A STRATEGY FOR COLLECTING GROUND-WATER DATA AND DEVELOPING A GROUND-WATER MODEL OF THE MISSOURI RIVER ALLUVIAL AQUIFER, WOODBURY AND MONONA COUNTIES, IOWA

by Robert C. Buchmiller

U.S. GEOLOGICAL SURVEY

Open-File Report 87-452

Prepared for the

U.S. ARMY CORPS OF ENGINEERS, Omaha District

Iowa City, Iowa
1988

DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief,
U.S. Geological Survey
Box 1230
400 South Clinton Street
Room 269, Federal Bldg.
Iowa City, IA 52244

Copies of this report can be
purchased from:

U.S. Geological Survey
Books and Open-File Reports
Section
Federal Center, Bldg. 810
Box 25425
Denver, CO 80225

CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

For the convenience of readers who may prefer to use metric (International System) units rather than the inch-pound units used in this report, values may be converted by using the following factors.

Multiply inch-pound unit	By	To obtain metric unit
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Hydraulic Conductivity	
foot per day (ft/d)	0.3048	meter per day (m/d)

A STRATEGY FOR COLLECTING GROUND-WATER DATA AND DEVELOPING A GROUND-WATER MODEL OF THE MISSOURI RIVER ALLUVIAL AQUIFER, WOODBURY AND MONONA COUNTIES, IOWA

By Robert C. Buchmiller

ABSTRACT

A ground-water-flow model and plan for obtaining supporting data are proposed for a part of the Missouri River alluvial aquifer in Woodbury and Monona Counties, Iowa. The proposed model and the use of the principle of superposition will aid in the interpretation of the relation between ground water and surface water in the study area, particularly the effect of lowered river stages on water levels in the alluvial aquifer. Information on the geometry, hydraulic characteristics, and water levels in the alluvial aquifer needs to be collected for use in the model and for model calibration. A plan to obtain hydrologic and geologic information by use of exploratory test-well drilling is proposed. Also proposed is a monitoring network to obtain information on the spatial and temporal variability of water levels within the study area.

INTRODUCTION

The Missouri River in western Iowa is regulated and channelized to support navigation on the river and to provide flood control. Streamflow in the river is controlled largely by releases from impoundments upstream on the mainstem of the river. Concern about the potential effects of channelization and flow regulation on the wetlands and the water table adjacent to the river, as well as the need to understand the hydraulic relation between the river and the adjacent alluvial aquifer for management purposes, has resulted in an investigation of the relation between ground water and surface water.

On March 1, 1985, the U.S. Geological Survey in cooperation with the Omaha District of the U.S. Army Corps of Engineers began a study of the relation between surface water in the Missouri River and ground water in the adjacent alluvial aquifer in Woodbury and Monona Counties, Iowa. The first phase of this investigation was to determine the extent of available information on surface-water and ground-water resources within the study area. This phase was completed in September 1985 and a report (Buchmiller, 1986) was produced. The report detailed the extent of available information within the study area and the investigations that have been conducted to date.

Purpose and Scope

This report proposes additional work needed to determine the flow of water in the alluvial aquifer and the flow of water between the Missouri River and the aquifer--that is, identifying a ground-water flow model for determining the general relation of the river to the alluvial aquifer; identifying the type of information needed for the model selected; and proposing a means of obtaining the necessary information. A description of the ground-water-flow system in the study area is based on data presented in Buchmiller (1986).

The investigation is limited to an analysis of the surface-water and ground-water resources within the flood plain of the Missouri River in parts of Woodbury and Monona Counties, Iowa. Parts of the flood plain in Thurston and Dakota Counties, Nebraska may be included if they are found to be hydrologically important to this investigation. The location and size of the study area is shown in figure 1.

STRATEGY FOR MODEL DEVELOPMENT

The modeling strategy proposed to meet the objectives of this investigation is one based on the principle of superposition. Briefly stated, superposition in ground-water hydraulics can be used to obtain solutions to individual parts of a problem, which can then be added to solve composite problems in terms of the changes that have occurred within a system.

Reilly and others (1984) present a concise explanation of the application of superposition to a simple hydrologic system. The example used by Reilly illustrates how superposition is used to compute the head distribution between a river and a canal given two known conditions and one unknown condition.

> "In example a (fig. 2B), the river stage is at datum, and the canal stage is 200 feet above datum; in example b the river stage is 50 feet above datum, and the canal stage is at datum. If the head distribution in the aquifer is known from field measurements or numerical calculations for examples a and b, then the head distribution in example c, where the river stage is at 50 feet and the canal is at 200 feet, can be obtained by adding the heads in examples a and b (lines A and B, fig. 2B(c)) to obtain line A+B."

The principal advantage to the use of superposition in this investigation is that a single stress, the change in river stage in this particular case, can be analyzed to determine its effect on a ground-water-flow system independent of other stresses on the system, such as recharge, pumpage, and evapotranspiration. Although the principle of superposition is strictly applicable to systems of linear differential equations, in practice the method can be used to solve problems if they are not extremely non-linear. Because in this problem the water-level changes are expected to be less than 10 percent of the saturated thickness of the aquifer, the problem is believed to be suitable for the application of superposition. Use of superposition reduces the quantity of data needed for developing the model because only selected stresses are simulated rather than all the stresses acting on the natural system. The resulting interpretations will provide an understanding of the effect river stage has on the aquifer within a range of hydrologic conditions. The simulated effects of the river stage may or may not match actual field measurements because of the combined effects of all stresses on the natural hydrologic system.

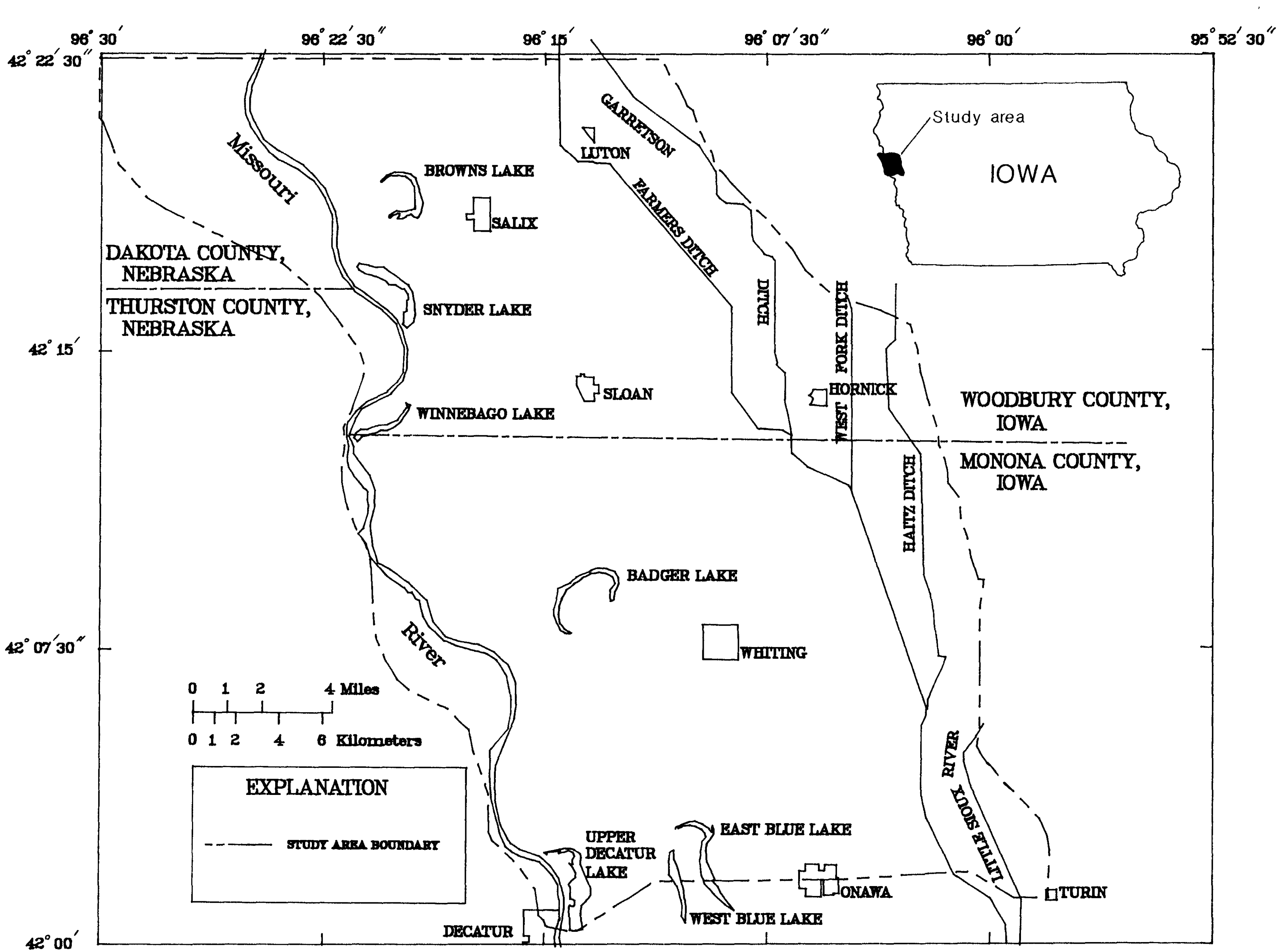
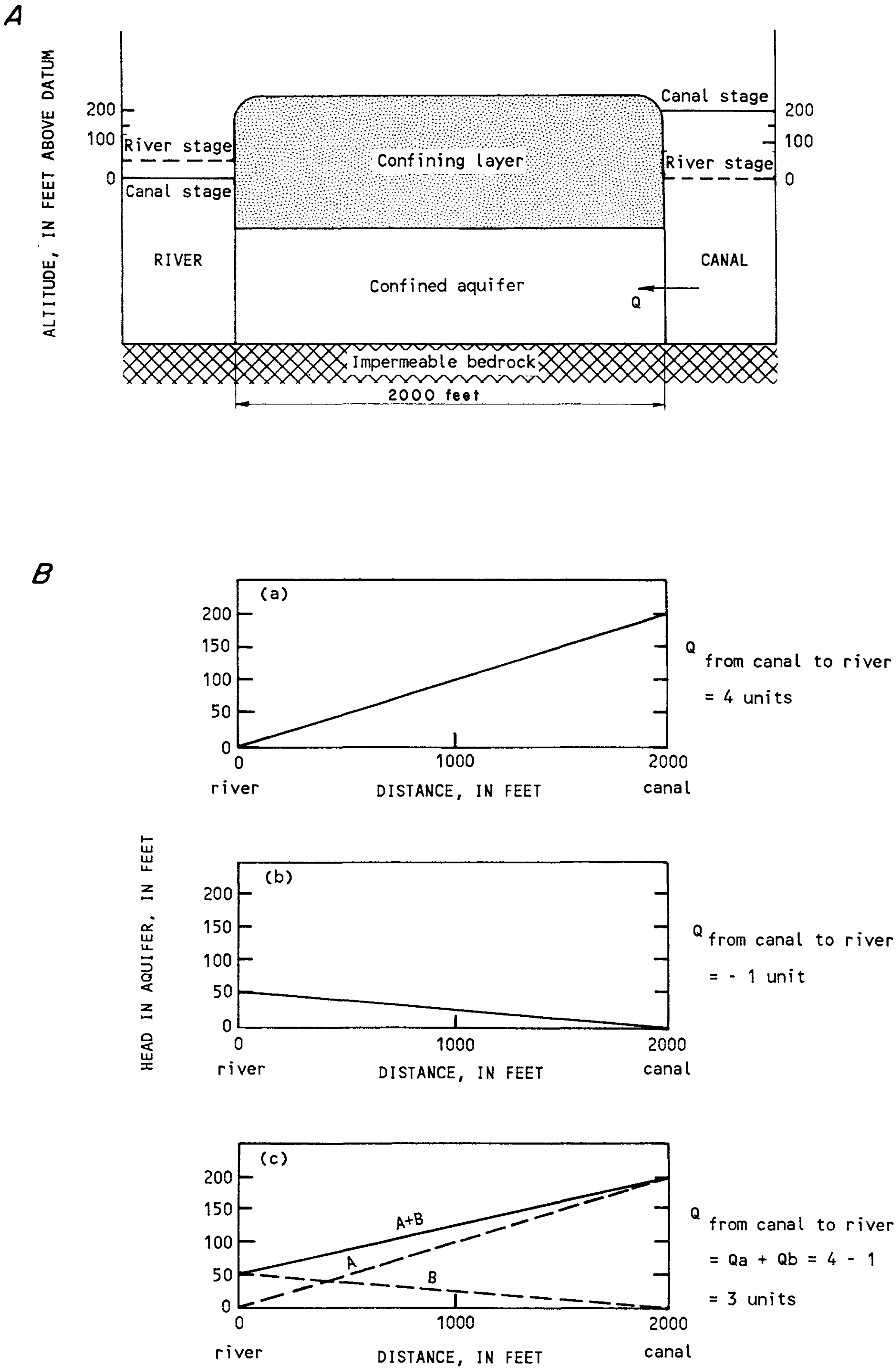


Figure 1.—Location of study area



Source: Reilly and others, 1984

Figure 2.--Superposition of heads and flows in a one-dimensional example--A. Confined aquifer bounded by a river and canal. B. Plots of head distribution under three conditions: (a) with river stage at datum (0 ft.) and canal stage at 200 ft.; (b) with river stage at 50 ft. and canal stage at datum (0 ft.); (c) addition of heads in (a) and (b) to obtain head distribution with river stage at 50 ft. and canal stage at 200 ft.

Proposed Model Design

The digital finite-difference three-dimensional ground-water-flow model selected for this investigation was described and documented by McDonald and Harbaugh (1984). The preliminary design of the proposed model is based on analysis and interpretations of the available ground-water data base that is described in Buchmiller (1986) and on assumptions about the flow system that may be changed as additional information becomes available.

The ground-water-flow model uses a block-centered, finite-difference numerical approach and the proposed discretization of the study area is shown in figure 3. The horizontal dimensions of each block are 2,640 feet by 2,640 feet, encompassing an area of 0.25 square miles, which is typically the closest spacing between irrigation wells in the area. The maximum width of the alluvial aquifer within the study area is about 18 miles and the maximum north-south length of the study area is 26 miles. This discretization is considered sufficient to determine the general nature of water flow between the alluvial aquifer and the river.

The alluvial aquifer may be divided into three preliminary layers based on an examination of the available descriptive well logs in the study area. Table 1 contains selected descriptive well logs and identifies the proposed aquifer layers.

Layer one consists of the upper part of the alluvial aquifer and contains the most recently deposited sediments. Within this layer are the post-Pleistocene deposits resulting from meandering and flooding of the Missouri River. The stratigraphy of materials in this layer may be extremely complex, with abrupt horizontal and vertical changes in types of materials due to changes in the erosional and depositional environments. Site-specific measurements of aquifer hydraulic parameters may vary considerably. This layer extends from land surface to about 40 feet below land surface. Although shallow domestic and livestock wells may be completed within this layer, withdrawal of water from these wells is not significant.

The second layer extends from about 40 to about 100 feet below land surface and may be more homogeneous than layer 1. Municipal, industrial and irrigation wells within the study area are completed within this layer.

The third layer consists of the very permeable gravels from about 100 feet below land surface to the bottom of the aquifer. This layer may be the most homogenous of the three layers. Few if any wells are developed in this layer. The thickness of this layer is not well known because of the sparsity of data for wells completely penetrating the alluvial aquifer. However, data from wells that have penetrated the aquifer indicate the bottom of the aquifer is less than 150 feet below land surface.

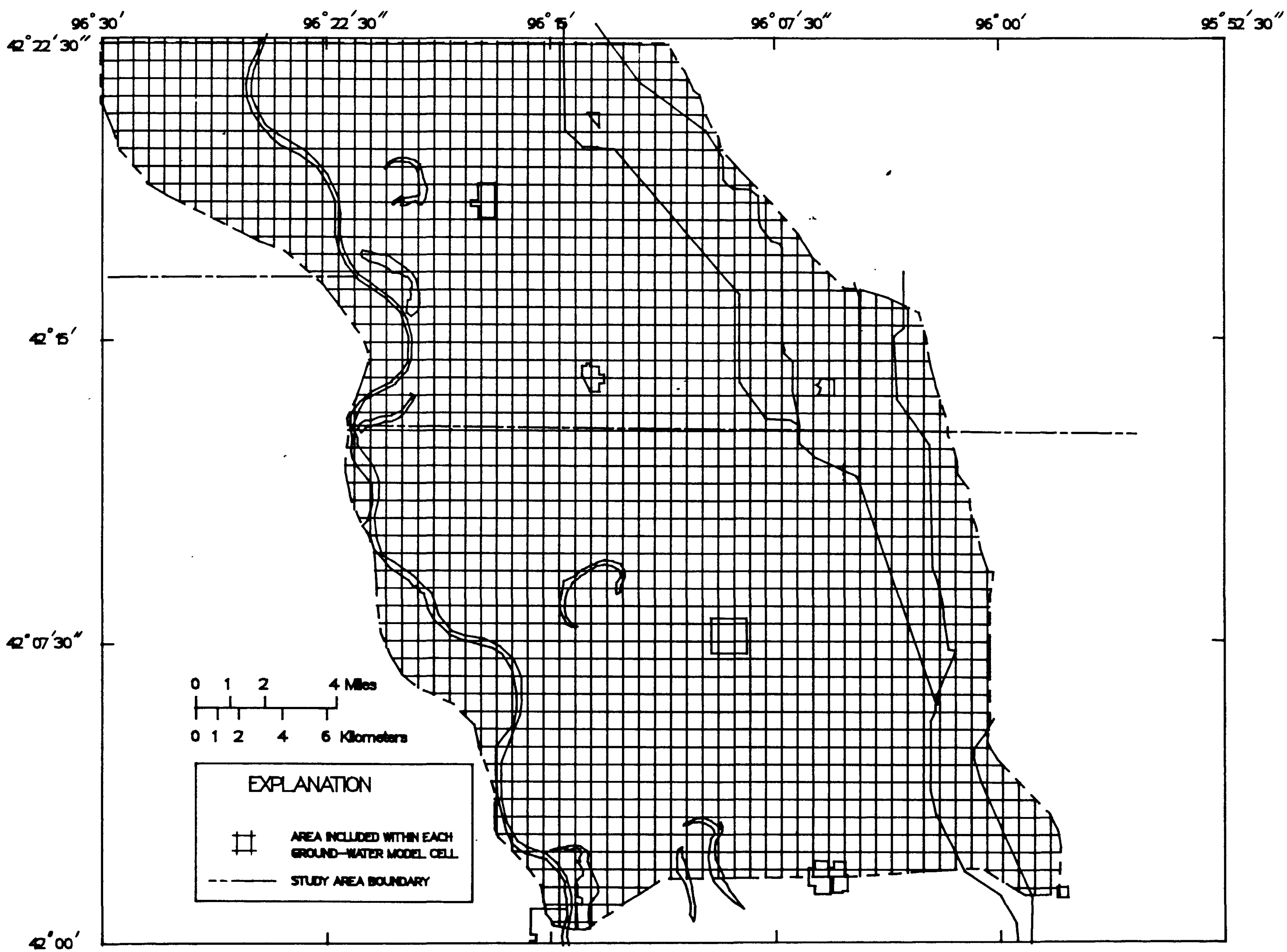


Figure 3.—Proposed discretization of study area for the ground-water flow model

Table 1.--Descriptive well logs showing the hypothesized alluvial aquifer layers

Well owner - City of Sloan
Location - Sloan

Interval (feet)	Material
	Layer 1
0- 3	Top soil
3-19	Yellow clay
19-28	Fine sand and lignite
	Layer 2
28-63	Coarse to fine sand
63-66	Lignite and wood
66-82	Medium sand and lignite
82-97	Sand and gravel

Well owner - City of Whiting
Location - Whiting

Interval (feet)	Material
	Layer 1
0- 4	Soil
4-24	Silt
24-30	Medium sand and silt
	Layer 2
30-49	Sand, grit, and gravel
49-60	Grit and gravel with clay balls and black rocks
60-77	Silt and fine sand
77-80	Coarse sand, grit and gravel
80-93	Sand and gravel
93-100	Coarse sand and grit, some pebbles
100-106	Grit and gravel, with some cobbles
	Layer 3
106-121	Sand, grit, and gravel with many well rounded pebbles

Well Owner - City of Onawa
Location - Onawa

Interval (feet)	Material
	Layer 1
0- 5	Black loam
5-22	Sandy clay
22-32	Blue clay
32-40	Fine sand
	Layer 2
40-57	Sand and gravel
57-64	Blue clay and fine sand
64-75	Fine sand
75-85	Sand and gravel
85-90	Coarse sand
90-100	Sand and gravel
100-104	Coarse sand
	Layer 3
104-110	Gravel

Well owner - City of Salix
Location - Salix

Interval (feet)	Material
0- 60	Blue clay
60-160	Coarse gravel
160-170	Sandstone

Well owner - Lakin Enterprises
Location - 3 miles east. and 3 miles north

Interval (feet)	Material
	Layer 1
0- 2	Black soil
2- 8	Brown clay
8-26	Gray clay
26-40	Silty sand
	Layer 2
40-50	Fine sand
50-60	Coarse sand, gravel, and fine sand
60-80	Coarse sand and gravel and fine sand
	Layer 3
80-114	Gravel and coarse sand few boulders at 105'
114-116	Red shale

Well Owner - Farmland Foods
Location - 4 miles west of Salix

Interval (feet)	Material
	Layer 1
0- 2	Fill
2-30	Fine sand
	Layer 2
30-36	Gravel, coarse sand
35-53	Coarse sand with clay
53-57	Blue clay
57-95	Gravel, coarse sand, pebbles
95-107	Coarse to fine sand
	Layer 3
107-154	Gravel, coarse sand, pebbles, loose
54-164	Sandstone

Model Assumptions

In order to develop the model described above, a conceptual model of the flow within the alluvial aquifer was used to describe the real system. The conceptual model of the flow system is diagrammed on figure 4. The conceptual model consists of hypotheses about the ground-water-flow system and assumptions about the geometry and physical properties of the flow system that are necessary to quantify the components for use in the model.

The principal assumptions of the conceptual model are:

1. The alluvial aquifer is horizontal and bounded by loess or till bluffs on the east and west and bedrock beneath. Flow into the aquifer from the loess, till, and bedrock boundaries is considered insignificant, at this time, compared to flow into the aquifer through recharge from precipitation and streamflow infiltration.

2. The Missouri River is considered to be the primary natural sink for flow from the alluvial aquifer. The river is assumed to be in direct hydraulic contact with the aquifer because studies have shown the streambed to be degrading (U.S. Army Corps of Engineers, 1985).

3. The effects of pumpage in Iowa on the aquifer are not large enough to cause significant flow under the Missouri River from the aquifer in Nebraska, therefore the part of the aquifer in Nebraska need not be included within the active area of the model.

4. Because superposition will be used to analyze the flow system for effects of river-stage changes, other stresses such as pumpage, recharge, and evapotranspiration do not need to be considered at this time.

Model Parameters and Initial Conditions

The differential equations that are numerically solved within the model to describe ground-water flow require information about the geometry and hydraulic properties of the aquifer at the center of each discretized block. The properties that need to be included in the model are; horizontal and vertical aquifer hydraulic conductivity, estimates of the saturated thicknesses of each model layer, and initial hydraulic head distributions.

The hydraulic properties of the aquifer need to be accurately defined in order to reliably predict the effects of stage changes on ground-water flow in the aquifer. Numerical estimates of hydraulic conductivity for each layer modeled will be determined from contoured maps of horizontal and vertical hydraulic conductivity derived from aquifer tests. The saturated thickness of each model layer will be determined from potentiometric water-level maps of the study area and geologic maps of the unconsolidated deposits comprising the alluvial aquifer.

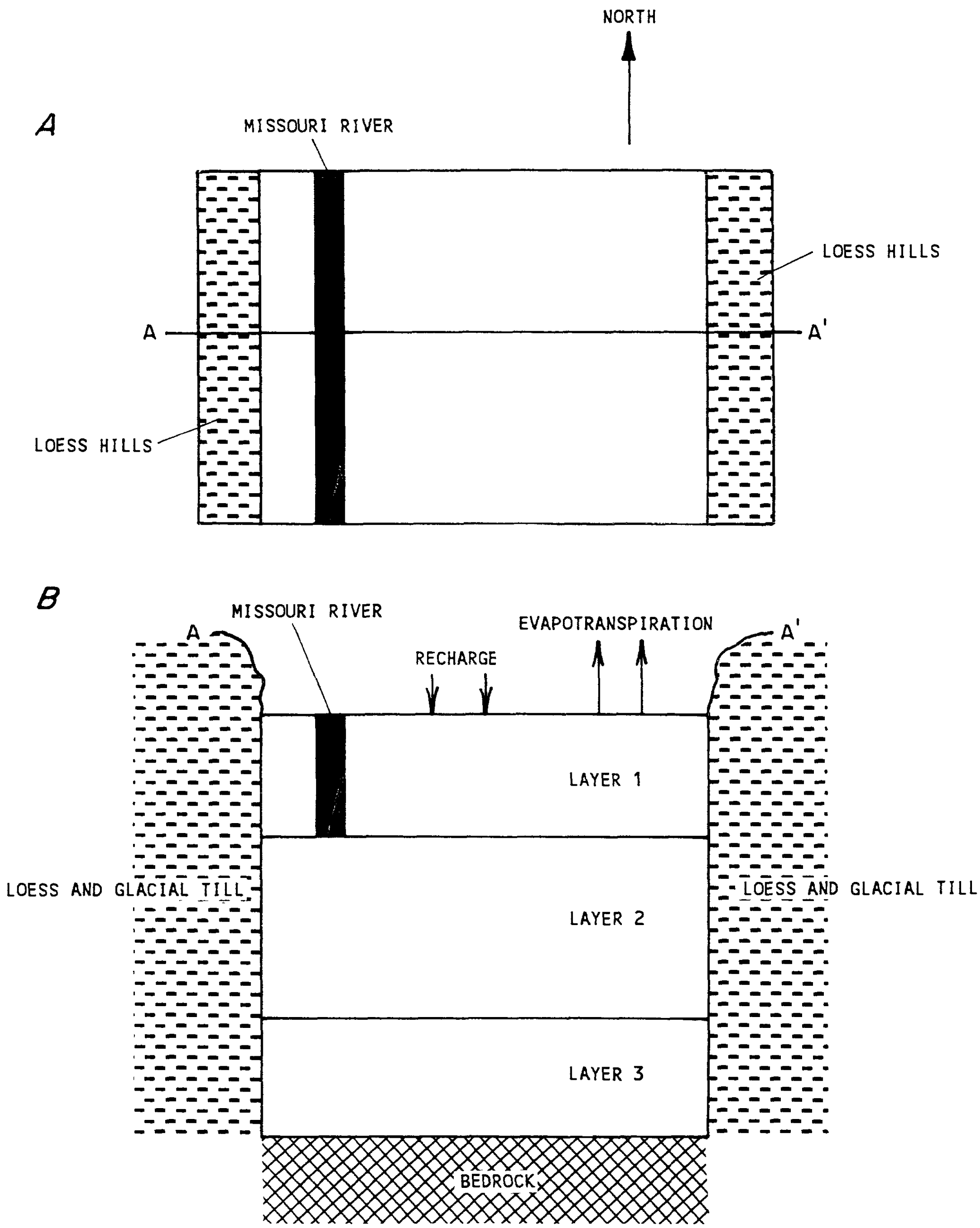


Figure 4.--Conceptual diagram of the hypothesized stream-aquifer flow system; A. Plan view; B. Cross section A-A'.

Use of superposition in the modeling strategy assumes a uniform elevation for all initial heads. The simulation solves for changes in head (drawdowns) as a result of a stress (change in river stage). In this way superposition provides a direct calculation of the effect of the stress on the system. The advantage of this strategy is that superposition avoids the problem of specifically defining initial hydraulic head distributions (Reilly and others, 1984, p. 17).

Boundary Conditions

The alluvial aquifer is an unconfined aquifer throughout most of the study area although deposits of silt and clay may cause confined-aquifer conditions in some areas. It is not known if the bluffs on the east and west sides of the valley occur at the limit of the aquifer or if at least some of the aquifer extends beneath the bluffs. The initial hypothesis is that they form a lateral boundary of the aquifer and are not significant sources of ground-water flow. There are no natural boundaries where the alluvial aquifer ends upstream and downstream along the flood plain within the study area. The alluvial aquifer is believed to be underlain by relatively impermeable shale of Cretaceous age throughout the study area. However, the Cretaceous Dakota Sandstone, a regionally important aquifer in northwest Iowa, is known to crop out in areas immediately to the north of the study area and may need to be considered as a potential discharge sink or recharge source.

The Missouri River is assumed to be the principal line of discharge for the alluvial-aquifer flow system. The river probably fully penetrates layer 1 as described above but does not penetrate any of the other layers. It is assumed that the river is in complete hydraulic contact with layer 1 because the streambed is degrading within the study area (U.S. Army Corps of Engineers, 1985). Within the study area, the areal extent and amount of ground-water development in the alluvial aquifer in Nebraska is small compared to the aquifer in the Iowa part of the study area. For these reasons the river is interpreted to be a hydrologic boundary separating the ground-water flow system on either side of the river. Modifications to these boundary interpretations may be necessary as additional information is obtained.

Calibration and Sensitivity Analysis

The results of ground-water-flow simulations within the study area need to be analyzed to determine if the simulation compares favorably to actual field conditions and measurements. This can be done by comparing simulated hydraulic-head values to measured head values or by analyzing the source and fate of simulated and measured amounts of water moving through the flow system. Objective criteria need to be developed during the modeling process to evaluate the quality of calibration comparisons.

A careful evaluation of calibration data is required for the superposition modeling strategy. Comparisons of model simulations to field observations may yield significant differences because of the effects on the field observations of stresses that were not considered as a part of the superposition modeling strategy. Field measurements can be used for calibration by careful screening and collection during time periods that minimize the effect of additional stresses on the system. An example of this would be measurements obtained during winter months when recharge, irrigation pumpages, and ET are at a minimum. Because these time periods contain dynamic changes in the hydrologic conditions in the aquifer, the model may need to simulate transient conditions to adequately compare with field measurements.

Once the model has been adjusted to adequately simulate measured water-level changes, the hydraulic properties should be varied and the sensitivity of the model to changes in these input properties measured. This sensitivity analysis is needed to determine the range of responses in the model to possible errors in estimates of the input parameters and interpretations of boundary conditions. Interpretations of model results based on estimates not supported by field data and estimates that substantially affect the results of the model may not be considered reliable. The sensitivity analysis provides insight for refining hydraulic properties of the model.

DATA NEEDS

The hydraulic characteristics and geometry of the aquifer need to be defined within an acceptable degree of error before model calibration. Efforts to simulate the ground-water-flow system by using the existing data base are limited in two ways. First, the near absence of data needed to define hydraulic properties discussed above requires a large range of properties to be considered. Estimates of alluvial-aquifer properties can differ by as much as seven orders of magnitude. These theoretical variations are summarized in table 2. The large range of values yields a variety of parameter combinations that may be too numerous to consider. Secondly, information regarding current and historical water levels throughout the study area generally is not available. Without specific measurements of hydrologic conditions, there is no means available to compare the model simulated results with field measurements and determine the quality of the simulation.

Plans for Obtaining Data

The use of superposition as a modeling strategy to determine the effect of river stages on the alluvial aquifer enables the effects of other stresses on the system such as pumpage, recharge, and evapotranspiration to be ignored. The advantage of this is that resources are not expended to collect and interpret this type of information. However, two types of data-collection activities need to be performed to obtain the information needed to model the ground-water flow system of the Missouri River alluvial aquifer using a superposition strategy. Exploratory data, consisting of information collected on the geometry and spatial relationships of aquifer materials as well as their hydraulic properties is needed. Water-level data from selected sites over a period of time are another type of information needed to define the range and variability of hydrologic conditions for use in calibration and verification of the model.

Stratigraphic and Hydraulic Properties

Traditional ground-water exploratory techniques have relied on test-well drilling to define and test aquifer materials. Test wells are drilled close enough together to allow confidence in the interpretations of stratigraphy from one well to the next. Construction of observation wells at these test-well

Table 2.--Estimates of theoretical alluvial aquifer characteristics

[in/yr, inches per year; ft/day, feet per day]

Parameter	Theoretical range	Initial estimate	Unit
Recharge	0 to 27	[a]3.0	in/yr
Hydraulic conductivity			
Layer 1	.01 to [b]1,300	[c].07 to 125	ft/day
Layer 2	.1 to [b]13,400	[d]267	ft/day
Layer 3	134 to [b]1,300,000	670	ft/day
Storage			
Layer 1	.01 to [b]0.30	.05	
Layers 2 and 3	.005 to [b]0.00005	[d].0005	
Vertical hydraulic conductivity			
Layers 1-2	.0001 to 134	16	ft/day
Layers 2 and 3	.1 to 1,300,000	270	ft/day

[a] J.T. Dugan, U.S. Geological Survey, Lincoln, Nebraska, 1985
[b] Freeze and Cherry, 1979
[c] Lohnes and others, 1977
[d] Data in files of U.S. Geological Survey, Iowa City, Iowa

sites provides an opportunity to obtain measurements of the hydraulic properties of the aquifer material and a point to measure the water-level fluctuations over time. Measurements of water-level responses due to local pumping may also help determine hydraulic properties of the aquifer. The proposed method to determine the stratigraphy and geometry of the Missouri River alluvial aquifer is to use this type of exploratory test-well drilling.

The location of existing observation wells in the alluvial aquifer and proposed locations for test-well sites and stratigraphic cross-sections is shown in figure 5. An extensive road network exists within the area and allows access along most east-west and north-south section lines. The proposed test-well sites and stratigraphic cross-sections will be located along public road right of ways. The location and number of test-well sites will be selected by the need to determine subsurface stratigraphic interpretations and the need for additional monitoring data. The first well drilled at a test-well site will be drilled to bedrock to define the stratigraphy at that location and determine the boundary conditions at the base of the aquifer. This well will then be completed in the deepest identified water-bearing layer, including the bedrock if it is determined to be a potential source or sink for alluvial-aquifer water. Additional wells will be drilled at each test-well site and completed in each identified water-bearing layer. This nest of wells at each test-well site will then provide measurements of vertical hydraulic gradients at the site.

Test wells will be used for preliminary testing of the hydraulic properties of the layer they penetrate. The specific capacity for each well will be determined and estimates of transmissivity based on slug tests or aquifer tests of short duration will be made. Head gradients between wells completed at different depths will be measured during well testing in order to provide information on the vertical anisotropy in the aquifer. Consideration of more extensive aquifer tests at each site, if needed, will be made when locating the test-well sites. Interpretive maps of the depth, thickness, and hydraulic properties of the aquifer will be prepared from this exploratory data. This information will then be used to generate the ground-water flow model.

Water-Level Data

A network of observation wells needs to be established to document water-level relationships within the study area at specific times. Water levels need to be measured within each layer to obtain estimates of the vertical head distribution, especially if exploratory data supports differentiation of the aquifer into distinct vertical layers. Wells drilled as part of an exploratory investigation of the alluvial aquifer would be used to augment existing observation-well data within the area. Water-level measurements in existing observation wells and surface-water locations need to be continued. Measurements need to be obtained over a long enough time period to define at least the seasonal variations in water levels. It would be advantageous to also obtain estimates of water-level fluctuations during hydrologic extremes, such as drought or flood. These measurements would be very useful when using a calibrated model in a predictive capacity. Long-term monitoring of the water levels in key wells would also be important for verifying and updating predictive models of the area.

Additional unpublished ground-water information in the Monona County part of the study area has been obtained since the report describing the available information for the area was produced. This information was collected by Dr. Ernest Pogge during the 1960's as part of an unpublished investigation to determine bank-storage relationships for streams in Iowa. Numerous shallow wells, usually less than 50 feet, were drilled into the alluvial aquifer along lines extending from the river toward the center of the valley. Water-levels in these wells and selected irrigation wells are available for some time periods. This information provides important documentation of historic hydrologic conditions within part of the study area. Although many of the observation wells have been destroyed, some still exist and can be utilized as part of an observation-well network in the area.

The location of observation wells within the study area is shown in figure 5. Also shown are proposed locations for additional observation-well nests. Measurements will be made on these wells frequently enough to determine the response time and magnitude of effects due to hydrologic conditions such as river-stage changes. Continuous-recording water-level gages will be installed at selected sites and may be moved to other sites once relationships have been defined at the initial locations. Monitoring-data collection can be conducted concurrently with the exploratory-data collection effort. Measurements will continue or begin in existing wells and other water-level measurements will be added to the network as observation wells are constructed. Hydrographs of the observed water-level fluctuations in selected wells and interpretive maps of the potentiometric surface of each identified water-bearing layer at selected times will be made and used as data for the ground-water flow model or as a reference for model calibration.

SUMMARY

A digital finite-difference ground-water-flow model is proposed as a means to aid in the interpretation of the relation between the Missouri River and the adjacent alluvial aquifer. A modeling strategy involving the principle of superposition appears to be especially suitable to the objectives of the investigation. Preliminary interpretations regarding the design of the model include: the model needs to incorporate three layers of aquifer material in hydraulic contact, a recharge and discharge boundary at the Missouri River, and no-flow boundaries at the base, east, and west sides of the aquifer. Hydraulic properties will include vertical and horizontal hydraulic conductivity and the saturated thickness of each identified model layer.

Hydrologic data needed to construct and calibrate the model of the Missouri River alluvial aquifer are not available. Information concerning the geometry of the ground-water system and hydraulic properties of the aquifer materials, in particular, is needed.

A plan to obtain stratigraphic, hydraulic, and water-level data within the alluvial aquifer is proposed. Stratigraphic data collection will consist of test-well drilling to define the geometry and stratigraphy of the alluvial aquifer. Test wells will be used to obtain preliminary estimates of aquifer hydraulic characteristics. Existing observation wells and new test wells will be monitored to define the hydraulic gradients and water-level fluctuations within the study area.

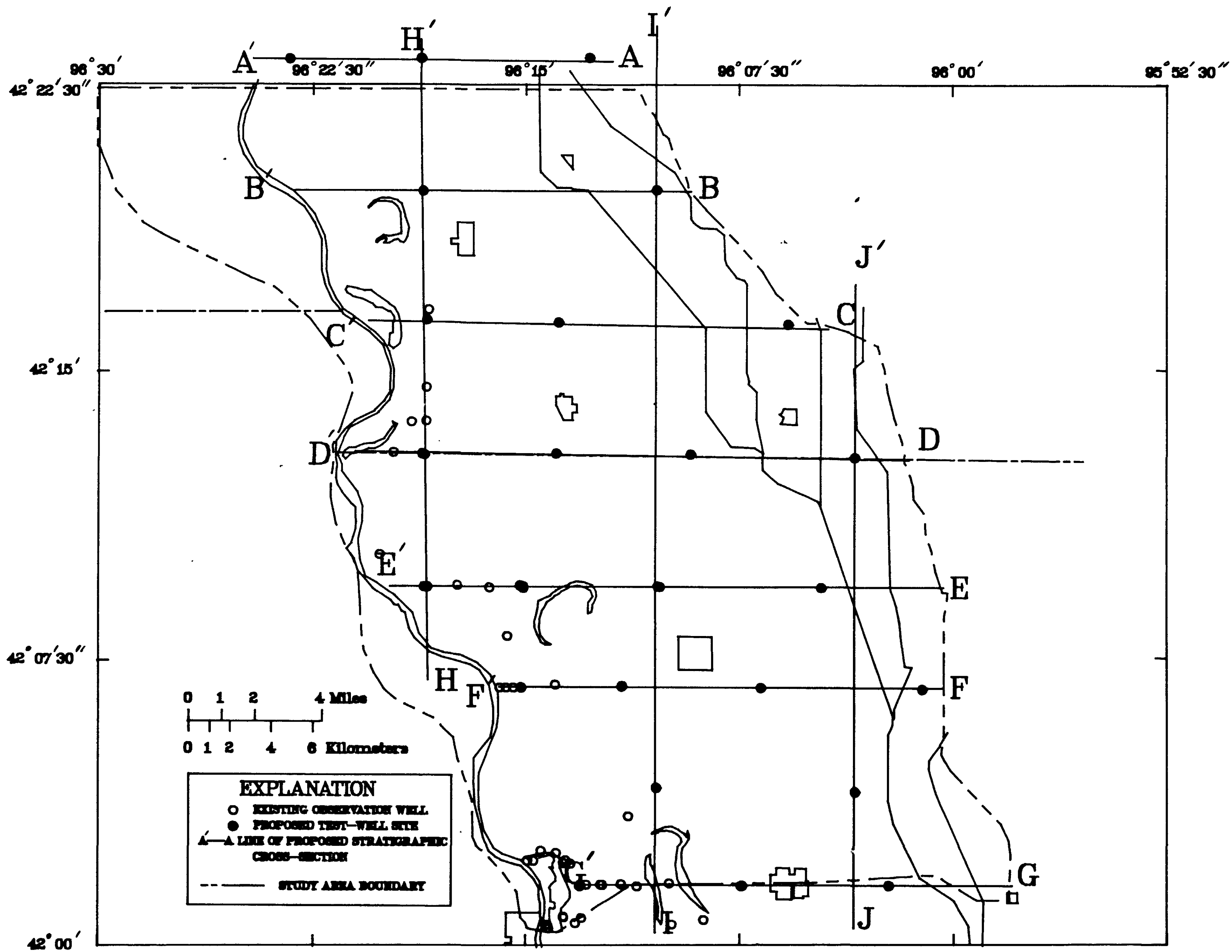


Figure 5.—Existing observation wells and proposed test—well sites and stratigraphic cross—sections.

REFERENCES CITED

Buchmiller, R.C., 1986, Hydrologic reconnaissance and summary of existing data on surface and ground-water resources in the Missouri River valley in Woodbury and Monona Counties, Iowa, 1985: U.S. Geological Survey Open-File Report 86-144, 21 p.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 604 p.

Lohnes, R.A., Dougal, M.D., and Speiran, G.K., 1977, Water management, water quality and alluvial-glacial morphology study of selected Iowa oxbow and shallow glacial-remnant lakes as they may be impacted by dredging: Initial report to Iowa Conservation Commission, 45 p.

McDonald, M.G., and Harbaugh, A.W., 1984, A modular three-dimensional finite-difference ground-water flow model: U.S. Geological Survey Open-File Report 83-875, 528 p.

Reilly, T.E., Franke, O.L., and Bennett, G.D., 1984, The principle of superposition and its application in ground-water hydraulics: U.S. Geological Survey Open-File Report 84-459, 36 p.

U.S. Army Corps of Engineers, 1985, Investigation of channel degradation, 1985 update--Missouri River Gavins Point Dam to Platte River Confluence, U.S. Army Corps of Engineers, Omaha District, Engineering Division.