallons per minute within a single homestead.

In Wisconsin, the water cycle generally operates with 30 to 32 inches of precipitation during an "average" year, from which about 75% (22-26 inches) returns to the atmosphere by evapotranspiration. The remainder either runs off on the surface or infiltrates into the ground as recharge to ground water. The ratio of surface runoff to ground-water recharge varies considerably around the state, depending on many factors such as topography, soil type, vegetative cover, rainfall intensity, and individual farming and general land use practices. For example, in the sand plain of Portage County during an average year, only one inch of water is able to run off the land surface. This is due to the flat topography and highly porous nature of the soil and underlying glacial outwash. Nine inches infiltrates the soil as recharge to a highly productive sand and gravel aquifer. Because of this high average yearly recharge, present ground-water use, including irrigation, consumes less than 4% of the average yearly renewable supply.

Ground water can move as quickly as several feet per day in the porous sand plain areas, or as slowly as several inches per year in the microfractured hard dense crystalline rock areas of counties such as Jackson, Marathon, Portage and Wood. However, no matter how rapidly or slowly the ground water flows, its natural direction of movement is from upland recharge areas (infiltration) to lowland discharge areas (springs and seeps). Most discharge areas are usually associated with a surface-water body, so ground water has a significant role in the development and environmental health of lakes, streams and wetlands.

Areas with either thin soil over a rock aquifer, or sandy soil with a high water table, are especially susceptible to ground-water pollution from surface infiltration. Ground water comes from water that percolates down from the land surface, so any water-soluble material that we put on or in the ground has the potential to be dissolved by infiltrating water and carried into the ground water. Soil is usually a good natural filter that removes harmful material from the recharging water as it percolates downward. However, thin or sandy soils are not an effective filter for many potential pollutants contained in liquid or solid waste products, or other materials that we purposefully apply to the land surface for our benefit, such as road salt, manure and chemical fertilizers, pesticides, and herbicides. Once a pollutant reaches the water table, very little filtering takes place; dilution will disperse the pollutant, but will not remove it.

Because ground water can seep as slowly as a few inches per year, pollution that occurs today may not become evident for several or even hundreds of years. Once polluted, the ground water is very difficult to purify, and may take many years, decades, or centuries to clean itself by the dilution process.

METHOD OF WORK AND PRODUCTS

Data Used

DNR well constructor's reports (1936-1979), Wisconsin Conservation Department Emergency Conservation Work (ECW) water-table survey notes, and more recent (post 1960) U. S. Geological Survey (USGS) topographic quadrangle maps were the most useful and important sources of data for this study. Because of the dramatic increase in acreage irrigated by ground water over the last few decades, and the increase in the number of domestic wells, there were many more DNR well constructor's reports available to this study than were available to the studies of the past. In addition, most of the more recent USGS topographic quadrangle maps are at a scale of 1:24,000, and replace older maps which are at a scale of 1:62,500 or 1:48,000. These larger scale (1:24,000) maps show more detail and include more cultural and hydrologic features than the smaller scale maps. This enables more precise location of irrigation and household wells, and of the elevation of streams, rivers, and seepage lakes. This in turn allows a better hydrologic interpretation to be made than was previously possible.

The data sources used directly in the preparation of the water-table elevation maps (Maps 1 to 10), and the regional aquifer-potential map (Map 11), are listed on those maps. For the page-size aquifer-potential maps (Maps 12 to 21), the data sources for all the maps are listed on the title page (page A-1) which precedes the set of maps.

Many other published and unpublished sources of data were utilized, including the files and records of the WG&NHS and its staff. Most of these were used as general background information, and were not utilized specifically during map preparation. A list of references and data sources occurs at the end of this report.

Sorting and Filming

The well constructor's reports received from the DNR were originally filed in chronological order (by drilling date). In the course of this study, they were resorted into geographical order, that is by township, range, and section. Through the use of plat books, topographic maps, and city and village maps, the locations as given on many of these reports were made more precise. Microfilming of all the reports dated from 1936 through 1979 is in progress. Upon completion, a copy of this microfilm will be filed at the WG&NHS. It will be available for public inspection and use, with geologic and hydrogeologic assistance from staff.

Plotting

All of the WG&NHS geologic logs, and all of the ECW data, were plotted onto the largest scale USGS topographic maps available, that is, onto 7½-minute or 15-minute quadrangles. DNR well constructor's reports were examined and checked against each other, and the most representative, reliable, and useful report available for each section was plotted. Some areas were entirely devoid of reports, and some areas had only sparse coverage, but most areas had at least one report per two square miles.

The original work maps with the plotted data are filed at the WG&NHS, (under the name "Golden Sands Resource Maps") and are available to assist the public in solving more site specific problems. A more detailed description of how the plotting was accomplished, and a guide on how to use the data, are kept on file with the maps.

Interpretation

Water-Table Elevation Maps (Maps 1 to 10)

Because measurements were made at different times of the year, and in different years, water levels as determined from the well constructor's reports and the ECW data were not often used as exact data points. Instead, they were considered to be part of a range of values, and were used as guides when drawing the maps. The elevations of springs, ground-water seepage areas and seepage lakes were used as data points. Because ground-water flow is perpendicular to the lines of equal water-table elevation, these maps show a generalized picture of the direction of shallow ground-water flow. They are not intended to be used in place of site specific evaluations.

The water-table elevation lines are solid where enough data are present to enable the lines to be located with a high degree of confidence. The horizontal position of the line is believed to be accurate to within ± ¼ mile. The lines are dashed (or dotted) where data are less abundant or reliable; their horizontal position is believed to be accurate to within ± ½ mile. In areas where question marks are present, more data are required; dashed lines which contain question marks are merely a best estimate, and are probably accurate to within ± 1 mile. Ground-water divides are shown as solid lines where their horizontal position is believed to be accurate to within ± ½ mile, and as dashed lines where accuracy is probably ± 1 mile.

Each of the ten water-table elevation maps has a primary interval of 20 feet, and half interval of 10 feet. Adams, Jackson, Juneau, Portage, and Wood Counties have quarter intervals of 5 feet. Different line weights are used for the 20-, 10-, and 5-foot intervals; these weights are consistent for all ten counties. In parts of Marathon and Monroe counties, the 20-foot lines were so closely spaced that it was necessary to suppress every other isopleth, that is, go to a 40-foot interval. Rather than use another line weight, these small areas were shaded, as indicated in the explanation on the maps. Map users should take care to study the explanations on the maps.

Federal- and state-owned lands are shown on the water-table elevation maps. This information was taken from the most recent plat book available for each given county. Parcels of land smaller than 40 acres were not included.

Aquifer-Potential Maps (Maps 11 to 21)

Interpretation of data for the aquifer-potential maps was done on the USGS 7½- and 15-minute topographic maps, and then transferred onto 1:300,000 base maps, which were used to produce the page-size maps (Maps 12 to 21). These maps were then combined and reduced photographically to produce the regional map (Map 11), which is at a scale of 1:500,000.

The aquifer-potential maps show both the range of yields to be expected in an area, and the aquifer(s) to be used to obtain those yields. The lines on the maps separate areas of differing aquifer potential. Solid lines are believed to be accurate to within ± ½ mile, and dashed lines to within ± 1 mile. The numbers represent the range of yields, and the letters represent the aquifers, as indicated in the explanation on the maps. Yields are based on fully developed wells which utilize the aquifer(s) shown on the maps.

Aquifers are listed in order of relative importance, with the potentially most productive aquifer for the area being listed first. In addition, major aquifers are indicated by bold face type, and minor aquifers by regular face type. The specified yield can usually be obtained from the major aquifer(s). It is necessary to use the minor aquifer(s) only when the yield from the major aquifer(s) is insufficient.

When the aquifer or aquifers to be used within a given small area are not shown on the map, they are the same as those indicated for the immediately surrounding larger area. For example, in the southeast corner of Portage County (Map 11 and Map 18), the two small areas of 1000+ gallons per minute (gpm) within the area of 500-1000+ gpm have S/G as their major aquifer.

WATER QUALITY

An assessment of ground-water quality was beyond the scope of this mapping project, however, the maps and geographically organized well log files form a data base to support water-quality studies. Aquifer characteristics and the ground-water flow system need to be understood and utilized in any ground-water quality analysis or management process.

CONCLUSIONS

The maps contained in this report provide a generalized source of information about the ground-water resources of the Golden Sands RC&D Area, and should prove useful to land- and water-use planners. In cases where more detailed or site specific information is needed, the original data as plotted onto USGS topographic maps (the Golden Sands Resource Maps) should be consulted. These are on file at the Wisconsin Geological and Natural History Survey, 1815 University Avenue, Madison, WI 53706.

Most comparisons between maps from previous studies and maps from the present study show a good correlation of results, at the scale of the maps in this study. Cases where correlation is not very good are believed to be due in large part to this study's access to more recent or complete information.

The authors believe that the results of this study demonstrate that useful ground-water resource maps can be produced using data sources and methods described in this report.

RECOMMENDATIONS FOR FUTURE WORK

Because the well constructor's reports are useful when they are in geographical order, it is recommended that updates be made every 5 to 10 years to the files of the geographically-sorted well logs stored at the WG&NHS. These records could then be used to update the maps for the Golden Sands RC&D Area, and also to produce similar maps for other counties in the state.

Site specific testing of aquifers in areas of sparse or conflicting data, as indicated by dashed lines and question marks on the maps, would facilitate more accurate interpretation of the water-table elevation and aquifer potential of these areas.

The maintenance of ground-water quality is vital to the long term economic development and environmental health of the Golden Sands RC&D Area. The geologic character of an aquifer can have a strong influence on its susceptibility to contamination. For this reason ground-water quality should be monitored in areas where the soil and aquifer materials allow the rapid infiltration of recharge water from the land surface, as occurs in the fractured rock and the highly permeable sandy aquifers of the Golden Sands RC&D Area.

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AQUIFER POTENTIAL

IRRIGABLE LANDS INVENTORY

PHASE I – GROUND WATER AND RELATED INFORMATION

By:

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Prepared by:

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY

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GOLDEN SANDS RESOURCE CONSERVATION AND DEVELOPMENT AREA

Funded by:

UPPER GREAT LAKES REGIONAL PLANNING COMMISSION

SEPTEMBER 1981

Sources:

Well Constructor's Reports (1936-1979) –
Wisconsin Department of Natural Resources
Published and unpublished Geologic Logs (1896-present) –
Wisconsin Geological & Natural History Survey
Major Public Open Space – Map 4
Land Resources Analysis Program –
Wisconsin Department of Administration (1974)
USGS Topographic Maps

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Adams, Jackson, Juneau

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Jackson, Wood

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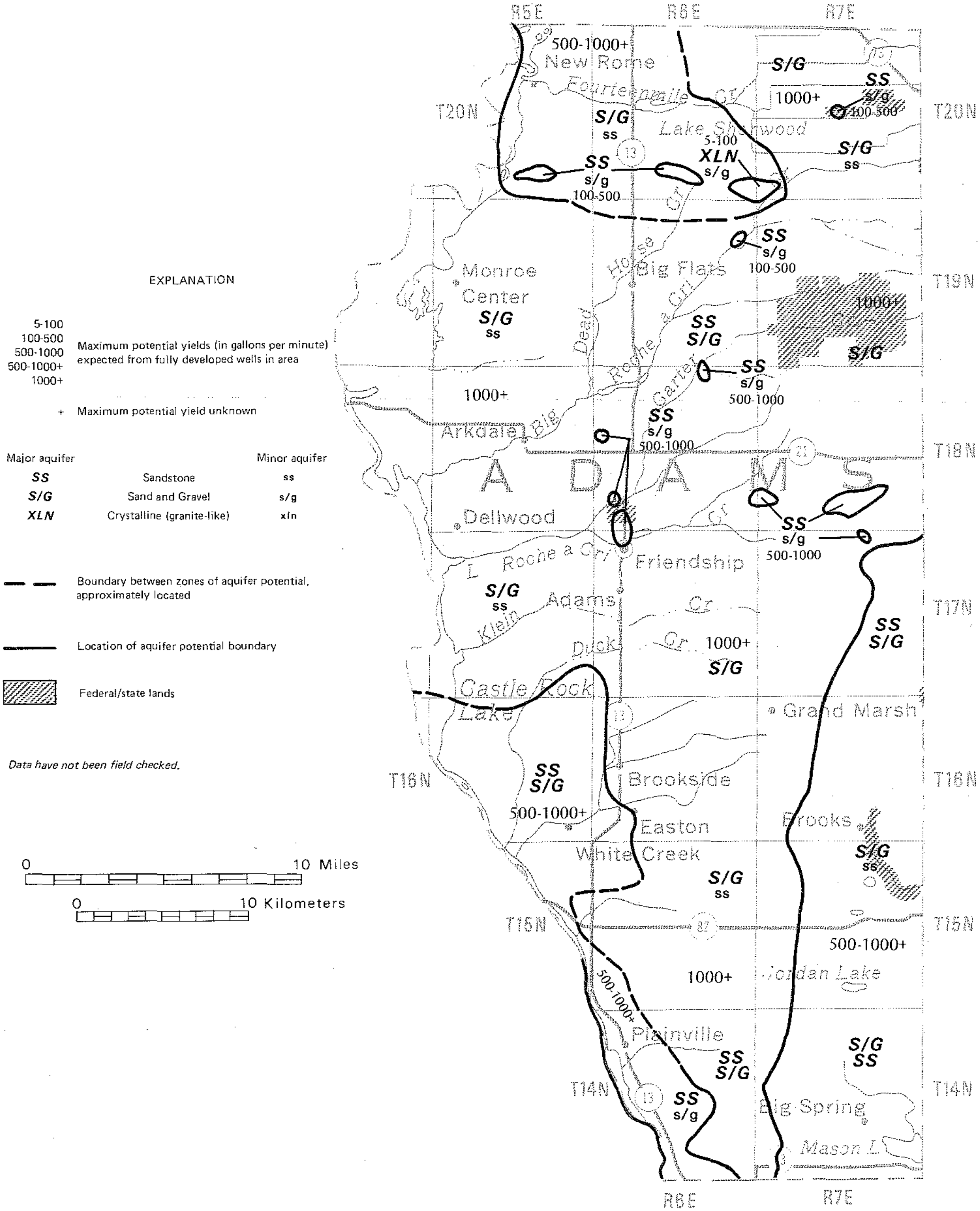
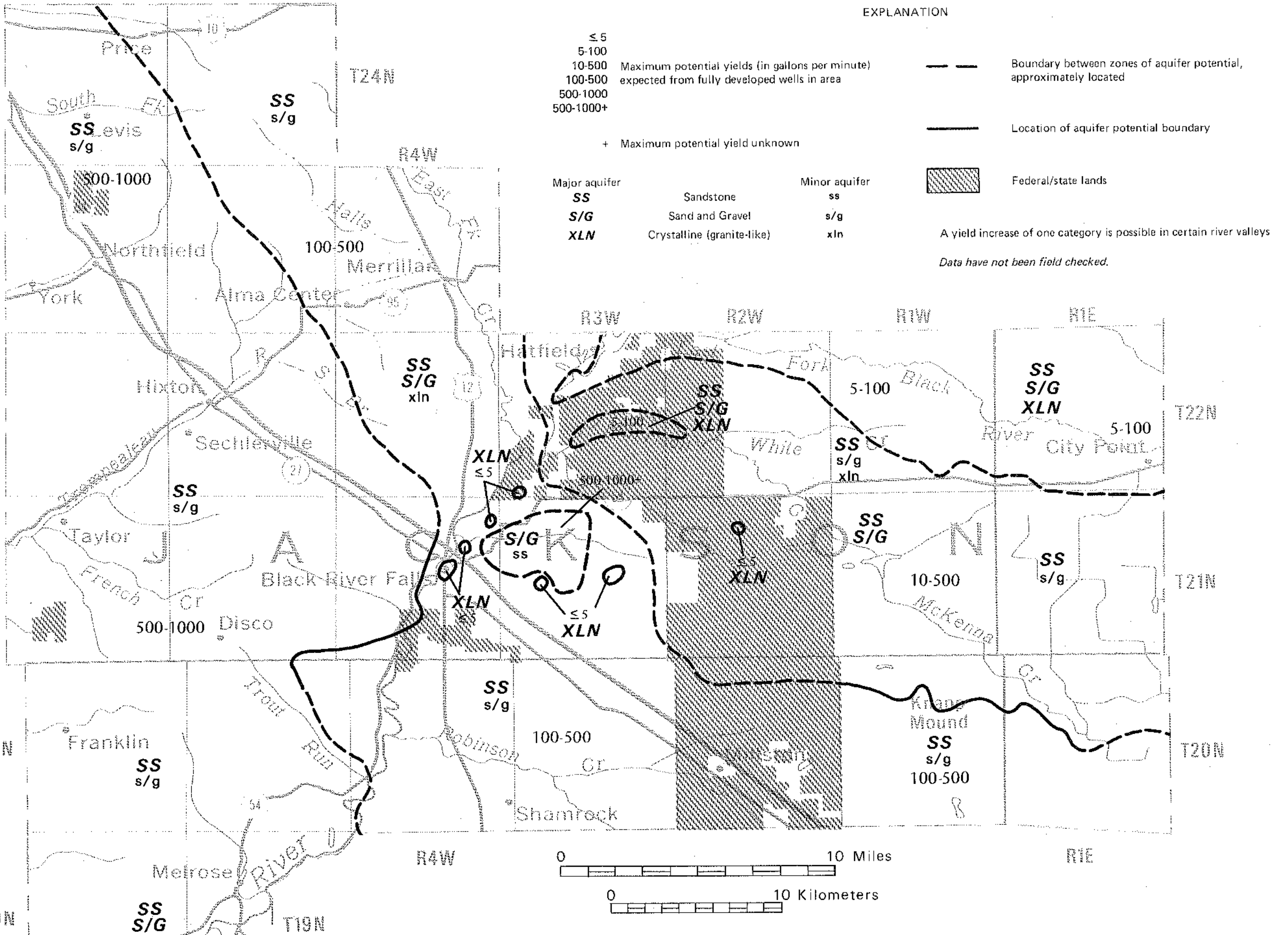
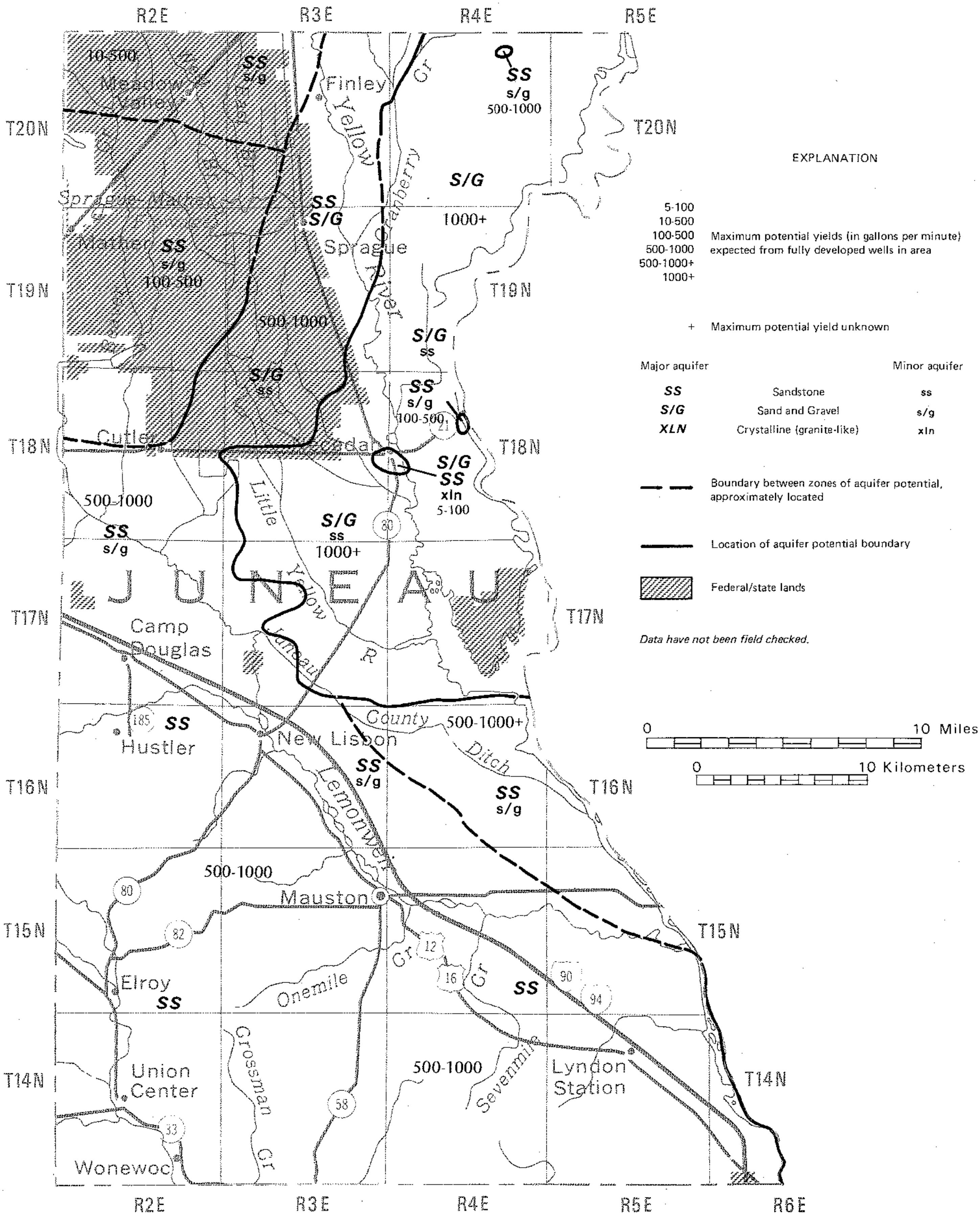


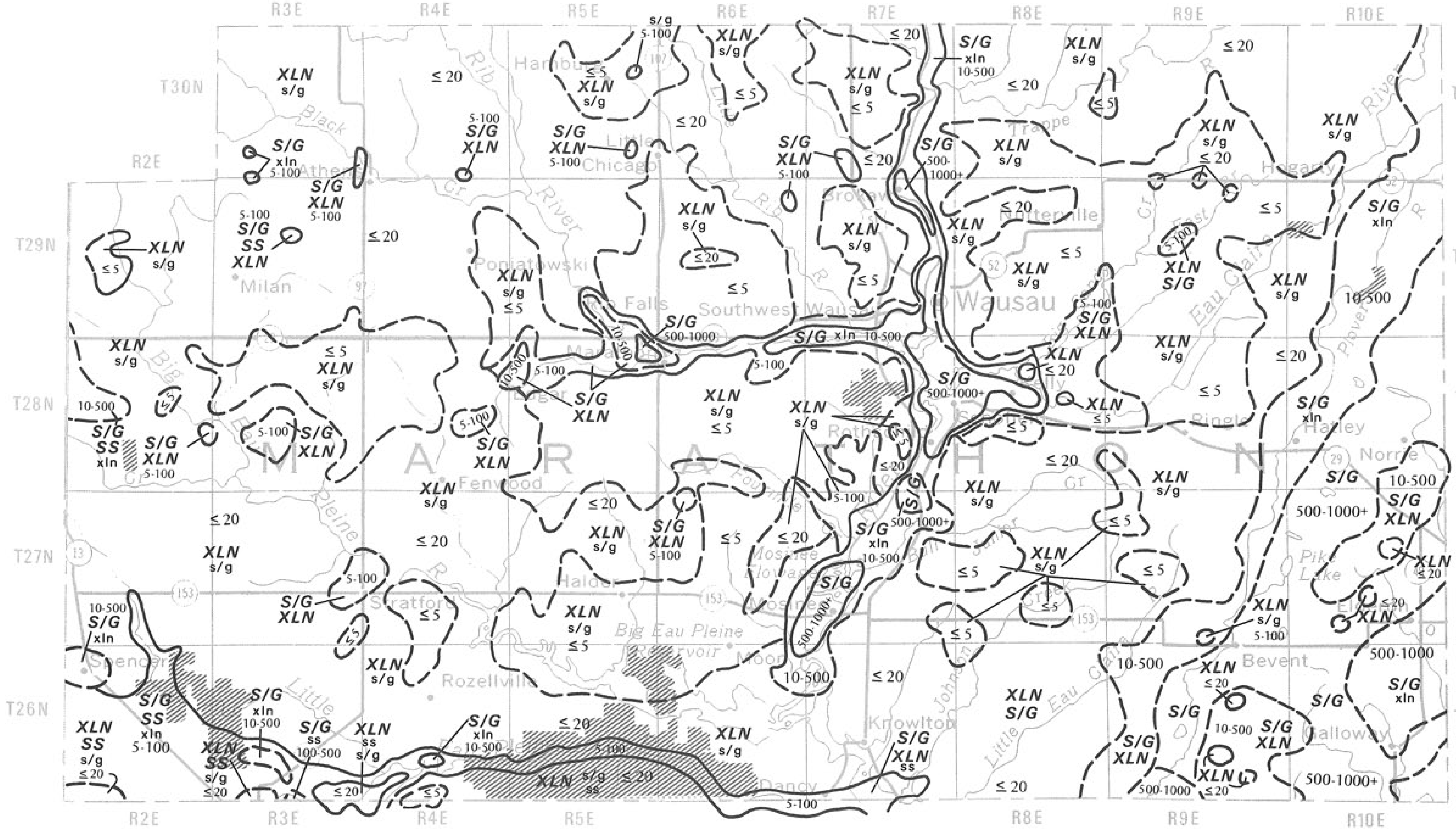
Map 12. Aquifer Potential of Adams County, Sept. 1981, by R.G. Hennings and I.D. Lippelt.



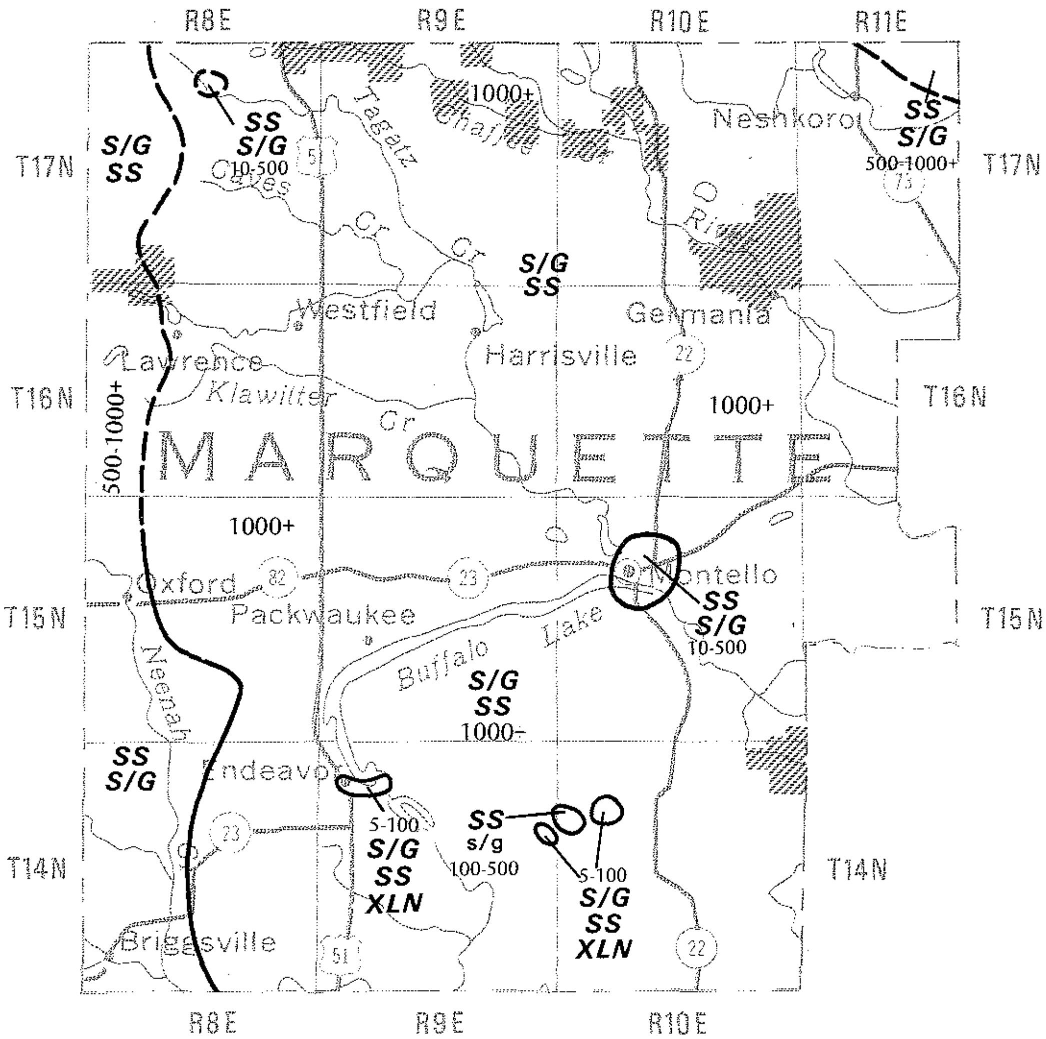
Map 13. Aquifer Potential of Jackson County, Sept. 1981,
by R.G. Hennings and I.D. Lippelt.



Map 14. Aquifer Potential of Juneau County, Sept. 1981, by R.G. Hennings and I.D. Lippelt.



Map 15. Aquifer Potential of Marathon County, Sept. 1981, by R.G. Hennings and I.D. Lippelt.



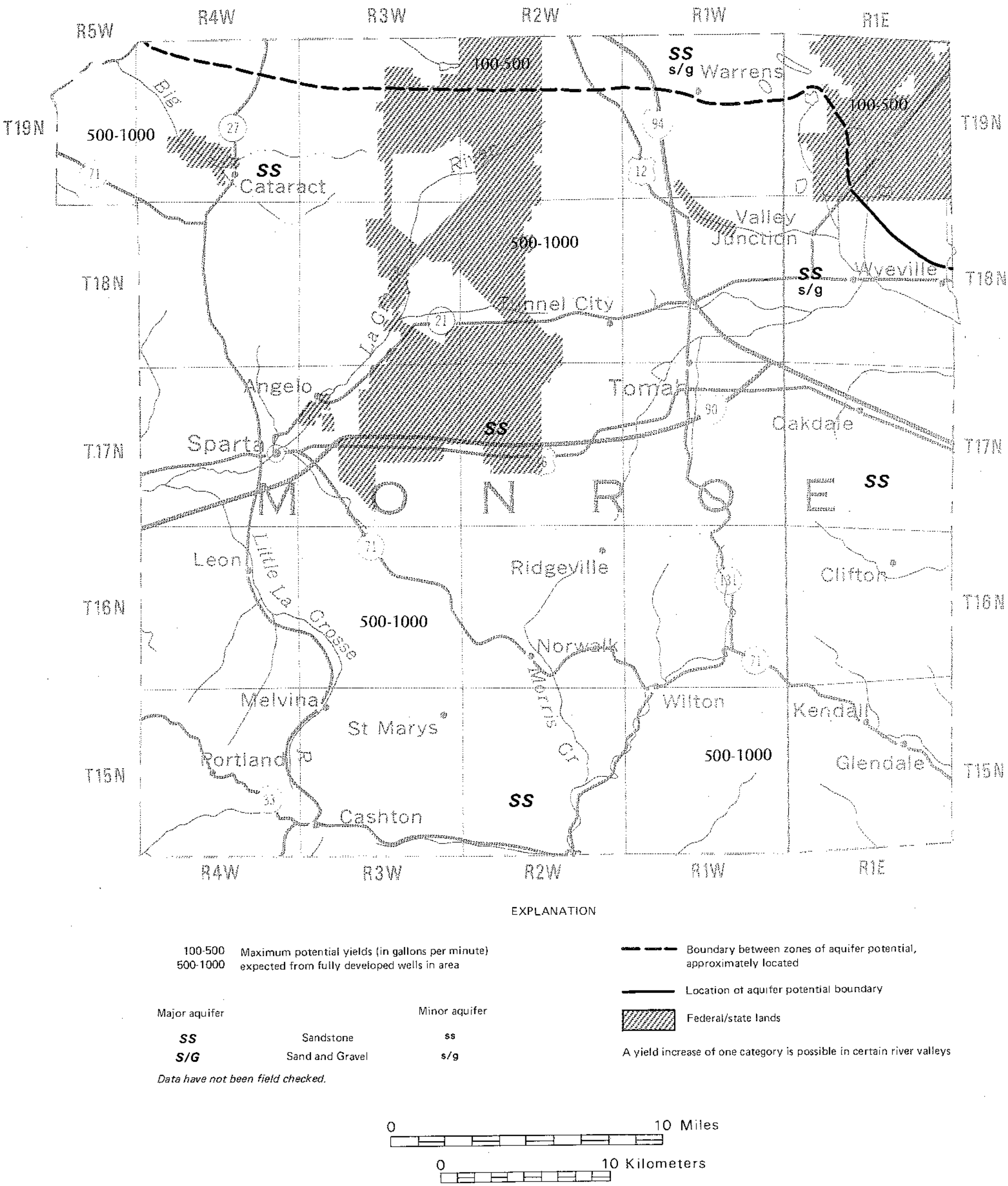
EXPLANATION

5-100 10-500 100-500 500-1000+ 1000+	Maximum potential yields (in gallons per minute) expected from fully developed wells in area
+	Maximum potential yield unknown
▬ ▬	Boundary between zones of aquifer potential, approximately located
▬▬▬	Location of aquifer potential boundary
▨	Federal/state lands

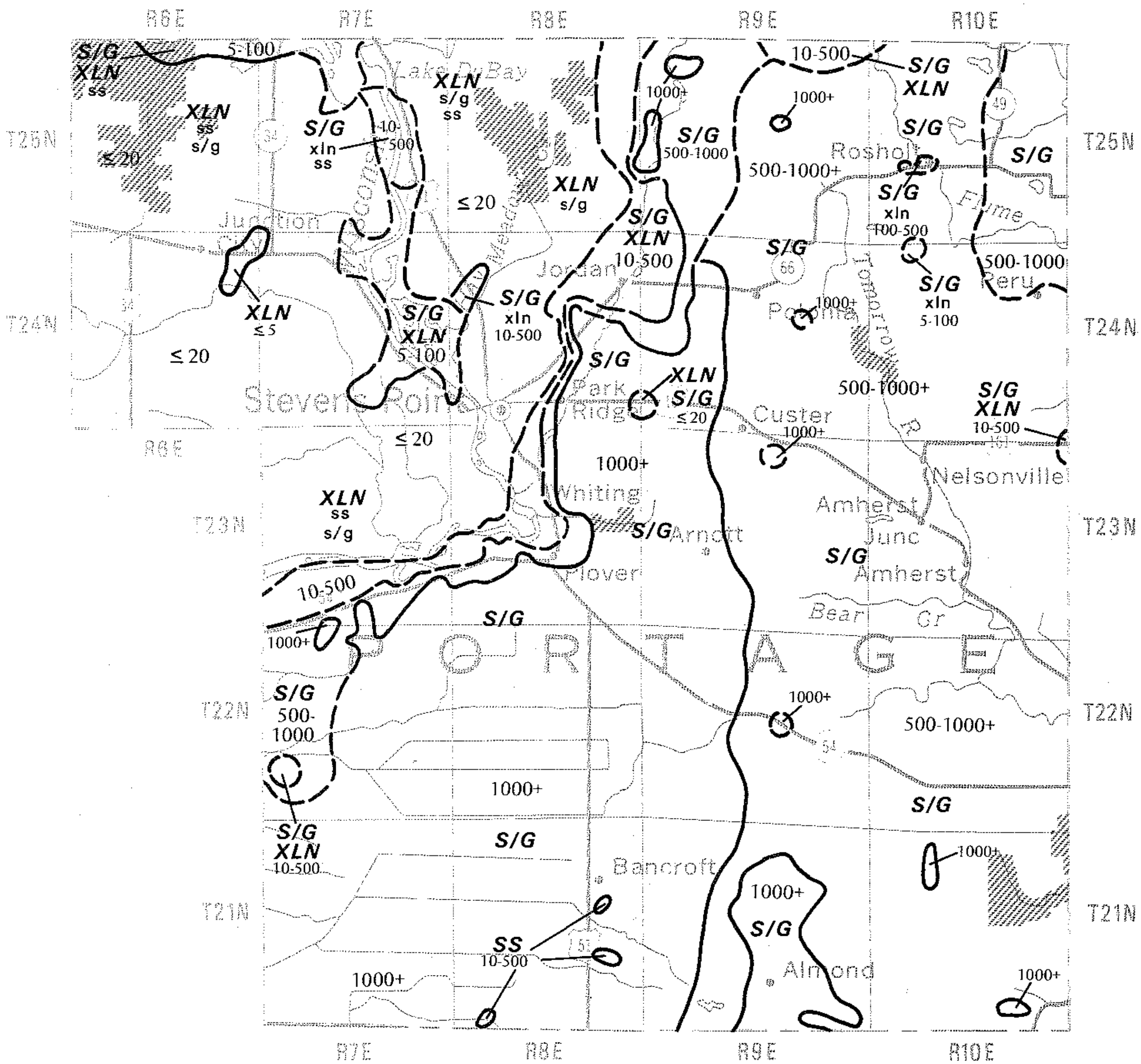
Major aquifer		Minor aquifer
SS	Sandstone	ss
S/G	Sand and Gravel	s/g
XLN	Crystalline (granite-like)	xln

Data have not been field checked.

Map 16. Aquifer Potential of Marquette County, Sept. 1981, by R.G. Hennings and I.D. Lippelt.



Map 17. Aquifer Potential of Monroe County, Sept. 1981, by R.G. Hennings and I.D. Lippelt.



EXPLANATION

≤ 5 ≤ 20 5-100 10-500 100-500 500-1000 500-1000+ 1000+	Maximum potential yields (in gallons per minute) expected from fully developed wells in area
+	Maximum potential yield unknown

Boundary between zones of aquifer potential, approximately located

Location of aquifer potential boundary

Federal/state lands

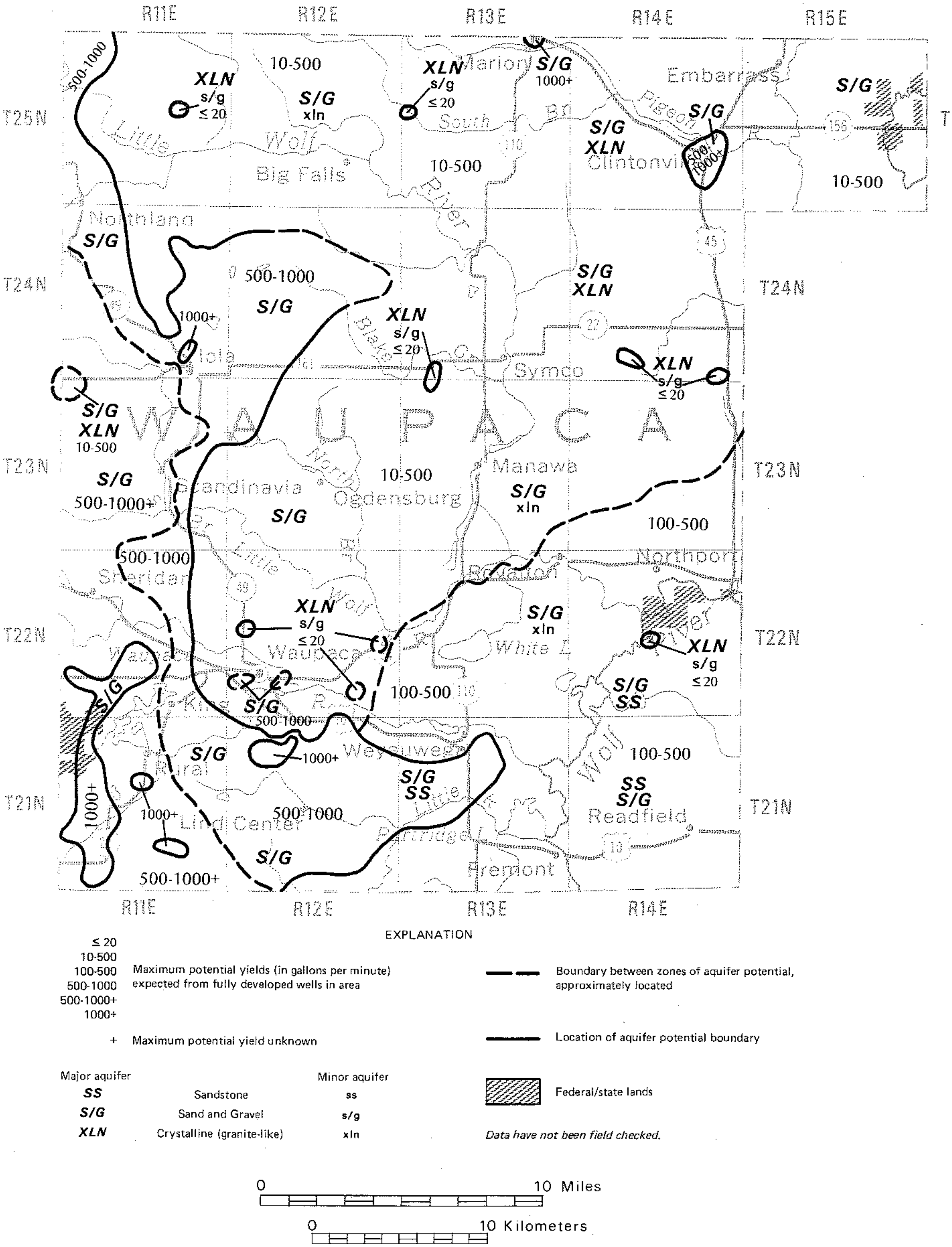
Major aquifer		Minor aquifer
SS	Sandstone	ss
S/G	Sand and Gravel	s/g
XLN	Crystalline (granite-like)	xln

Data have not been field checked.

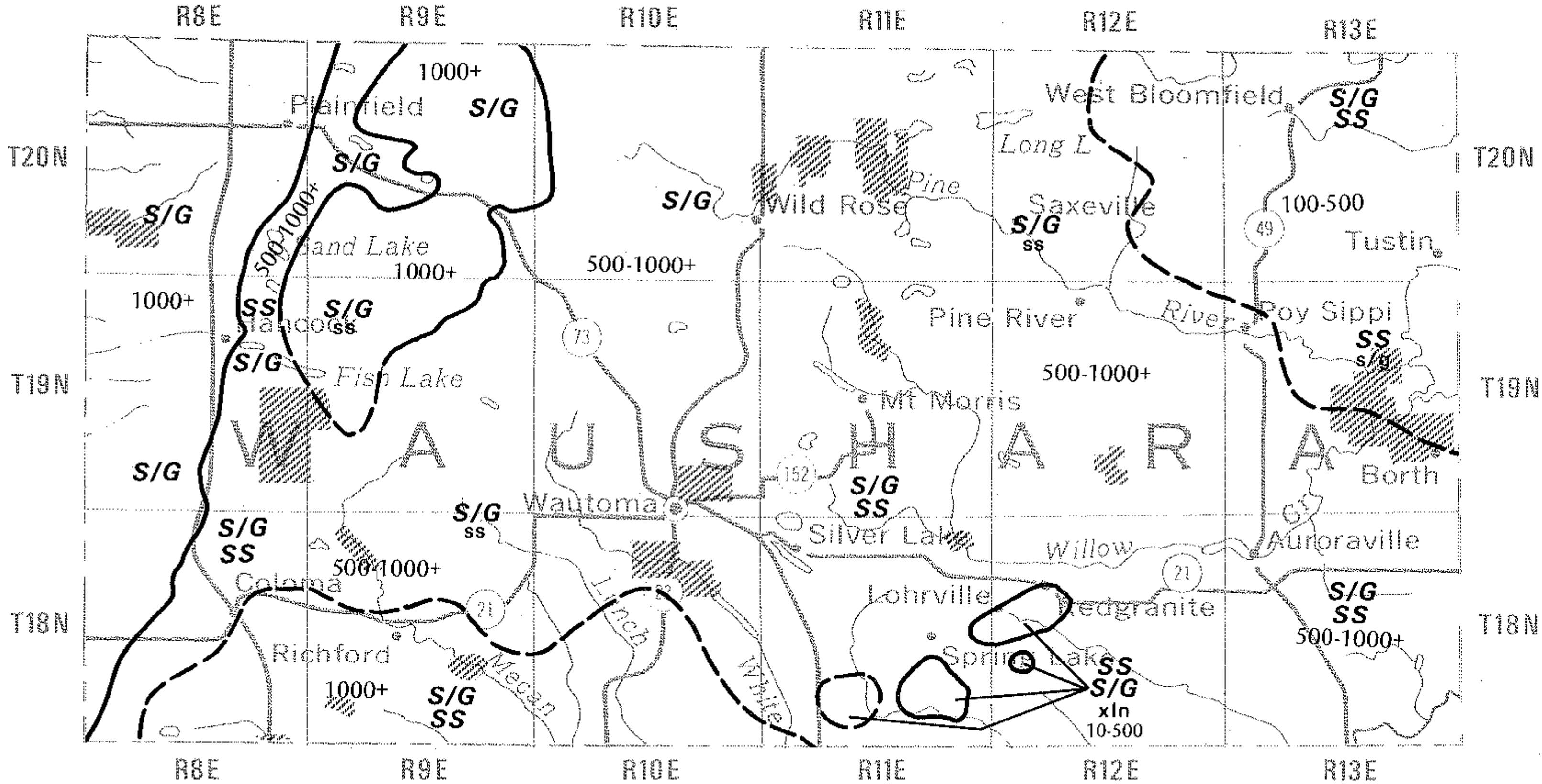
0 10 Miles

0 10 Kilometers

Map 18. Aquifer Potential of Portage County, Sept. 1981, by R.G. Hennings and I.D. Lippelt.



Map 19. Aquifer Potential of Waupaca County, Sept. 1981, by R.G. Hennings and I.D. Lippelt.



EXPLANATION

10-500
100-500
500-1000+
1000+

Maximum potential yields (in gallons per minute) expected from fully developed wells in area

\+ Maximum potential yield unknown

Major aquifer		Minor aquifer
SS	Sandstone	ss
S/G	Sand and Gravel	s/g
XLN	Crystalline (granite-like)	xln

Boundary between zones of aquifer potential, approximately located

Location of aquifer potential boundary

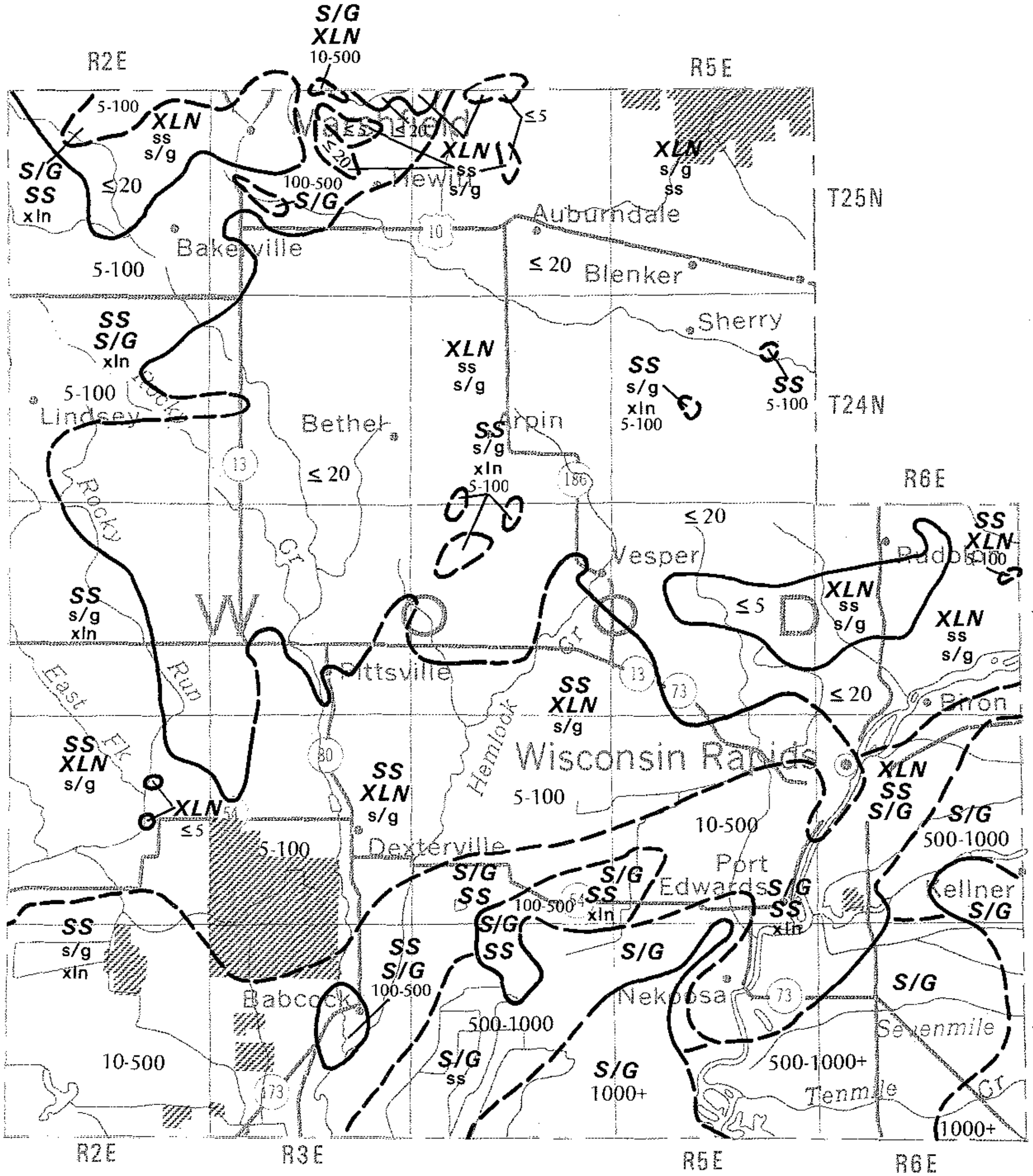
Federal/state lands

Data have not been field checked.

0 10 Miles

0 10 Kilometers

Map 20. Aquifer Potential of Waushara County, Sept. 1981, by R.G. Hennings and I.D. Lippelt.



EXPLANATION

≤ 5 ≤ 20 5-100 10-500 100-500 500-1000 500-1000+ 1000+	Maximum potential yields (in gallons per minute) expected from fully developed wells in area
+	Maximum potential yield unknown

Boundary between zones of aquifer potential, approximately located

Location of aquifer potential boundary

Federal/state lands

Major aquifer		Minor aquifer
SS	Sandstone	ss
S/G	Sand and Gravel	s/g
XLN	Crystalline (granite-like)	xln

Data have not been field checked.

0 10 Miles

0 10 Kilometers

Map 21. Aquifer Potential of Wood County, Sept. 1981, by R.G. Hennings and I.D. Lippelt.