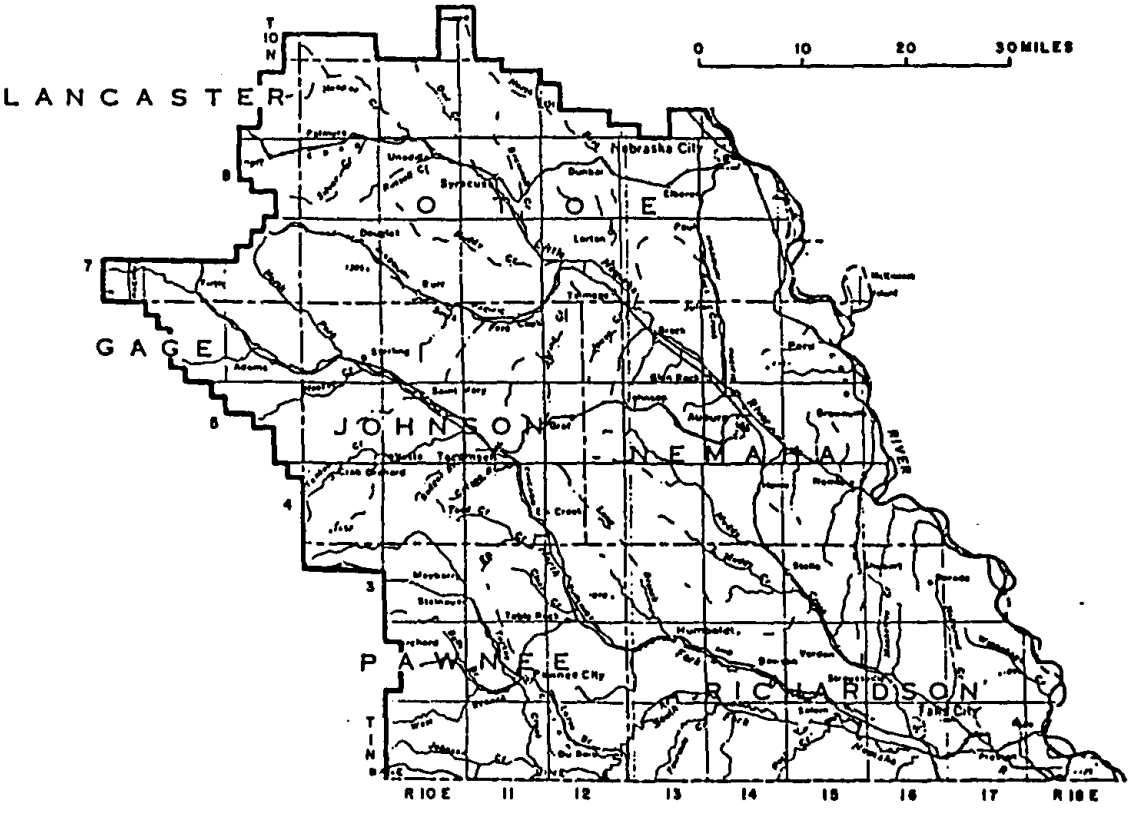
PROPERTY OF DEPARTMENT
OF WATER RESOURCES

NEMAHA
NRD

PLAN



GROUNDWATER MANAGEMENT

TABLE OF CONTENTS

Introduction 1
General Description 1
Problems & Needs 2
Management Area #I 4
  Purposes & Scope 6
  Location & Physical Setting 6
  Methods of Investigation 6
  Previous Investigation 11
  Hydrogeology 12
  Potentiometric Surface 12
  Transmissivity 17
  Storage Factor 19
  Base of the Aquifer 19
  Saturated Thickness 19
  Recharge 26
  Discharge 28
  Water Chemistry 33
Management Area #II 33
Management Area #III 38
Groundwater Reservoir Life Goals 40
Reservoir Life Goals Policy 41
Policies 41
Groundwater Physical Properties 44
  Dissolved Solids 44
  Hardness 45
  Sodium Plus Potassium 45
  Alkalinity 46
  Sulfate 46
  Chloride 47
  Fluoride 47
  Silica 47
  Boron 48
  Iron 48
  Manganese 48
  Selenium 48
  Phosphorus 48
  Nitrate 49
  Nitrogen 50
  Phosphorus 51
  Nutrients 53
Policies: Nutrients (Nitrates), Pesticides, Chemicals . . . 57
Agricultural Water Use Efficiency 62
Policies: Agricultural Water Use Efficiency 63
Agricultural Runoff 65
  Nonpoint Sources 65
Policies: Agricultural Runoff 66
Irrigation Return Flows 68
Policies: Irrigation Return Flows 68
Animal Wastes 70
  Pastured Animals (Non-Recoverable Wastes) 70
  Fencing and Filters 71
  Rotational Grazing 72
  Settling Basins 72
  Transport Extenders 72

Animal Wastes (Con't.)
Confined Animals (Recoverable Wastes) 72
Collection 72
Management Practices 73
Structural Practices 73
Treatment or Storage 73
Land Application 75
Policies: Animal Wastes 77
Municipal Water Use Efficiency 78
Industrial Water Use Efficiency 78
Municipal Water Needs 78
Source of Supply Problems 80
Operation & Maintenance & Replacement of Systems 82
Problems in Financing & Evaluation of Municipal Water Service Provided to Customers 83
Municipal Water Needs Policy 84
Policies: Municipal Water Needs 84
Improper Operation & Maintenance of Wastewater Treatment Plants & Insufficient Operator Training 86
Policies: Wastewater Treatment Plants 86
Urban Runoff 88
Policies: Urban Runoff 88
Residual Waste Disposal Site Contamination of Surface & Groundwater & Land Application of Wastewater Effluent & Sludge 90
Policies: Waste Disposal 92
Construction Site Runoff 95
Policies: Construction Site Runoff 95
Septic Tank Systems 97
Policies: Septic Tanks 97
Siting, Drilling, Casing, Sealing, & Plugging of Domestic, Stock, Irrigation, & Industrial Water Wells 99
Policies: Well Construction & Abandonment 100
Roadside Erosion 101
Policies: Roadside Erosion 101
Streambank Erosion 103
Policies: Streambank Erosion 103
Pollution from Truck Washes, Fertilizer, & Pesticide Wash-down Facilities 106
Policies: Washdown Facilities 106
Storage of Chemicals & Petroleum 107
Policies: Storage of Chemicals & Petroleum 107
Spillage or Leakage of Petroleum Products & Designated Hazardous Substances 109
Policies: Spillage or Leakage of Petroleum & Hazardous Substances 110
Groundwater Plan Implementation 112
Public Involvement 112
Ad-Hoc Subcommittee 118
Questionnaire 118
Special Citizens Advisory Subcommittee 118
Public Hearings 119
Groundwater Management Plan Questionnaire 120
Maps 124
References 147

INTRODUCTION

This plan is prepared pursuant to Section 46-673.01 R.R.S. enacted by the 88th Nebraska Legislature requiring Natural Resources Districts to prepare a groundwater management plan prior to January 1, 1986.

This plan is the first comprehensive effort to address the water resources to include the management of groundwater within the Nemaha Basin. Although the legislative mandate requires only consideration of groundwater resources, it becomes necessary to consider surface water when discussing water quality, quantity, and recharge of groundwater supplies.

As the plan is formulated, the District recognizes a great need exists for research, studies, and analysis of many of the factors having an impact upon groundwater with the Nemaha River Basin. To fully and adequately plan for the wise use of groundwater resources will require an expanded concern for these precious resources in both our rural and urban areas and communities.

GENERAL DESCRIPTION

The Nemaha Natural Resources District located in the southeast corner of the State includes the drainage area of all streams entering the Missouri River between the mouth of the Platte River and the Nebraska-Kansas state line with the exception of that portion of the Big Nemaha River drainage lying in northeastern Kansas.

The District lies entirely within the glaciated portion of the State where loess soils lie on undulating glacial deposits. This creates a land surface consisting of a series of rolling hills which run down to the flat valleys of the major streams flowing into the Missouri River. These valleys are nearly level with poor drainage. The drainage pattern in the remainder of the District is well defined, and surface runoff is rapid.

Many of the steeper slopes in this District are wooded, particularly the steep bluffs bordering the Missouri River valley. More different species of trees are found in the District than any other part of the state.

District Resources: Most of the land is suitable for agricultural use. Nearly 1.7 million acres are classified as agricultural lands, and 1,573,000 are considered arable. About two-thirds of the arable land, almost 1.1 million acres, is classified as irrigable; but only about 15 percent of the irrigable lands are well suited to irrigation. The remaining 85 percent have some limitations such as slope, which give them only limited suitability for irrigation.

This District receives more precipitation than any other in the state varying from a state high of about 35 inches in the southeast to 28 inches in the northwest part. Most of the

rainfall comes during the growing season and is usually adequate for all types of crops grown.

Most of the streamflow is direct runoff from rainfall which creates high flows during periods of heavy rainfall and results in low flows during dry periods. Base flow from groundwater, especially in the upper reaches of the streams, is very low or nonexistent.

Groundwater is difficult to obtain in this glaciated area. That which is available usually produces only small yields to wells and is often highly mineralized. The principal stream valleys containing alluvial deposits and the bedrock valleys buried under the glacial till which are filled with sand, gravel, or finer grained fluvial sediments provide moderate yields to wells. Locally, specific layers of bedrock may also be a source of water in some locations; but it is highly mineralized.

PROBLEMS AND NEEDS

Rainfall often comes in intense storms and produces rapid runoff when it falls on the steep slopes of clayey soils. For this reason large floods occur frequently. Flood damage ranks second in the state with estimated average losses of slightly over 2.5 million dollars annually. Nearly 15 percent of the land in the District or about 265,000 acres is subject to overflow flooding from the 100-year frequency flood.

Serious gully and streambank erosion is prevalent throughout much of the District. A part of this problem is a result of past channel straightening. The Big and Little Nemaha Rivers have carved deep canyons into the loess soils. These are now becoming stabilized, but tributary channels are still subject to degradation and streambank erosion; and a sustained period of high flows would produce additional erosion in many channels.

Recharge of groundwater is minimal because of the relative impermeability of the soils. The supply of good quality groundwater for municipal, industrial, rural domestic, and livestock uses is limited. Very few aquifers in the District will yield large amounts of water to wells, and most good aquifers cover only small areas. The quality of the available groundwater is generally adequate in some areas and very poor in others.

Water uses are directed at agricultural purposes since the economy of the District is largely dependent upon intensified farming operations. However, there are some light businesses within the District which help provide for a diversified economy and help support the municipalities with economic stability. Independent development of the land and water resources will continue in order to meet the needs of the people and the demands of agriculture and industry. Agricultural development will depend upon the need for agricultural products and the economic capability of landowners. Growth of municipalities and industrial development will create demands for additional water. Projected independent development includes additional municipal,

industrial, and rural water supplies and other developments such as land treatment for conservation of soil, which indirectly affects the amount of water available.

Municipal & Industrial: Present water use for municipal and industrial purposes is about 5,500 acre-feet per year and is expected to increase to about 12,000 acre-feet per year by 2020.

Rural, Domestic, & Livestock: Rural domestic water use is expected to increase slightly from 1,800 acre-feet per year to about 2,000 acre-feet per year by 2020.

The requirement for livestock water is expected to increase considerably from about 5,400 acre-feet per year to nearly 8,000 acre-feet per year by 2020. A large part of this requirement will come from groundwater, but surface water from farm ponds and watershed reservoirs will be needed where groundwater availability is poor.

Irrigation: Future private irrigation development is expected to be minimal because of adequate amount of rainfall normally received in the District and the absence of adequate groundwater supplies.

Within the Nemaha Natural Resources District, an ancient drainageway eroded into Paleozoic bedrock and filled with alluvium was later capped with glacial till. The soils are predominantly weathered loess and glacial till with moderately low permeabilities. During dry periods wide and extensive cracks occur in these soils. The topography of the area is generally rolling to rough except for the flood plain adjacent to the two major river systems which transect the District. Both the Little Nemaha and Big Nemaha Rivers have north and south forks making up the Nemaha River Basin hydrologic unit. The average gradient of these rivers is just over 10 feet per mile having been influenced by channelization of the rivers during the 1920's.

Very limited groundwater supplies exist within the District with two basic areas of principal concern to the citizens within the area. The remaining land area has available perched aquifers or areas void of any groundwater supplies.

It is with this knowledge that this groundwater management plan will consider three possible management areas.

1. Stream-Aquifer System near Cook, Nebraska
2. Stream-Aquifer System near Humboldt, Nebraska
3. Perched aquifers remaining throughout the District

In this context the District began implementing a study program in 1977 with the installation of a continuous recorder well near Cook. In addition approximately fifty (50) wells are monitored with water level measurements taken three (3) times each year during the months of March, August, and December. This information is gathered throughout the District in an effort to monitor supply as well as build a data base upon which management policies and decisions can be made. Also the District financially supported the services of Bob Hiergesell to conduct a study analysis of the stream-aquifer system near Cook using a computer model. This study was completed in July, 1985.

MANAGEMENT AREA #I (Stream-Aquifer System near Cook)

This management area as shown on Exhibit I consists of the stream-aquifer system near Cook, Nebraska, and extends westward including the communities of Sterling, Adams, and Firth. The western boundary is in southeastern Lancaster County and northeastern Gage County with the majority of the system within Johnson County and southern Otoe County.

The area involves the majority of irrigation systems found within the District. Pivot irrigation sprinkler systems are developed throughout this management area with some surface irrigation occurring near Sterling and east of Adams.

Although an extensive study performed by Bob Hiergesell concentrated the ocmputer analysis of the stream-aquifer system of the Little Nemaha River between Burr and Cook, additional computer modeling studies in the western portion of the management area would be beneficial since more groundwater irrigation systems are located within this area. Studies have

also been conducted in 1976 (Goodenkauf) and 1978 (Avery) which provide additional data to support a computer modeling program.

Data taken from the comprehensive analysis of the study performed by Bob Hiergesell provide an initial understanding of the groundwater resources of this management area and are included as follows.

The relationship between the quantity of flow in streams and pumpage of groundwater from aquifers adjacent to and having an hydraulic connection with these streams is of great interest not only in Nebraska but also in many parts of the United States. Extensive pumping of wells adjacent to a stream can lower the groundwater levels sufficiently so that streamflows are significantly reduced. These reductions can be of critical importance to streamflow users. Quantification of the timing and magnitude of the effect of groundwater pumpage on streamflow is usually quite difficult and must be accomplished by detailed measurements of both streamflow and groundwater levels and by acquisition of information on aquifer and streambed hydrologic characteristics.

In the area surrounding the communities of Burr and Cook, approximately 40 irrigation wells have been developed. The communities of Burr, Cook, Syracuse, and Tecumseh have municipal well fields constructed in this area as does a Rural Water District in Otoe County. In the case of Syracuse, Tecumseh, and the Rural Water District, the pumped water must be transported many miles to their users because a suitable alternative supply of water is not available to them.

The aquifer in the vicinity of Cook, Nebraska, is a buried paleovalley filled with sand and gravel and overlain by 50-150 feet of glacial till. Its axis trends roughly west to east, and near Cook the east-northeast flowing South Fork of the Little Nemaha River crosses directly over the aquifer. Where it passes over the aquifer, the South Fork of the Little Nemaha River gains a signficant amount of flow from aquifer discharge to the river system. During the summer irrigation season, rapid drawdowns in the potentiometric surfaces have been recorded followed by a rapid return to original levels after the pumping season. This pattern is typical of the response of a confined aquifer to pumpage. The rate of streamflow in the South Fork of the Little Nemaha fluctuates in accordance with the change in the potentiometric surface. Folkman (1980), in his thesis, was able to quantify the gain in flow attributed to the aquifer and the drop in the rate of gain caused by the drop in the potentiometric surface during the summer irrigation pumping season.

The limited extent of the aquifer and increasingly large withdrawals of groundwater for irrigation and municipal use have caused some concern as to the long-term capacity of the aquifer to meet future needs. Crops are irrigated using streamflow from the South Fork of the Little Nemaha River, and there is also concern as to the potential effect of groundwater level declines on the streamflow during the summer months if further development of the aquifer continues.

Purposes and Scope

Purposes of the study are (1) to briefly describe the stream-aquifer system in the vicinity of Cook, Nebraska; (2) to describe the changes in water levels and streamflows that have taken place in the system; (3) to establish baseline water quality for the area and assess the potential for groundwater contamination; and (4) to project by model simulation the changes in water levels and streamflows that would occur under a high and a low rate of groundwater development.

The history of water level changes in the area has been documented in detail since 1979 with detailed water level measurements and records of a continuous recorder well installed near Cook in 1977. The existing information about hydrogeologic parameters that influence water levels was reviewed and in some cases modified where new geologic data has become available. Other parameters that affect the changes in water levels such as soil permeability, climatic conditions, and pumpage rates also have been quantified. New data obtained as a part of this study are limited to water level and streamflow measurements, water pumpage, and water quality analyses. Projected changes in water levels and streamflow are made using a digital groundwater model that has the capability of simulating the relationship between an aquifer and an adjacent stream.

Location and Physical Setting

The study area illustrated in Figures 1 and 2 is located in southeastern Nebraska and includes a portion of northern Johnson County and southern Otoe County. The study area covers approximately 85 square miles and includes the towns of Cook and Burr.

Fenneman (1938) included this area within the Dissected Till Plains of the Central Lowlands west of the Mississippi Province. Surface deposits are glacial drift in part covered by loess and dissected by post-glacial drainageways. Topography is generally rolling to rough.

The area is transversed from west to east by the perennial South Fork of the Little Nemaha River. Several of its tributaries within the study area also are perennial in their lower reaches. The South Fork of the Little Nemaha River has a flood plain that is approximately 3/4 mile wide throughout the study area and has an average gradient of just over 10 feet per mile. This gradient has been influenced by channelization of the river for flood control purposes.

Elevations in the study area range from approximately 1220 feet above mean sea level in the upland areas at the western end of the study area to approximately 990 feet above mean sea level where the river flows out of the study area northeast of Cook.

Methods of Investigation

The data compiled and evaluated as a part of this study were collected over the past 25 years by investigators from state and local agencies and by different graduate students. These data

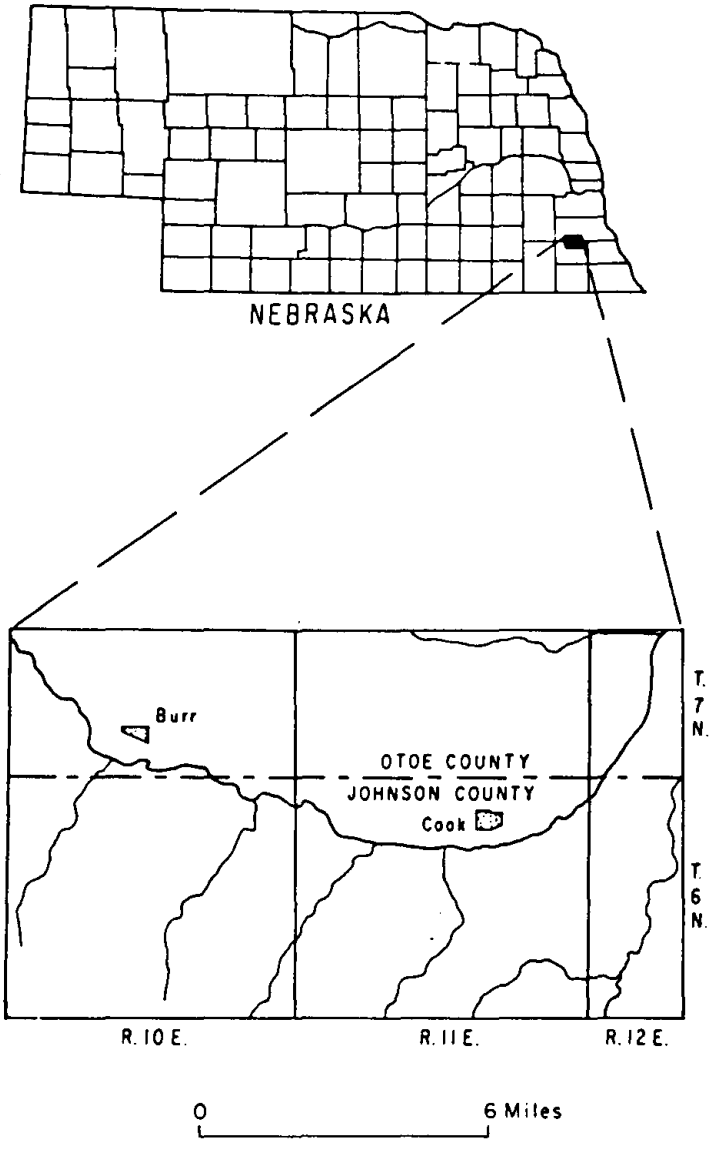


Figure 1. Location of Study Area within Nebraska.

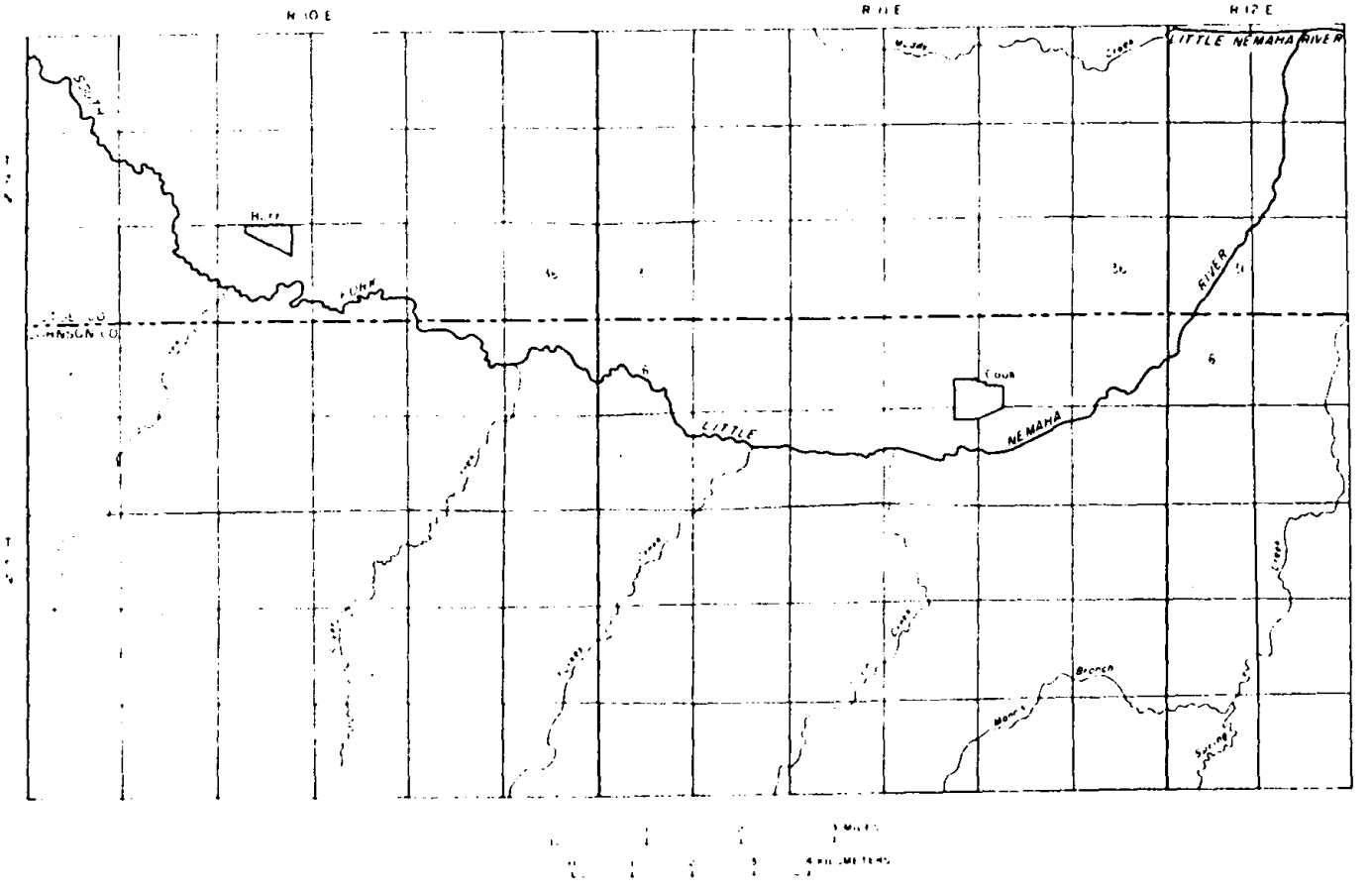


Figure 2. Location of Features within Study Area.

include test hole logs, irrigation well logs, mass water-level measurements, streamflow measurements, weather information, and crop acreages. Although much of the data was obtained from other sources, a great deal of data was acquired as a part of this study. These efforts included water-level measurements, streamflow measurements, water-quality sampling and analysis, and compilation of land use and cropping pattern information.

Three mass water-level measurements were conducted at different times. Those conducted in May, 1983, and May, 1984, reflect conditions prior to irrigation pumping while the one conducted in July, 1984, reflects water levels at the highest rate of irrigation pumping. In each mass measurement approximately 20 irrigation wells were measured for depth to water beneath the land surface. A steel tape graduated to hundredths of a foot and marked with chalk was used to accomplish this. Surface elevations for each well were obtain from USGS 7 1/2 minute topographic maps. Water levels were measured only in wells that were not pumping and which had not been pumped for at least one day prior to measurement.

Surface water flows in the South Fork of the Little Nemaha River and several of its principal tributaries were measured on three separate occasions, each being within a few days of the mass water-level measurements. Each streamflow measurement or seepage run involved the measuring of streamflow at 11 points spaced along the river and its main tributaries. The diagram on Figure 3 shows the location of these sites. At each point of measurement, the channel was divided into approximately 25 vertical segments for which a representative depth of flow and velocity of flow was measured. Fewer vertical segments were used for the tributaries because channel widths ranged from three to eight feet. A topset rod was used to measure flow depths and to hold a pygmy meter at the correct depth to acquire a representative flow velocity over the cross sectional area of each vertical segment. The flow rates for each vertical segment were calculated from the measurements and then summed together to give the total flow at that point. Seepage runs were not made if a significant amount of precipitation had fallen within the river basin during the preceding five days. This was to assure that streamflow measurements reflected conditions where streamflow gains between measurement points could be attributed solely to aquifer discharge.

A total of five water quality samples were acquired to establish baseline water quality for the area. Samples were acquired from four irrigation wells that had been pumping for at least 12 hours and from a naturally flowing well. Water samples were kept chilled until they were delivered to the Nebraska Department of Health Laboratory for analysis.

A digital groundwater flow model was used to simulate the groundwater levels for the spring of 1980 prior to irrigation pumpage (steady-state simulation). The model was then adapted to simulate water level changes from 1980 to 1985 and aquifer discharge along the riverway of the same time period (transient model). Following these simulations, the model was used to predict changes in groundwater levels and aquifer discharge along

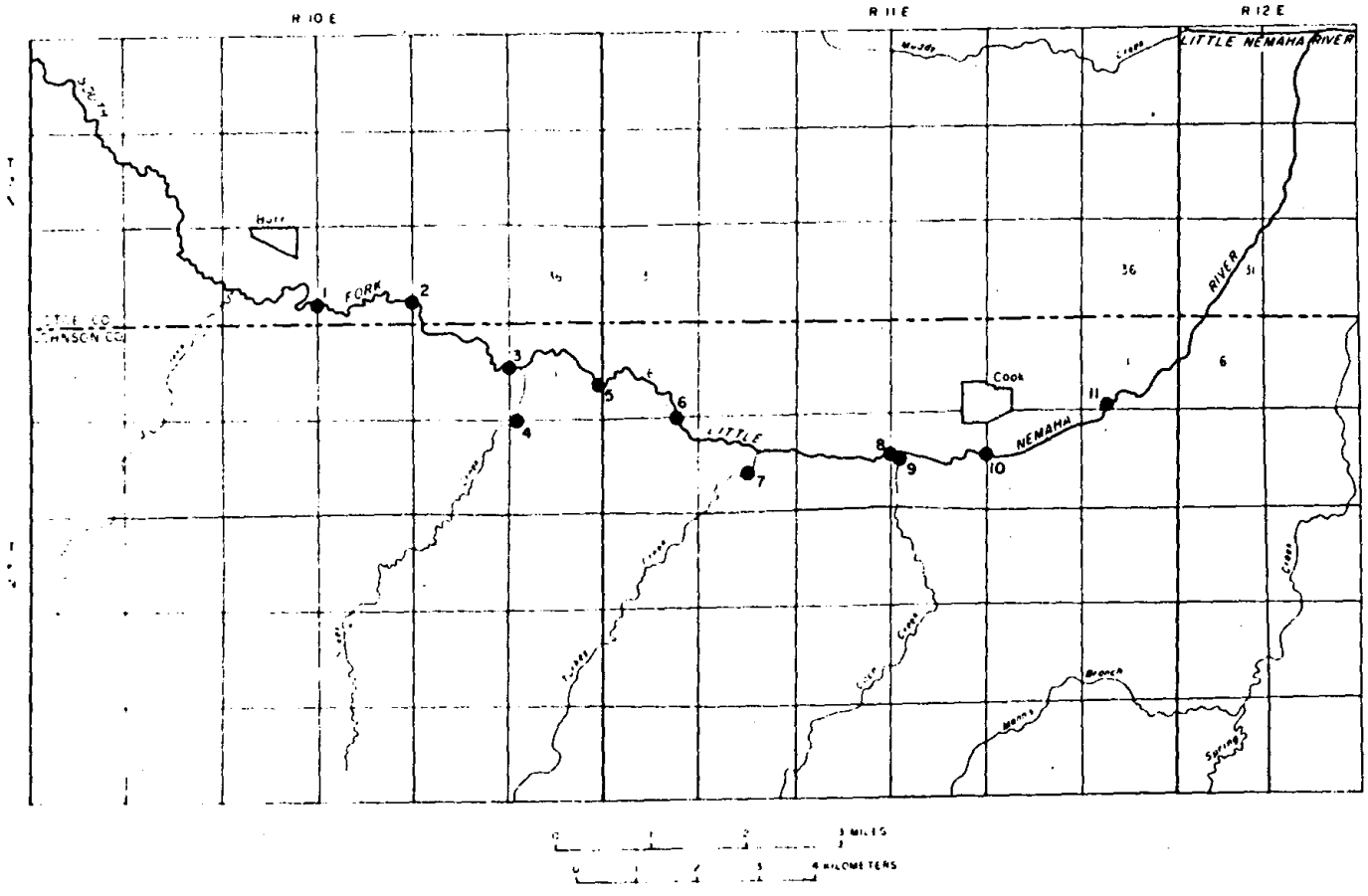


Figure 3. Location of Seepage Measurement Sites.

the river over a 10-year period under the current level of pumpage and then under an increasing rate of pumpage (predictive model).

Previous Investigation

Two master's theses investigations were conducted in areas that include all or part of the area of interest of this report. Both investigations generated a considerable amount of information pertinent to this study. In one of these theses, Avery (1978) described the groundwater geology for Johnson County, which includes much of this study area. The aquifer found in the vicinity of Cook is described in a more regional fashion and aquifer characteristics are presented for the specific area covered in this report. In the other investigation Folkman (1980) presented an analysis of the relationship between water levels in the vicinity of Cook and the base flow in the South Fork of the Little Nemaha River. A thorough discussion of the groundwater flow system of the area is also presented along with a water budget for the area.

Other more generalized investigations describing the regional geologic setting for southeastern Nebraska have been published by Burchett and Carlson (1966) and Burchett and Reed (1967).

Although other studies have been conducted in which digital models have been used to simulate groundwater - surface water relationships, Hiergesell (10/85) was not aware of any dealing with the relationship between a confined or semi-confined aquifer and river system to which the aquifer loses water as is the case in the Cook area. Lapalla (1977), Pettijohn and Chen (1984), and Peckenpaugh and Dugan (1983) are examples of studies in which a digital model was used to simulate groundwater - surface water relationships where the aquifer is unconfined.

Table 1. Hydrologic Characteristics of Soils Found in the Study Area

	Average Permeability of 60" Profile (in./hr.)	Average Available Water Capacity (in./inch)	Average Maximum Soil Slope (percent)
Kennebeck-Nodaway-Zook	1.11	0.20	1
Pawnee-Wymore-Burchard	0.27	0.13	11
Wymore-Pawnee	0.24	0.14	10

(Conservation and Survey Division)

Hydrogeology

The hydrogeologic analysis of the aquifer near Cook is concerned with the movement of water through the system from the time it enters the aquifer to the time it is discharged either to the river system, to the atmosphere, or out of the study area by groundwater outflow. A discussion of the parameters of the flow system related to water movement and storage are presented in this section of the report.

Potentiometric Surface

The aquifer in the vicinity of Cook is a confined to semi-confined system. In this type of setting there is sufficient pressure on the water in the aquifer to force it to rise above the base of overlying confining layer within any well screened in the aquifer. The imaginary surface to which water would rise in a well at any point in the aquifer is referred to as the potentiometric surface.

The potentiometric surface can be constructed by plotting the altitudes of measured water levels in wells on a base map and drawing contour lines such that the points of equal altitude are connected.

Throughout the spring and summer of 1980, 23 observation wells were measured at various times to observe how the potentiometric surface fluctuated throughout an irrigation season in the Cook area (Folkman 1980). These potentiometric surface area maps are presented in Figures 5 and 6. As a part of this study mass water-level measurements were conducted in the springs of 1983 and 1984 and during the summer of 1984. The potentiometric surface maps generated from the 1984 readings are presented in Figures 7 and 8.

In both spring and summer the contour lines on the potentiometric surface bend sharply upstream in the vicinity of the South Fork of the Little Nemaha River. Because water in the aquifer flows in a direction perpendicular to the equipotential lines and in a direction of decreasing potential, flow is toward the river.

The configuration of the potentiometric surface changes in response to the stress applied to the system by groundwater pumpage throughout the irrigation season. Examination of the spring and summer potentiometric surface maps shows that contour lines of a particular altitude can move upstream over two miles as water levels decline due to irrigation pumping. In Figure 9 below the hydrograph from a continuous recorder well located one mile west of Cook illustrates the changes in the potentiometric surface from 1978 to 1985. The decline in levels observed on the hydrograph during the summer months are consistent with those illustrated on spring and summer potentiometric surface maps in Figures 5, 6, 7, and 8.

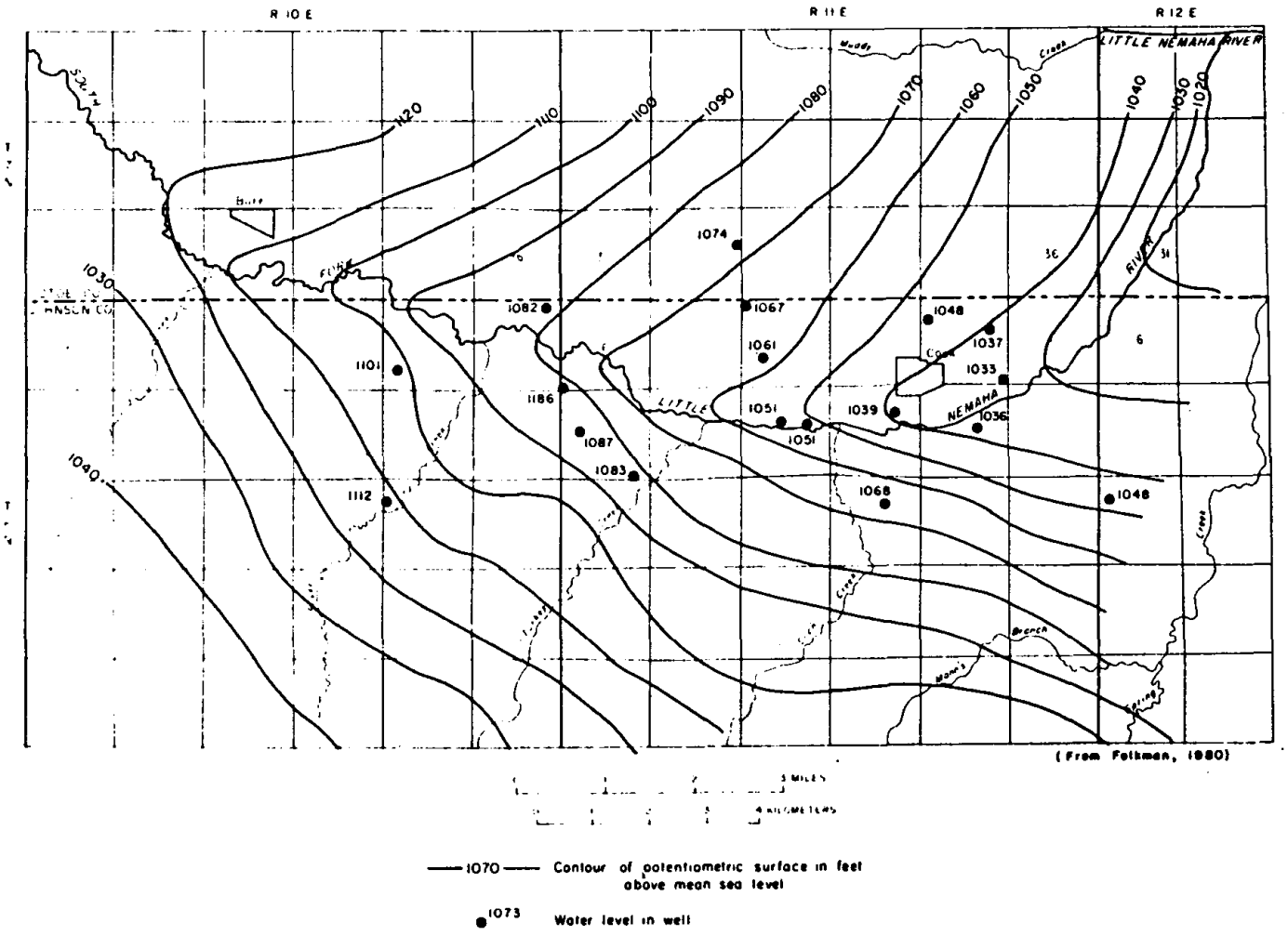


Figure 5. Potentiometric Surface on May 12-19, 1980.

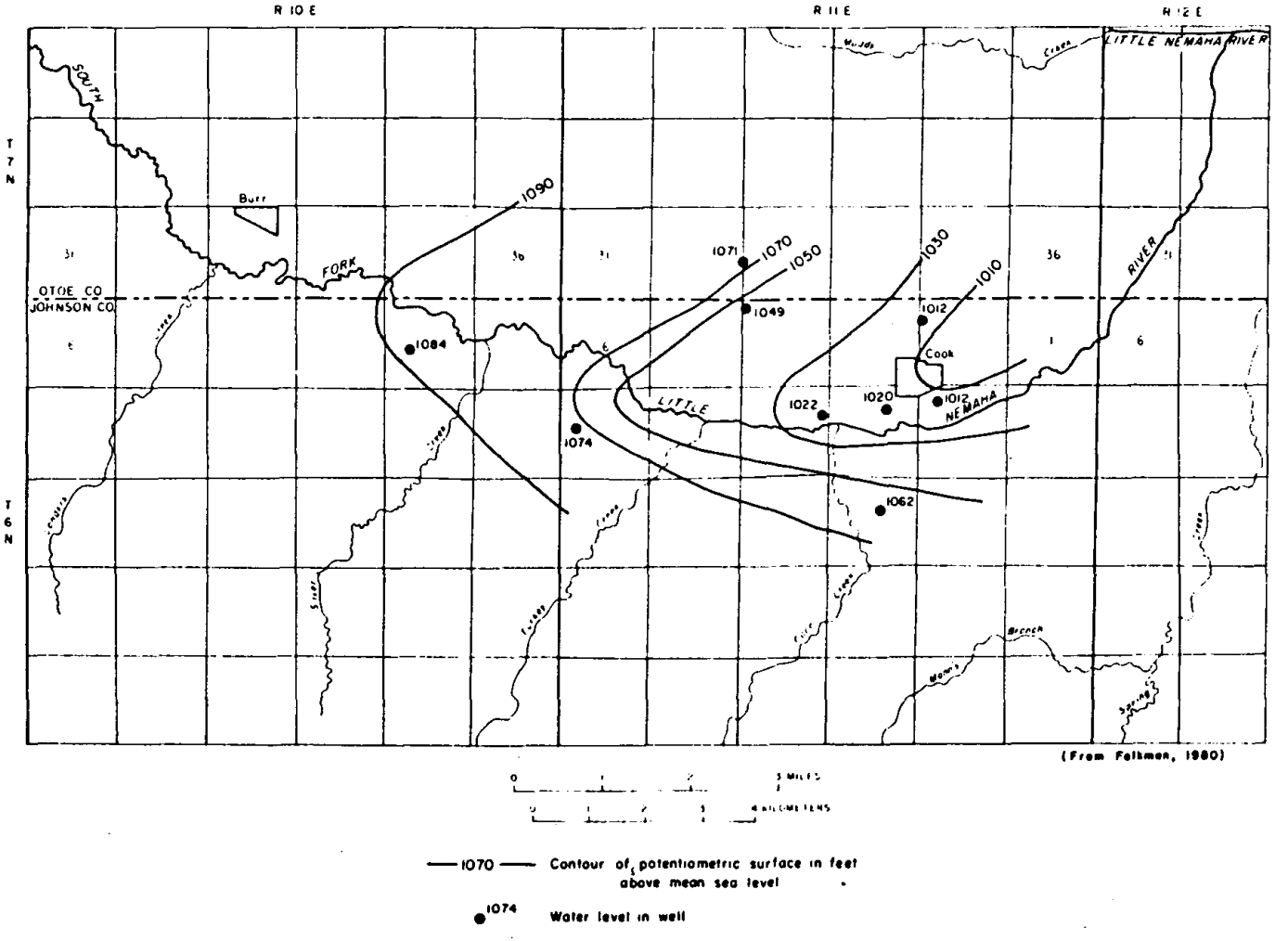


Figure 6. Potentiometric Surface on July 28, 1980.

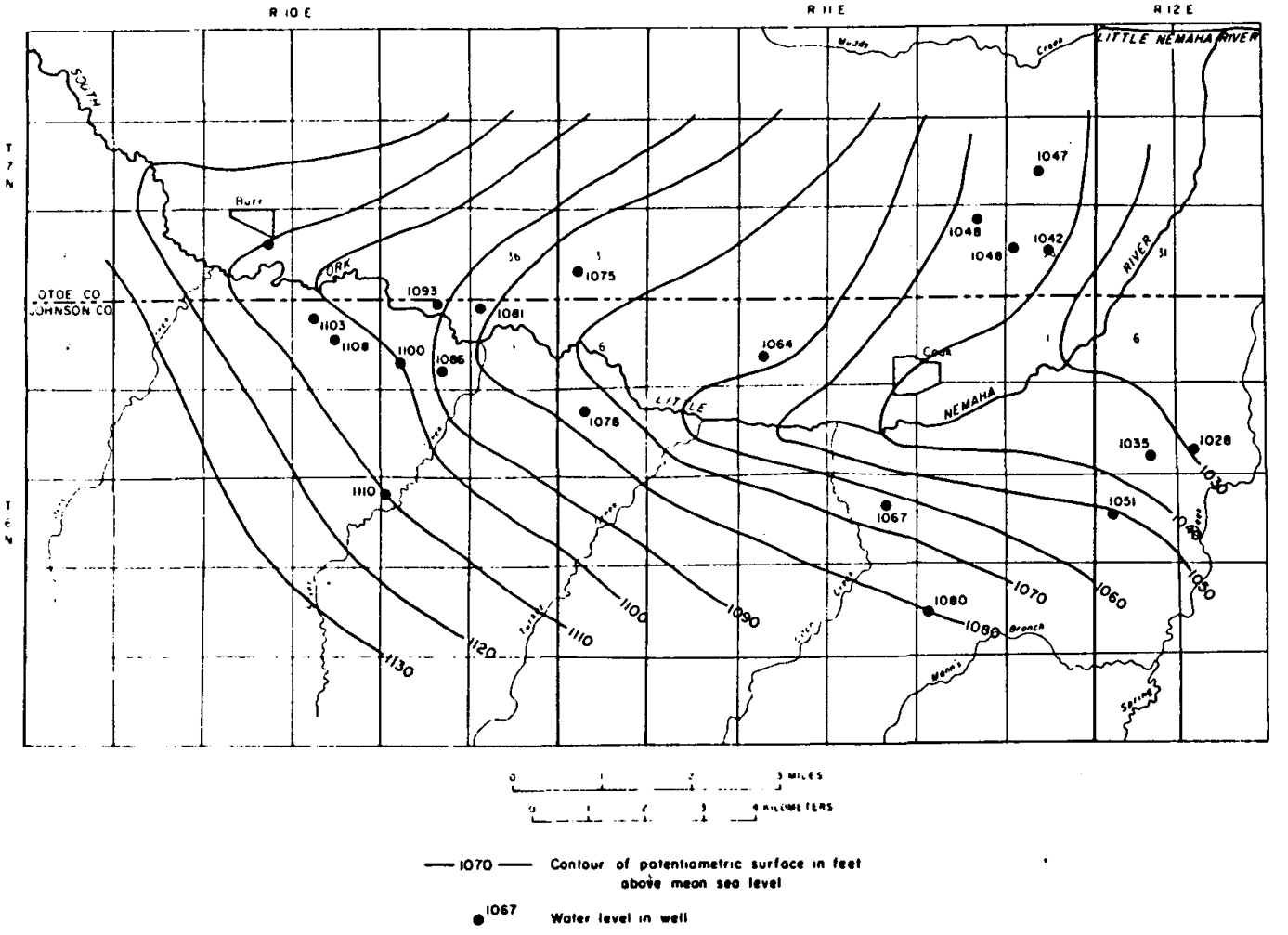


Figure 7. Potentiometric Surface on May 28, 1984.

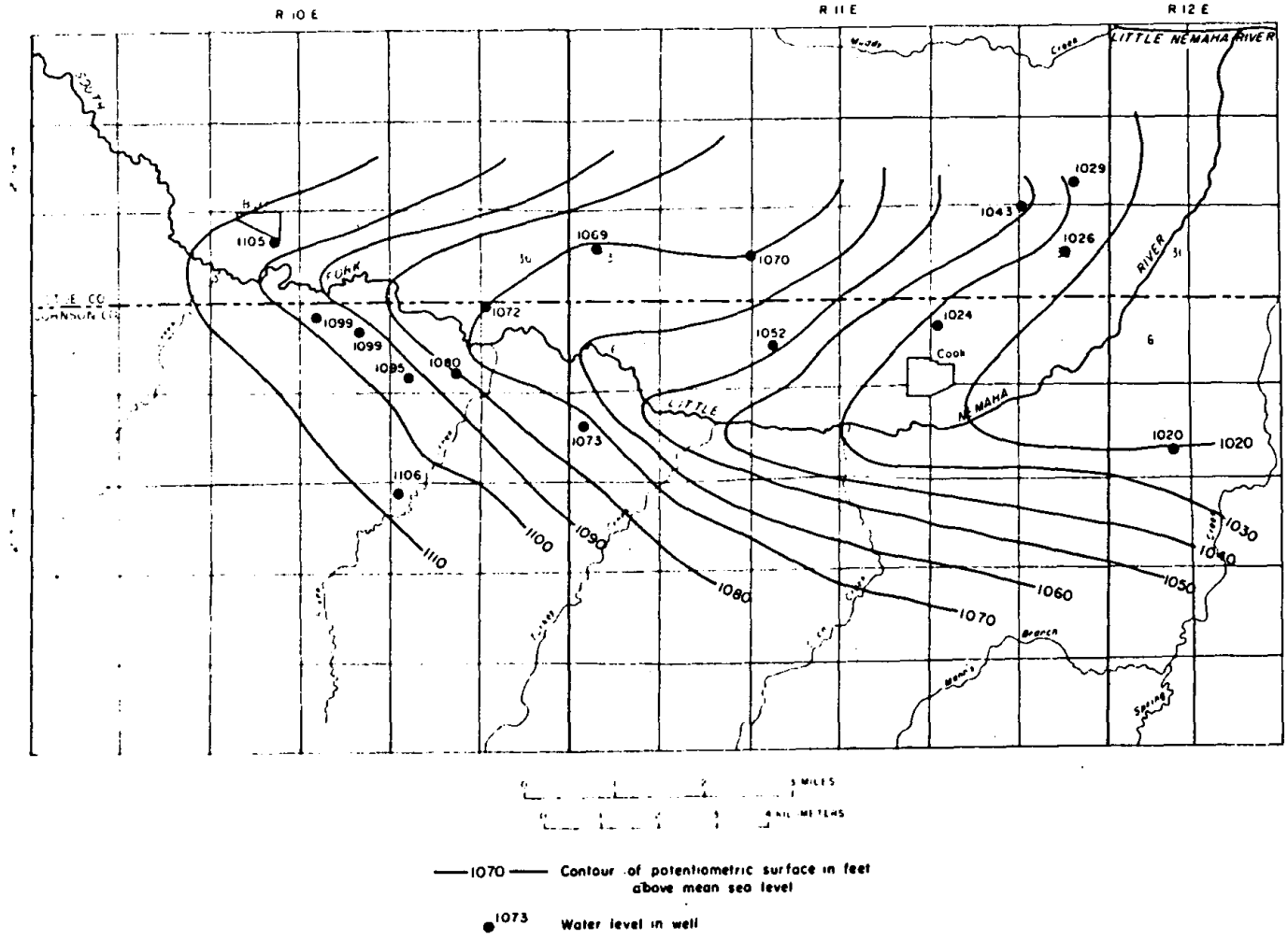
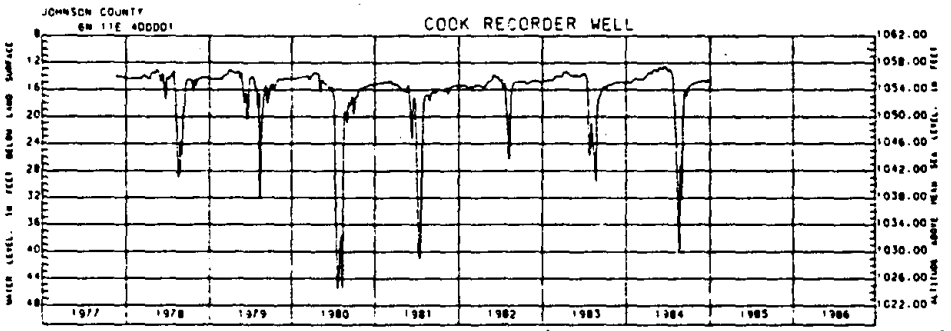


Figure 8. Potentiometric Surface on July 26, 1984.



(Ellis and Pederson, 1985)

Figure 9. Hydrograph of Cook Recorder Well

Transmissivity

Transmissivity is defined as the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient (Lohmann, 1979). It is a measure of the aquifer's capability to transmit water at any point. Units of transmissivity used in this report are gallons per day per foot (gpd/ft).

The usual methods of determining the transmissivity of an aquifer include aquifer pump-test analyses or aquifer grain-size and saturated-thickness analyses. No pump-tests have been performed in this study area, but some drawdown-pumping rate data is available from irrigation well registration forms. Grain size descriptions and saturated thickness information is also available from the well registration forms and from the descriptive logs from the test holes.

Transmissivity values estimated from drawdown-pumping rate data is based on the equation:

$$T = 2000\ Q/S \qquad \text{(Huntoon, 1974)}$$

where T = transmissivity in gallons per day per foot
Q = pumping rate in gallons per minute
S = the drawdown in feet or the difference between static and pumping water levels.

Transmissivity values estimated from grain size descriptions are based on the equation:

$$T = K_n b_n$$

where K = hydraulic conductivity in gallons per day per square foot, and
b = saturated thickness, in feet.

Transmissivity maps generated by each of these methods for the study area are presented in a report by Folkman (1980), and a map based on grain size analysis is presented by Avery (1978). Transmissivities were, therefore, not recalculated as a part of this study. Values generated by the grain size technique are illustrated in Figure 10 and were used for initial input to the digital model. Although somewhat inadequate descriptions of materials encountered during the drilling of wells affect the

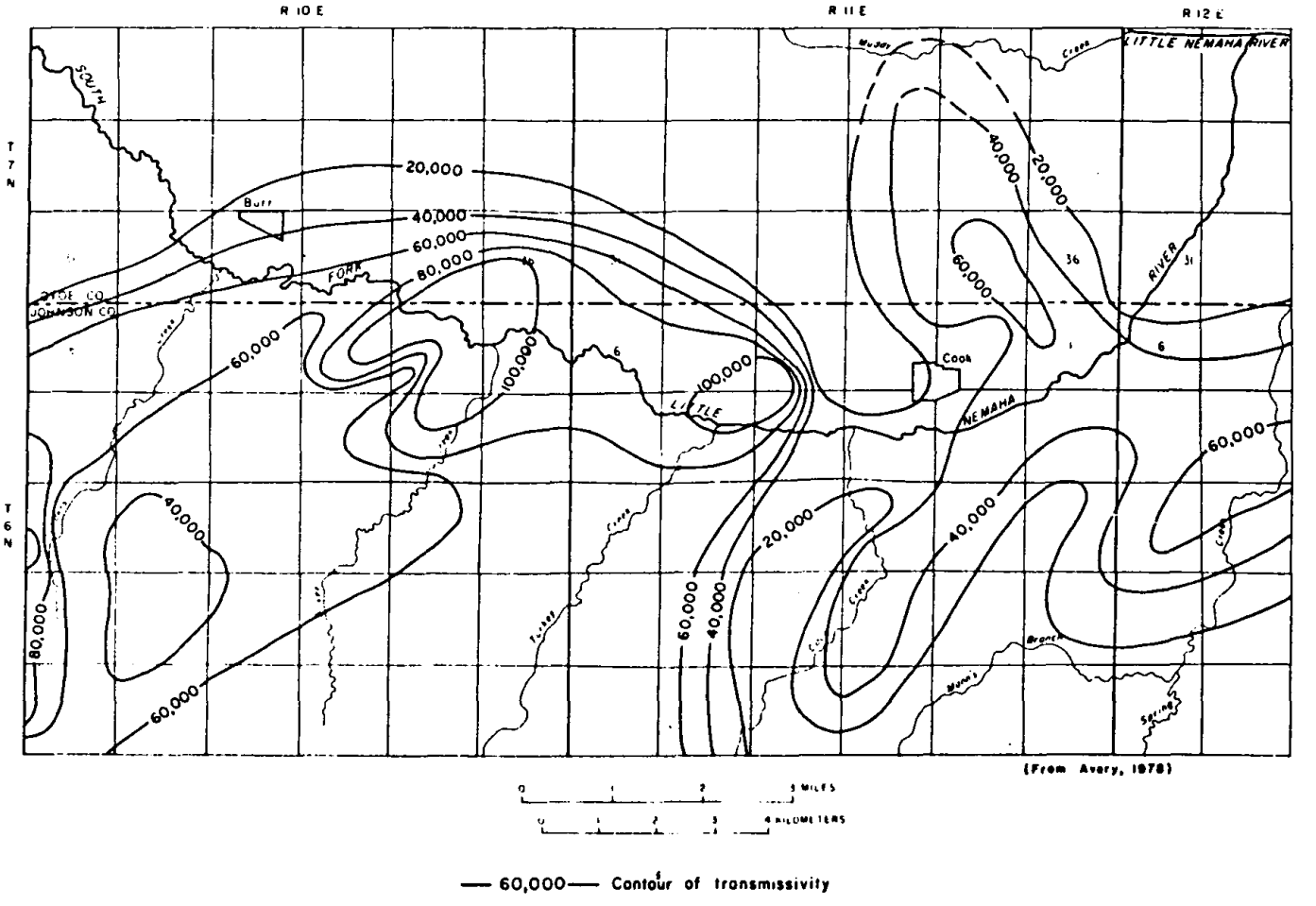


Figure 10. Transmissivity of Aquifer.

reliability of transmissivity estimates from some well logs, it is felt that these estimates are more reliable than those generated from the drawdown-pumping rate method. With that method drawdowns may be biased by poor well construction limiting the supply of water to the well, poor estimates of pumping rates, and often an insufficient duration of pumping to allow the pumping level to stabilize.

Storage Factor

The term for yield of water for a given decline in hydraulic head in an aquifer differs according to the type of aquifer being considered. For a confined aquifer the term is called the storativity or storage coefficient. For an unconfined aquifer the storage term is called the specific yield. Both terms describe the volume of water that an aquifer will release from storage per unit surface area for a unit decline in hydraulic head. The terms are dimensionless. Values of storage coefficients of confined aquifers are typically in the range of usually range from 0.1 to 0.3. The term is much greater for unconfined aquifers because aquifer material is actually being either dewatered or saturated when the water table fluctuates. The specific yield can approach the porosity of the aquifer material. When hydraulic head of a confined aquifer rises or declines, water is released or stored due to the compressibility of water and/or of the aquifer.

In the aquifer near Cook, conditions range from confined to semi-confined. Storage coefficients along the floodplain of the South Fork of the Little Nemaha River are approximately .001. In the upland areas storage coefficients are in the range of .003 to storage coefficients used for input to the digital model are shown in Figure 11.

Base of the Aquifer

The base of the aquifer in the study area is the bedrock surface which consists of Paleozoic limestones and shales. These sediments are from the Waubaunsee Group of Pennsylvanian age and the Admire Group of Permian Age (Folkman, 1980).

The bedrock surface is an erosional surface cut by pre-glacial drainageways. Figure 12 gives a picture of the configuration of these drainageways in the region surrounding the study area. A more detailed map of the bedrock configuration is shown in Figure 13. The paleovalley had several tributaries that drained into it from the north and south. Two of these entered the paleovalley from the north, one just east of Cook, and the other about 2 1/2 miles west of Cook. The other tributary entered the paleovalley from the south in the vicinity of Coon Creek.

Saturated Thickness

The saturated thickness of the aquifer ranges from less than 10 feet to around 150 feet as seen on Figure 14. The thickest sequence is found south of Burr where the axis of the paleovalley enters the study area. Generally the zone of gravel thickness greater than 50 feet follows the axis of the paleovalley axis.

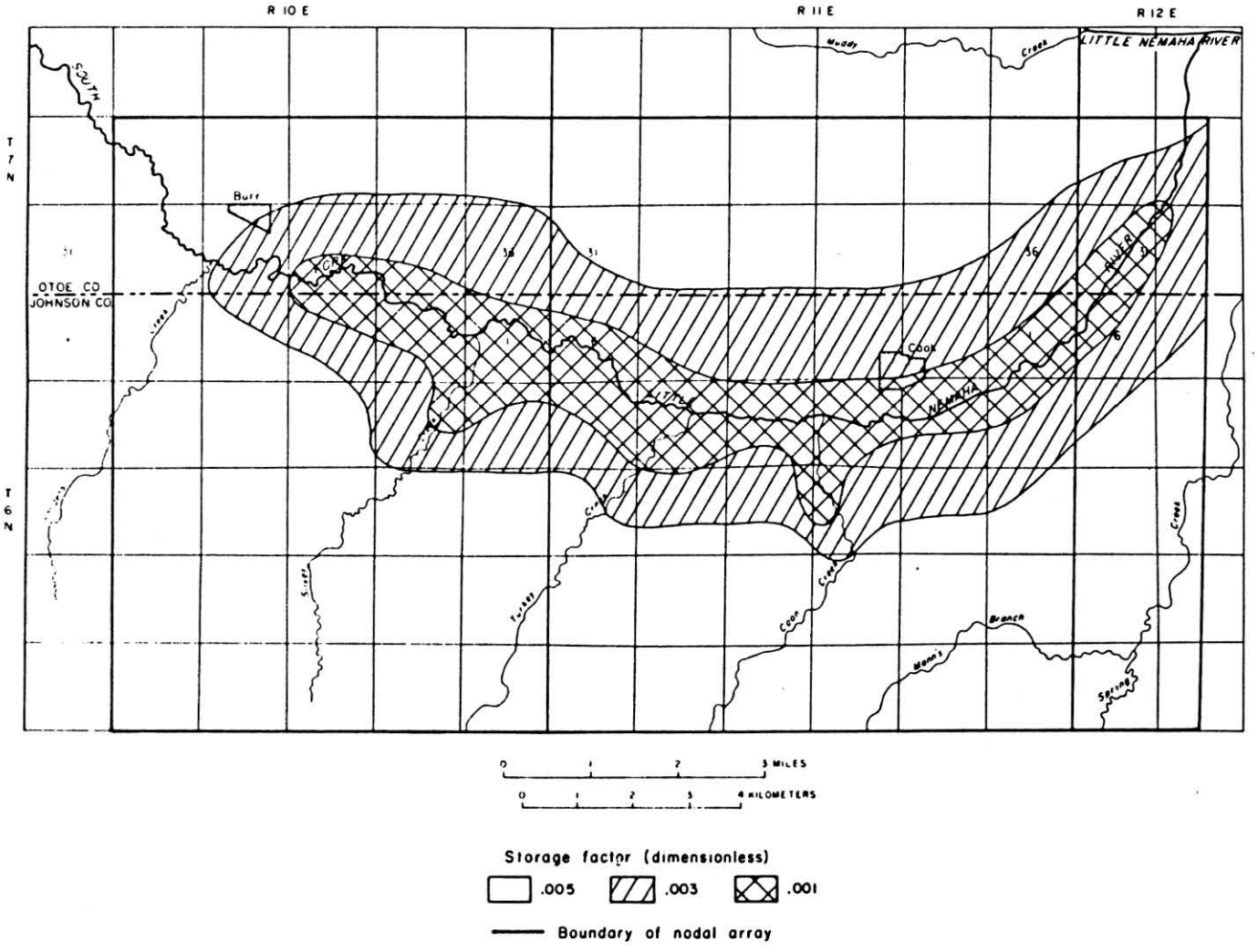


Figure 11. Storage Factor of Aquifer.

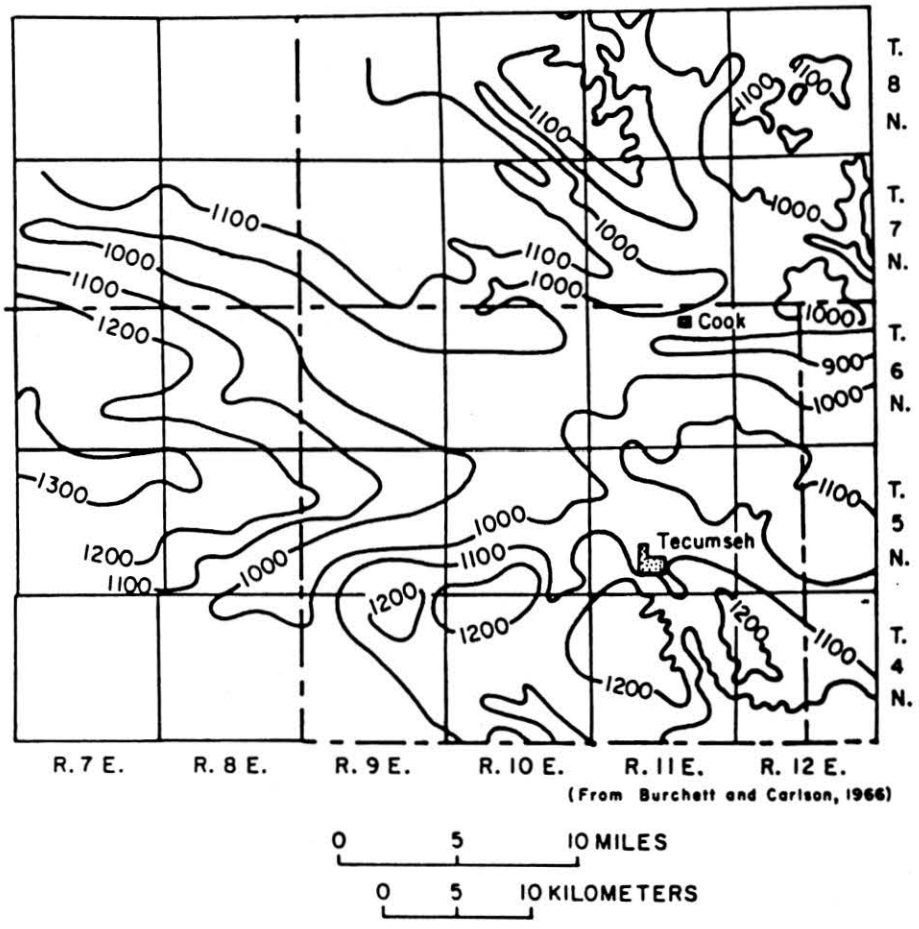


Figure 12. Regional Bedrock Surface.

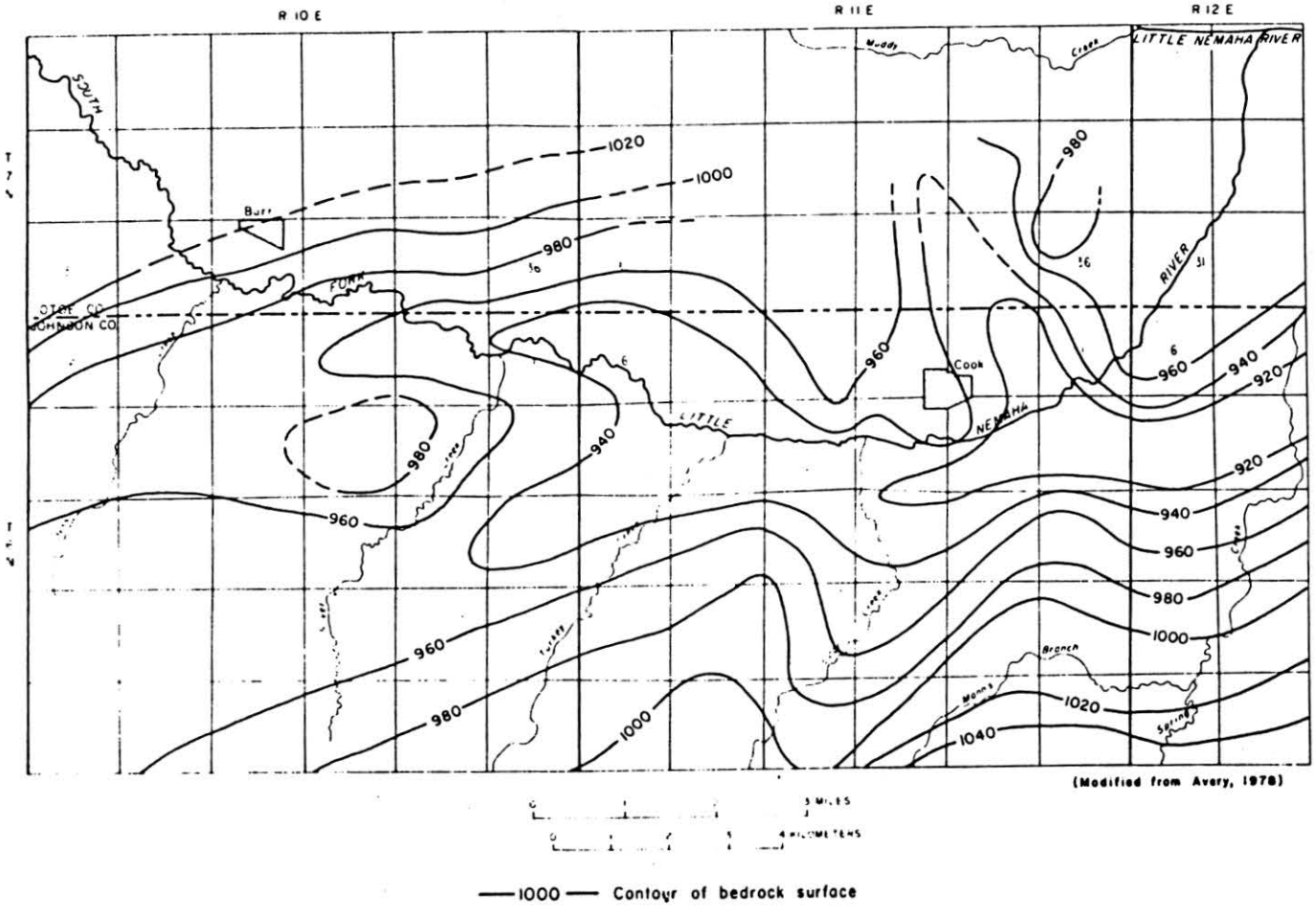


Figure 13. Configuration of Bedrock Surface in Study Area.

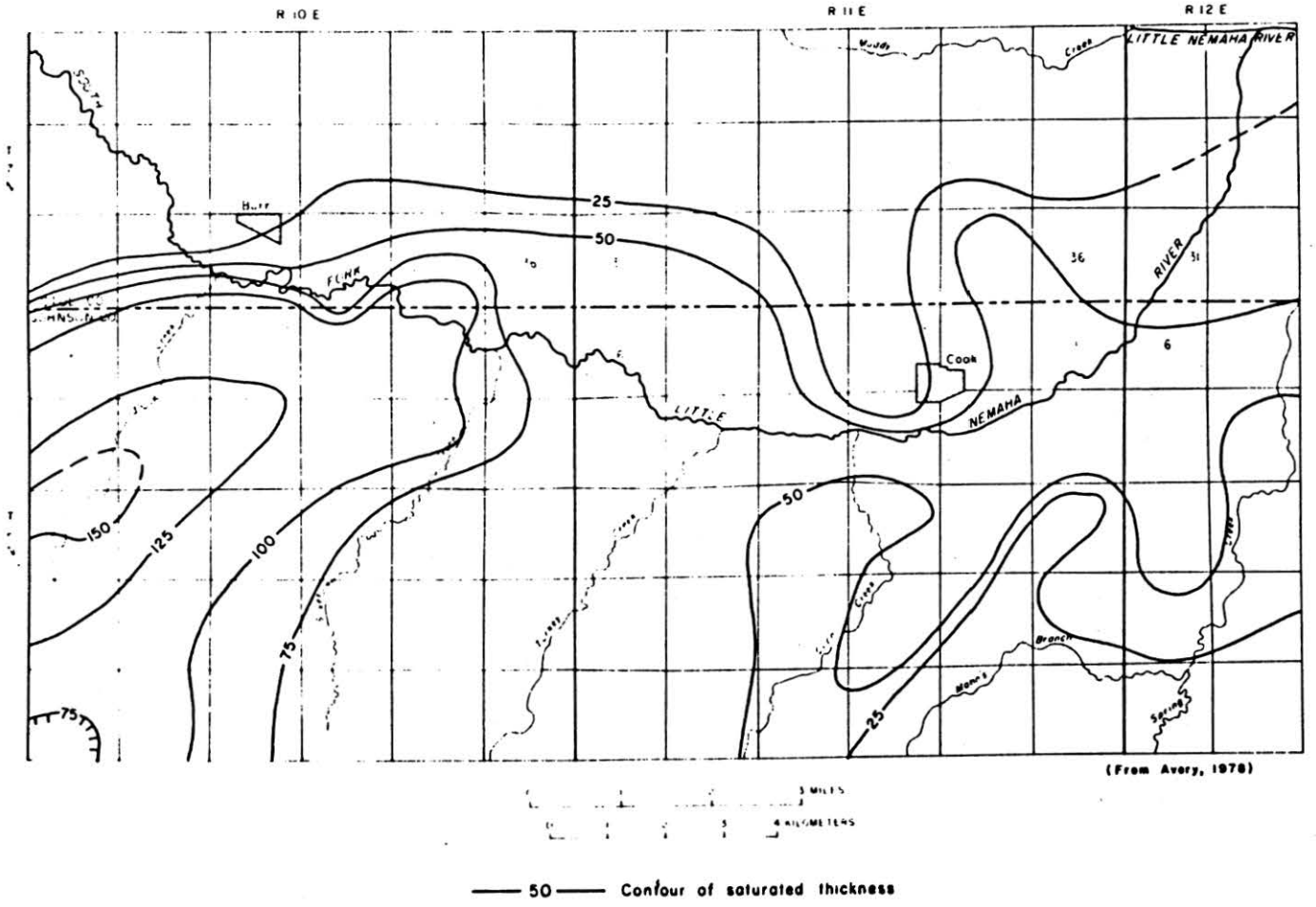


Figure 14. Saturated Thickness of Sand and Gravel.

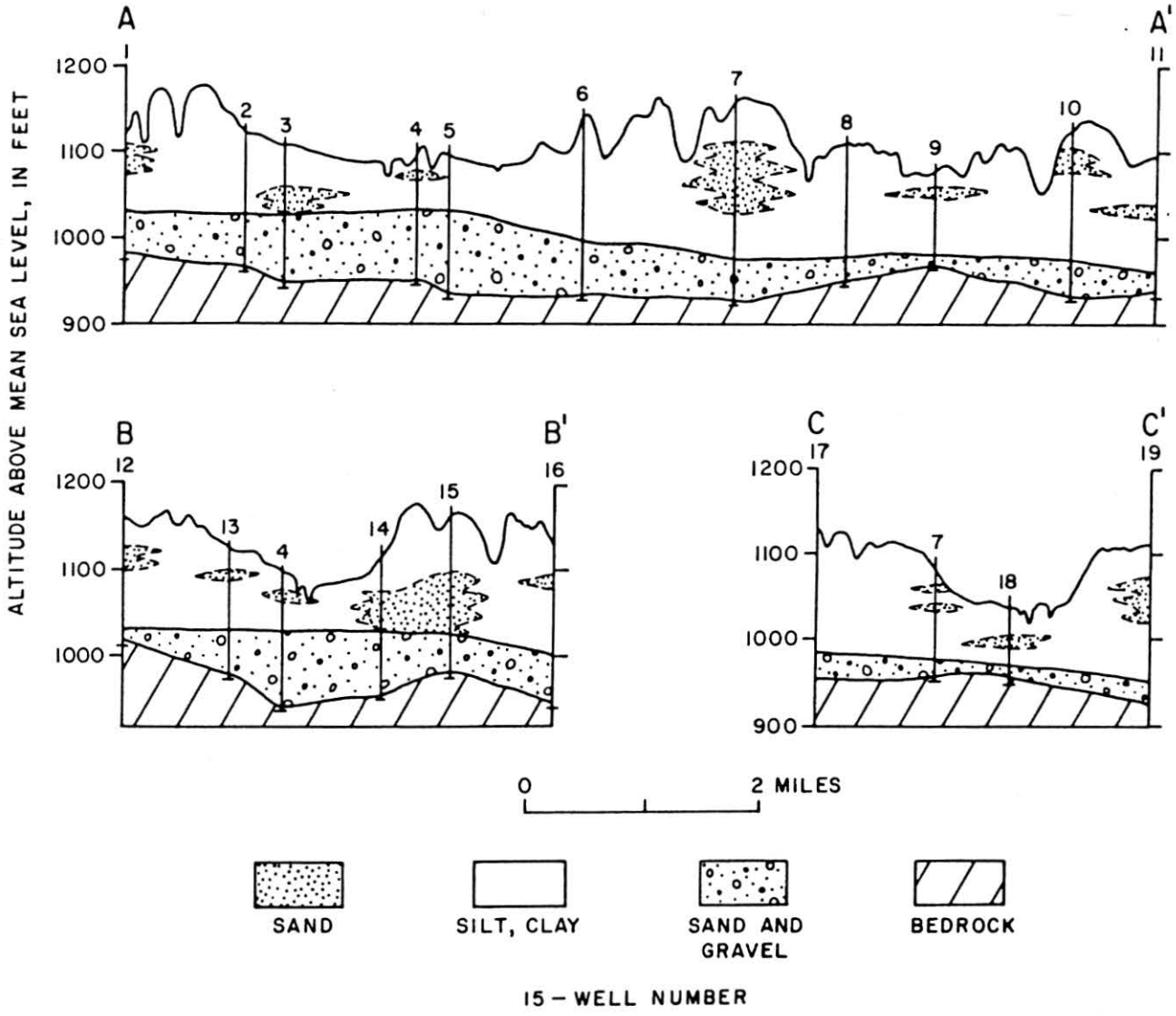


Figure 15. Geologic Cross-Sections within Study Area.

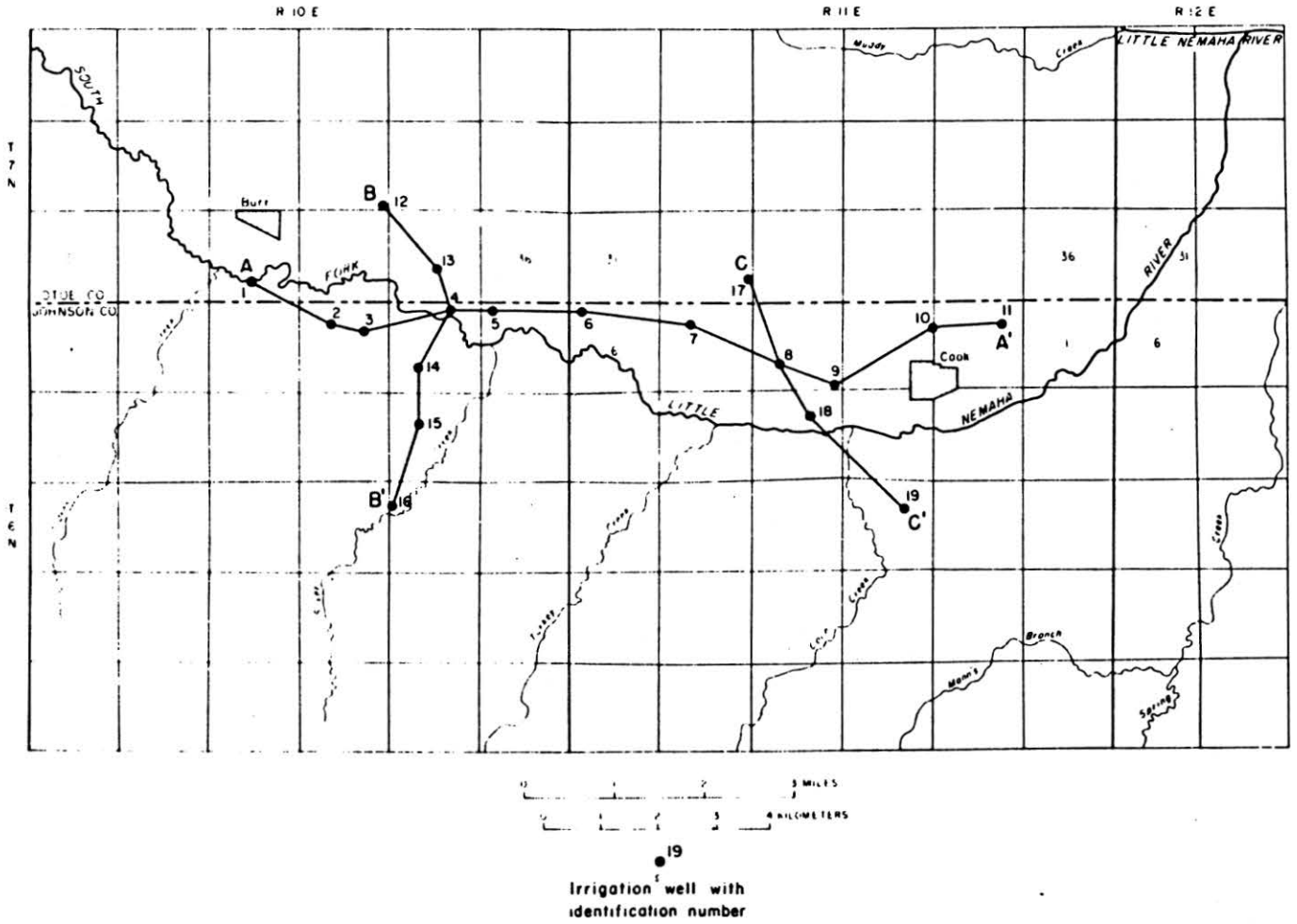


Figure 16. Location of Geologic Cross Sections.

The geologic cross sections shown in Figure 15 illustrate this. Their locations within the study area are shown on Figure 16.

Recharge

The aquifer system is recharged naturally by infiltration from precipitation and from ephemeral streams that exist in the study area. Some recharge also comes from sub-surface inflow to the area, primarily in the south and west portion of the area.

Long-term average precipitation at the Tecumseh and Syracuse weather stations is just over 30 inches per year. Rainfall often occurs in intense, short-lived thunderstorms during which much of the water runs off the drainageways and flows in the south fork of the Little Nemaha River. Much of the precipitation also infiltrates the soil. Of this water most is transpired through plants or evaporated from the near surface and is circulated back into the atmosphere. That water which infiltrates the soil and is not lost to evapotranspiration percolates slowly downward until it reaches the saturated zone where it can then flow laterally in the direction of the hydraulic gradient. No recharge to the aquifer occurs along the flood plain of the South Fork of the Little Nemaha River. In this area the potentiometric surface is higher than the land surface, and there is a slow upward movement of water through the confining layer.

Recharge occurs in the area away from the flood plain of the South Fork of the Little Nemaha River. Recharge is greatest along the ephemeral streams that flow during periods of precipitation since those are the areas which stay wet the longest. Recharge is lowest in areas which have slopes since water runs off most rapidly in these areas. Recharge rates also vary throughout the year. In the digital model it was assumed that no recharge reached the aquifer in the summer months because of higher evapotranspiration rates of the vegetative cover and lower precipitation amounts. Recharge during the pumping season was limited to subsurface inflow. It was assumed that the annual rate of recharge from infiltration ranged from 1.6 to 1.8 inches per year and occurred entirely within the 9-month non-pumping season. The distribution of recharge from infiltration is shown in Figure 17.

Recharge from groundwater inflow to the study area was estimated by Folkman (1980) using Darcy's Law:

$$Q = -KA\ dh/dl$$

where Q = volume of flow
K = hydraulic conductivity
A = cross sectional area over which flow occurs
dh/dl = hydraulic gradient

He estimated inflow to be 2400 acre-feet from May to November. Assuming that the hydraulic gradient remains approximately the same throughout the year, this would amount to about 4100 acre-feet per year. Folkman's study area was smaller than this study area; and, consequently, his estimate of groundwater inflow is lower than groundwater inflow to this area. Groundwater inflow

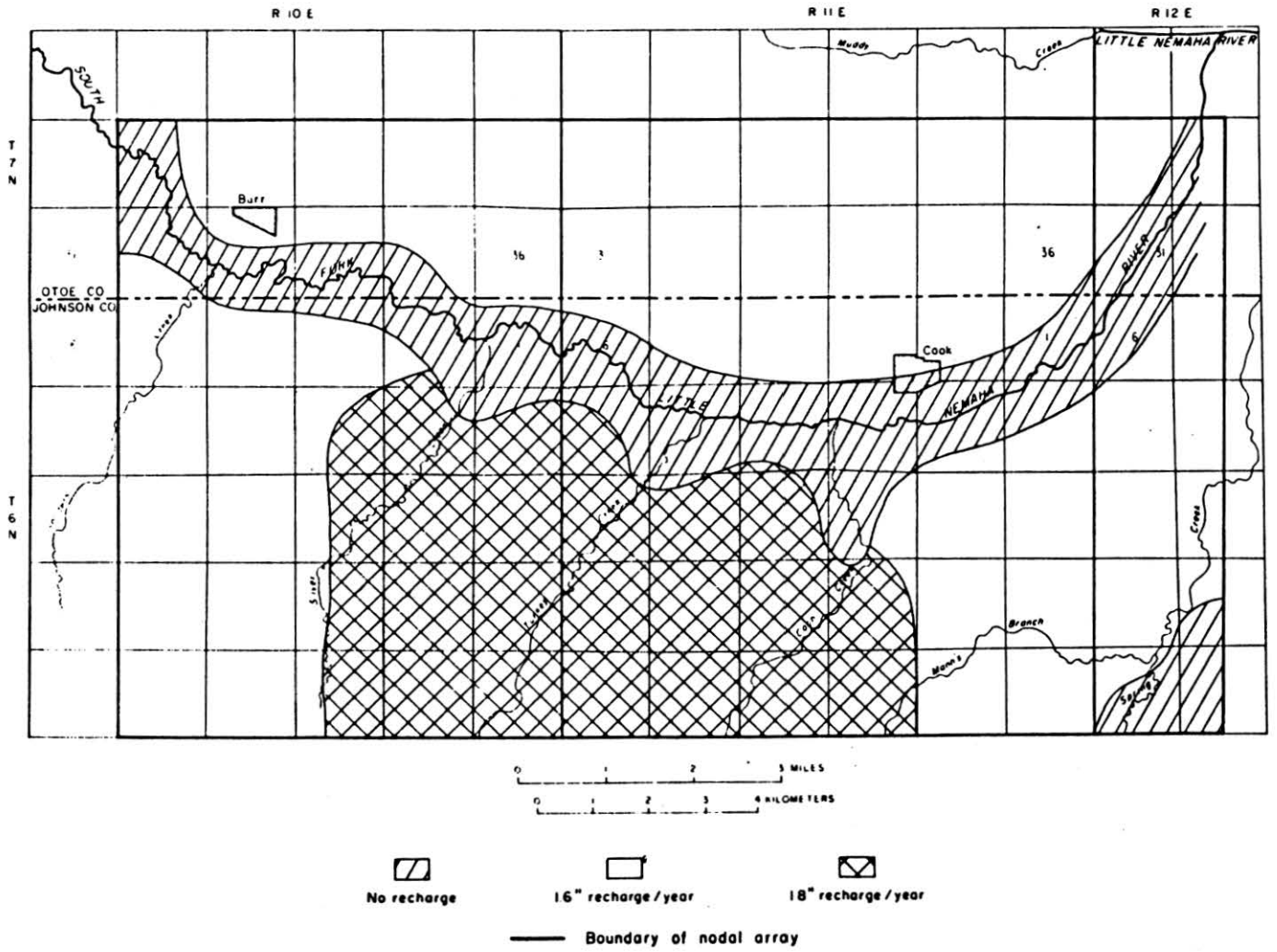


Figure 17. Recharge to Aquifer.

for this study area has been estimated to be in the range of 7,000 to 8,000 acre-feet per year.

Discharge

The discharge of groundwater from the aquifer is by evaporation, transpiration, subsurface outflow, seepage to streams, and by well pumpage. Transpiration is often difficult or impossible to separate from evaporation, so the two are combined and referred to by the term evapotranspiration. Evapotranspiration occurs primarily in areas where the water table is within 10 feet of the land surface and is accessible to the root systems of the vegetative cover. This condition occurs along the South Fork of the Little Nemaha River where numerous trees are located. The trees intercept water which is flowing through the confining layer toward springs and seeps along the river bank and have the effect of reducing stream baseflow. Evapotranspiration occurring in uplands is primarily by transpiration from plant cover and has the effect of reducing deep percolation through the soil zone. Actual evapotranspiration rates are related to climatic conditions.

Average evapotranspiration amounts were estimated by Folkman (1980) by measuring the amount of streamflow gain when trees along the river lost their leaves in November and then assuming a one-to-one relationship between changes in potential evapotranspiration (PET) rates and changes in the rates at which groundwater was intercepted by trees. By simply looking at the ratio of PET from any given month and the PET in November, calculation of water intercepted by trees for other time periods was possible.

Folkman's estimates were for an area smaller than the area being considered in this study, so his estimates were reduced to a rate per mile of river reach and then applied to the river lengths of this study. The rate of total evapotranspiration along the South Fork of the Little Nemaha River used in this analysis was 2.23 cubic feet per second during the irrigation season and 0.63 cubic feet per second during the non-pumping season. These values convert to a total of 745 acre-feet per year. The estimates of average evapotranspiration rates associated with each of the river measurement stations are listed below in Table 2.

Table 2. Average Evapotranspiration Rates (cubic feet/sec.)

	Station Number									
	2	3	4	5	6	7	8	9	10	11
Pumping Periods	.22	.25	.09	.31	.22	.09	.40	.16	.22	.25
Non-Pumping Periods	.06	.07	.03	.09	.06	.03	.11	.04	.06	.07

The discharge of groundwater to streamflow occurs along the entire length of the South Fork of the Little Nemaha River and the lower parts of its tributaries within the study area. Seepage runs were conducted by Folkman (1980) and as a part of this study to measure the average rate of flow gained by the stream, from the aquifer, during the irrigation season, and during the non-irrigation season. The seepage runs made in May of 1983 and 1984 showed base-flow gains between stations 1 and 11 of 15.73 and 22.27 cubic feet per second, respectively. The seepage run made in November of 1984 showed a baseflow gain of 12.12 cubic feet per second. The seepage runs conducted by Folkman in 1980 show considerably less baseflow gain for his study area, but this can probably be attributed to the fact that he studied a shorter length of the river and did it in a somewhat drier time period. Folkman's study did help to establish a general relationship of what happens to baseflow gains throughout the year (Fig. 18).

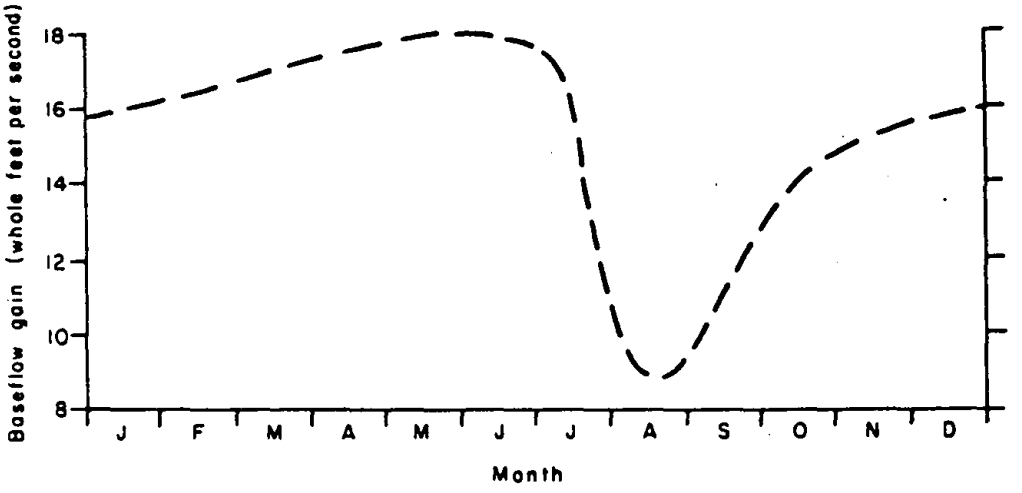


Figure 18. Seasonal Trend of Baseflow Contribution to the South Fork of the Little Nemaha River

Baseflows gains reach their highest point in the spring and early summer. Sharp declines occur in July and August, and a gradual recovery occurs from September to early spring.

Baseflow gain was applied as one constant rate for June, July, and August, and a second for the November through May period. The constant baseflow gains selected for the entire river reach were 14.82 and 18.85 cubic feet per second for the pumping and non-pumping periods, respectively. These representative baseflow gains were distributed amongst the individual river measurement sites according to the proportion of gain found at each of the stations in the May, 1984, seepage run.

The total amount of water discharged along the South Fork of the Little Nemaha is the sum of the stream gain and the water lost to evapotranspiration. Representative average values for this sum

were used for input to the model and are listed below in Table 3. Rates of total discharge are broken down according to the station numbers for which stream baseflow measurements were made.

Table 3. Total Discharge Along Stream Reaches (cubic feet/sec)

	Station Number									
	2	3	4	5	6	7	8	9	10	11
Pumping Periods	1.42	.51	1.0	1.98	5.02	.84	2.12	.86	1.70	1.59
Non-Pumping Periods	1.50	.39	1.09	2.04	5.58	.92	3.97	.94	1.84	1.2

Water is discharged from the aquifer as subsurface outflow along part of the eastern boundary of the project area. Folkman (1980) estimated this value using Darcy's Law as mentioned in the discussion on recharge. The estimate for outflow was 950 acre-feet for May to November of 1980. Assuming that hydraulic gradients do not change appreciably from year to year and estimating in a like manner the outflow for the months of January to April and December, total annual subsurface outflow is estimated at 1630 acre-feet.

Water is also discharged to 44 irrigation wells, to 4 municipal well fields, and to 1 rural water district well field. The 44 irrigation wells are pumped only during the summer irrigation season. The average rate of pumpage is 800 gallons per minute (Folkman, 1980). The location of these wells and well fields is shown in Figure 19.

Actual rates of pumpage for the growing seasons of 1980, 1981, 1982, 1983, and 1984 were estimated by first taking a survey of field sizes to determine the number of acres irrigated by each well. Individual farmers were contacted to determine the crop types grown during these years. If farmers could not remember, the crop type was assumed to be a mixture of crops in the ratio reported for all irrigated acres of different crop types for Johnson County in the handbook of Agricultural Statistics published by the Nebraska Crop and Livestock Reporting Service for each of these years. Consumptive requirements for the different irrigated crop types grown in Johnson County were taken from the Water Use Efficiency Policy Issue Study conducted by the Nebraska Natural Resources Commission and are listed as follows:

Crop	Water Requirement (inches)
Corn	26.5
Soybeans	23.0
Sorghum	23.0
Alfalfa	33.0

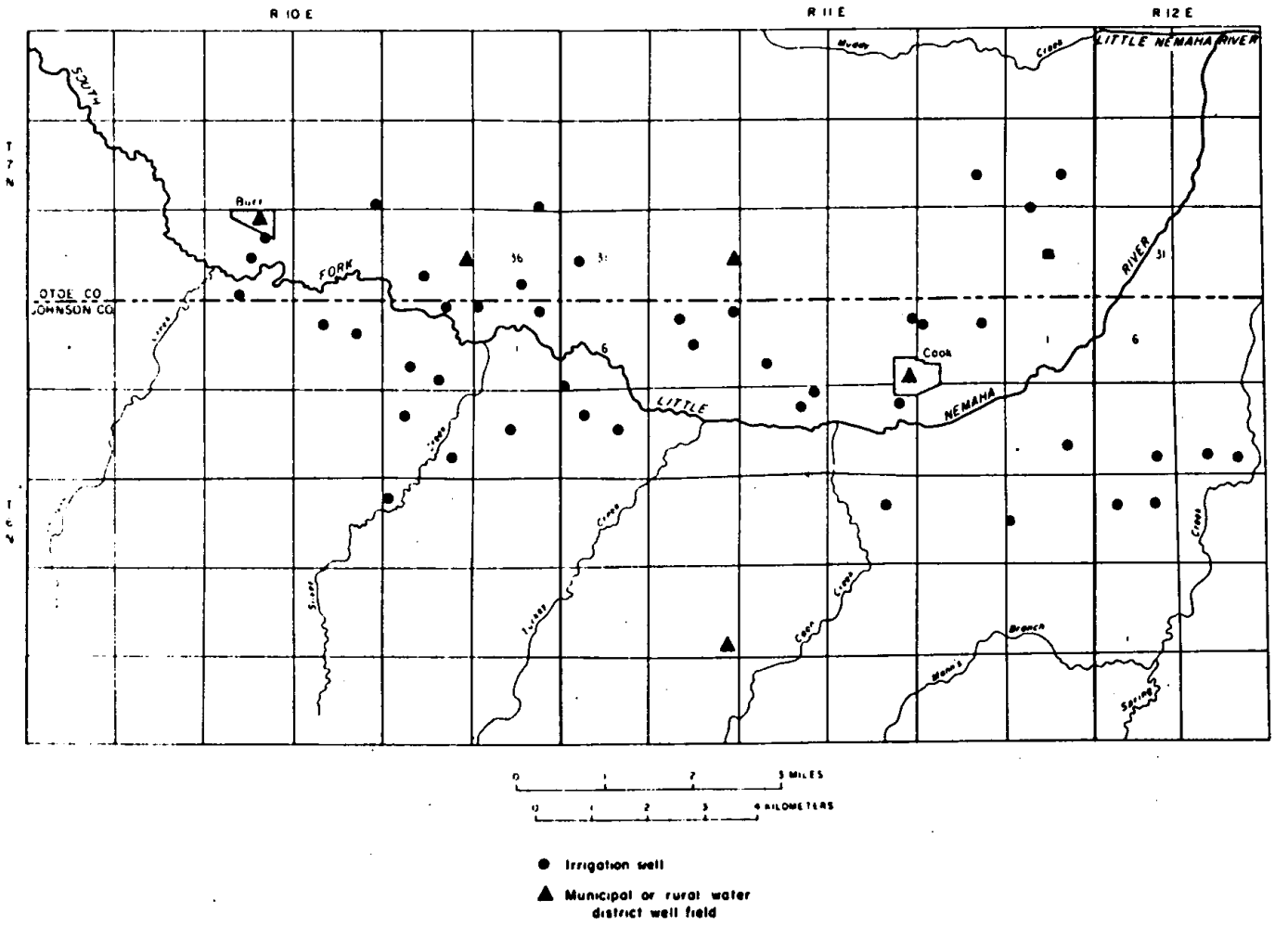


Figure 19. Location of Irrigation Wells and Municipal Well fields.

Precipitation records from the Syracuse and Tecumseh weather stations were examined to determine antecedent soil moisture conditions and precipitation amounts for each growing season.

Estimates were then made of the amount of pumpage required each year by each well to meet the total consumptive requirement. The estimates for the 1984 growing season were then compared to irrigation records kept by a local irrigator, and a ratio was calculated that related estimated pumpage to actual pumpage. This factor was then applied to all well pumpage estimates for each year. Pumpage estimates are tabulated in Appendix A at the back of the report.

Municipal pumpage records were obtained for the period of interest from the University of Nebraska Conservation and Survey Division files for the towns of Burr, Cook, Syracuse, and Tecumseh, all of which have well fields developed in the aquifer, and for the Otoe County Rural Water District #3, which also has a well field in the aquifer. Municipal wells pump all year around, and the annual pumpage volumes are presented below in Table 4.

Table 4. Total Annual Municipal Water Use

Town	Year	Gallons Pumped	Acre-Feet	Cubic Feet per second
Cook	1980	15,713,000	48.2	.066
	1981	13,672,000	42.0	.058
	1982	16,847,000	51.7	.071
	1983	15,411,000	47.3(est.)	.065
	1984	15,411,000	47.3(est.)	.065
Burr	1980	10,341,000	31.7	.044
	1981	9,245,000	28.4	.039
	1982	7,950,000	24.4	.034
	1983	9,707,000	29.8	.041
	1984	9,707,000	29.8(est.)	.041
Tecumseh	1980	338,489,000	1038	1.435
	1981	316,650,000	972	1.343
	1982	346,958,000	1065	1.471
	1983	363,132,000	1115	1.540
	1984	363,132,000	1115 (est.)	1.540
Syracuse	1980	92,351,000	284	.392
	1981	82,561,000	253	.350
	1982	71,601,000	220	.304
	1983	86,629,000	266	.367
	1984	86,629,000	266 (est.)	.367
Otoe Co.	1980	179,645,000	551	.762
Rural Water	1980	155,912,000	479	.661
Dist. #3	1982	142,524,000	438	.604
	1983	135,350,000	415	.574
	1984	135,350,000	415 (est.)	.574

Water Chemistry

The chemical quality of the groundwater is determined by the amounts of dissolved solids carried by water that infiltrates the soil zone and eventually reaches the aquifer, the mineral constituents of the grains in the aquifer, and the residence time of the water in the aquifer. The quality of water in the Cook aquifer is currently of sufficiently good quality to meet the standards required for all municipal supplies.

Several groundwater quality analyses for the municipal well fields of Cook, Tecumseh, and Syracuse are presented by Folkman (1980). Four samples were taken from irrigation wells and one from a flowing well as a part of this study. A comparison of the analyses reported by Folkman (1980) and those by Hiergesell (1985) show that the water quality has not changed significantly since 1980 except for a slight increase in nitrate concentrations found in the groundwater from two irrigation wells at the eastern end of the study area. These nitrate concentrations were 8.9 and 5.9 parts per millio which is below the 10 parts per million limit that has been established for drinking water standards. The chemical analyses are presented in Table 5.

Some potential for further degradation of groundwater quality from nitrates does exist. Sources of nitrates can be either point or non-point. Point sources originate at a discrete point and include abandoned feedlots, and barn yards while non-point sources are dispersed over an area and include nitrogen. All of these sources exist within the study area.

A potential for contamination such as fertilizer applied to fields exists in the upland areas away from the South Fork of the Little Nemaha River. In these areas there is a downward component of flow through the sands, silts, and clays which overlie the sand and gravel aquifer. In the river valley where there is an upward component of flow through the sands, silts, and clays, contaminants cannot seep downward to the aquifer. A potential exists in the river valley because groundwater in the aquifer moves slowly from upland areas toward the river where it is discharged. If contamination occurs in the upland areas, contaminants would migrate slowly toward the South Fork of the Little Nemaha River.

The potential for pesticide contamination appears to be less than that for nitrate contamination. Molecules of pesticide tend to be adsorbed by clay particles found in the soils and subsurface above the aquifer, thus limiting their movement. The Nebraska Department of Health maintains a program to monitor for pesticide contamination in municipal supplies throughout Nebraska. To date no traces of pesticides have been found in the municipal waters pumped from the aquifer within the study area.

MANAGEMENT AREA #II (Stream-Aquifer System near Humboldt)

The location of this management area is limited to an area in northern Pawnee County and northwestern Richardson County. (Exhibit I).

Table 5. Groundwater Chemistry of Municipal, Irrigation and Flowing Wells
(parts per million)

Well	Date Sampled	Total Alkalinity	Total Hardness	T.D.S.	Na	Ca	Fe	Mn	F	Cl	So_4	$N-NO_3$	pH
Cook 43-1	8/7/75	276	260	358	22	83	3.7	Nil	.28	6	47	Nil	7.5
Cook 56-1	8/7/75	276	272	362	21	80	Nil	0.1	.27	12	52	Nil	7.7
Tecumseh 48-1	7/16/76	300	324	438	10	101	Nil	Nil	.34	4	78	3.2	7.4
Tecumseh 68-1	7/17/76	252	340	510	13	104	Nil	Nil	.34	4	93	3.7	7.5
Syracuse 68-1	9/27/76	228	208	290	37	80	0.1	Nil	.32	2	11	2.1	7.7
Syracuse 68-1	1/28/80	248	224	312	13	67	Nil	Nil	.29	4	11	1.4	7.4
Syracuse 76-1	3/22/77	232	236	282	17	67	Nil	Nil	.39	2	15	1.5	7.7
	Mean	259	226	365	19	83	0.5	0.1	.32	4.9	44	1.7	7.6
										(From Folkman, 1980)			
6N,10E,Sec. 2 SW¼	7/27/84	320	240	516	90	69	Nil	0.1	.29	48	31	0.1	7.3
6N,11E,Sec. 7 NW¼	7/27/84	480	300	480	26	91	Nil	Nil	.22	10	27	0.5	7.1
6N,11E,Sec. 9 NE¼	7/27/84	458	200	458	35	74	0.3	0.2	.26	12	11	<.1	7.1
7N,11E,Sec. 36 NW¼	7/27/84	152	156	360	40	48	Nil	Nil	<.20	2	25	8.9	6.7
6N,12E,Sec. 7 SE¼	7/27/84	120	384	598	42	110	Nil	Nil	.21	8	111	5.9	7.2
	Mean	306	256	482	47	78	.1	.1	.2	16	41	3.1	7.1

Only limited groundwater information is presently available indicating a need for developing a comprehensive study similar to the study prepared in Management Area #I.

The area is generally agricultural land in the lower Big Nemaha drainage basin. Most of the farms are cash grain-livestock operations.

The soils are predominantly weathered loess and glacial till with low permeabilities.

Southwestern Richardson and south and central Pawnee Counties are high bedrock areas, thus adequate groundwater supplies are difficult to locate. The wells are generally shallow and penetrate the top 10 feet (3 m.) of bedrock which are predominantly shale and limestone. While adequate groundwater supplies are available where the uppermost bedrock is limestone, water deeper than 100 feet (30 m.) in the bedrock is highly mineralized. The groundwater level responds rapidly to recharge which is primarily from precipitation and averages 34 inches per year. Most of the precipitation falls in the late spring and summer. Within the principal aquifer area, the geology of the area shows there are over 100 feet of saturated, unconsolidated sediments; however, the sediments are fine textured and the wells generally poor producers. All of these wells are screened in glacial or alluvial fill. The remainder of the area is underlain by less than 100 feet of saturated, unconsolidated sediments.

Well yields range from almost zero to over 100 gallons per minute. The most productive wells are screened in coarse-textured alluvial bottomland sediments. Since the area has some of the poorest groundwater in Nebraska with regard to both quantity and quality, rural water districts have been established. Presently Pawnee County has 50 percent of its farms subscribing to the rural water system. Likewise, approximately 48 percent of the Richardson County farms also are served by rural water districts.

Water quality as indicated is very poor. A study was completed by Mary E. Exner and Roy F. Spalding in 1984 to examine pollutants in the groundwater. Groundwater samples were taken from household and stock wells during the fall of 1981 and spring, summer, and fall of 1982. At each sampling site the well's characteristics (type of construction, casing, depth, age, and use) were documented in addition to the well's location relative to the land surface and potential sources of nitrate contamination. A source of nitrogen was defined as a potential contaminant if it was upgradient and within 100 feet of the well. In cases where the gradient could not be determined, only the 100 feet radius criterion was used. Information on the use of agricultural chemicals in the surrounding area was also obtained for those wells sampled for pesticides.

Results of the study of Management Area #II showed groundwater nitrates concentration at the 268 sampling sites ranged from greater than 0.1 to 233 mg/l. (Figure __). At 37 percent of the sites, nitrate levels exceeded the 10 mg/l maximum permissible concentration (MPC). The presence of such a wide range of

nitrogen concentrations and the high degree of heterogenity over such aerial distance (Figure ___) is indicative of point source contamination. A conclusion of the analysis support the logical contention that nitrogen fertilizer used in dryland farming in this area has less impact on the groundwater quality beneath these fields than do the larger amounts of fertilizer used in the irrigated areas.

The common usage of atrazine, alachlor, propachlor, carbofuran, and carbaryl and their relatively high aqueous solubilities (33 mg/l, 242 mg/l, 580 mg/l, 700 mg/l, and 40 mg/l, respectively) suggest that they may be candidates for vertical transport to the aquifer. Only atrazine and alachlor were found in detectable quantities in some of the 47 samples analyzed for pesticides, and the concentrations were well below potential hazardous levels. The evaluation of collected data indicate that human and animal wastes are the primary source of nitrate contamination (Kreitler, 1975) and suggest that fertilizers and/or mineralized soil nitrogens are not major sources of groundwater nitrate contamination in this area.

In this area the major source of nitrate is the dissolution of manure in feedlots, barnyards, and corrals. The potential for nitrate loading in the aquifer through manure covered soils is dependent upon the intensity of activity in the lot. Nitrate-nitrogen is less likely to accumulate in the deep soil profile of feedlots that are stocked continuously and have an undisturbed and continuously accumulating manure pack where hoof compaction and urine excretion keep the surface sealed, damp, and reducing. When the feedlot is abandoned, surficial drying and cracking promote mineralization and the subsequent leaching of nitrogen-nitrates into the aquifer. Abandoned barnyards are very similar to abandoned feedlots in the manner nitrogen contributes to the aquifer.

Human wastes from septic systems appear to be a much less frequent potential source of nitrate contamination than animal wastes. At only 17 sites were wells located within 100 feet of the septic systems. The wells, however, had a high incidence of elevated groundwater nitrogen concentrations which could result from human wastes.

In general, groundwater from wells near abandoned barnyards not only had the highest rate of contamination but also the highest average nitrate concentration.

Deficiencies in well construction within this area were very common. Forty-seven percent of the wells have serious flaws in their construction. These wells were either augered or holes usually two or more feet in diameter. Thus, it is difficult to adequately cover the hole in order to protect the well from surface contaminants. They are lined with a variety of open-jointed materials -- wood, brick, or clay tile -- that permit the entry of contaminated surface water into the well. Since most of these wells are at least 60 years old, they were in use long before a cap and formation seal were recommended to safeguard the aquifer from surface contamination.

Only 10 percent of the wells meet all of the criteria set for private well construction in Nebraska (Nebraska Dept. of Health et al., 1981). These include protecting the well from surface drainage and locating the well away from the pump pit and at least 100 feet from any suspected source of contamination. While grouting is also a recommended procedure in Nebraska, its use is almost nonexistent in private well construction. An additional 9 percent of the wells met all of the construction requirements except that the well was located near a source of contamination.

The remaining 34 percent of the wells were properly drilled and cased but in poor locations. Most of these wells were located in the pump pit. Approximately 15 percent, however, had the top of the casing above ground; but the well was in a depression where ponding occurred.

Wells least likely to contain groundwater with excessive nitrate levels met all of the construction criteria and had only a four percent rate of contamination. The incidence of nitrate contamination sharply increased when deficiencies in location and construction occurred. Thus the proximity of the well to a potential source of nitrogen, the placement of a well in the pump pit or a lowlying area, or the use of nonwatertight casing make these wells prime candidates for contamination. Contamination was most frequent in wells lacking a watertight casing and probably stems from the many potential entry paths for a contaminant.

Deficiencies in well construction should not pose a threat of contamination due to poor septic system placement unless, of course, the well is located near the drainfield. The high incidence of contamination (>25%) even in wells with good construction could be statistically biased since there was only a very small number of wells in each construction class.

Wells with unacceptable construction but not situated near a potential N source occasionally contained contaminated groundwater. Since many of these wells are very old (>60 yrs), a potential source could be buried or no longer readily detected. The average groundwater No3-N concentration in these wells increased with construction deficiencies.

Atrazine was detected only in water from wells in pump pits or in wells lacking a watertight casing. The one groundwater sample containing alachlor also was from a well in a pump pit. The data, however, may be biased since samples usually were taken from wells with high NO3-N levels and/or wells in pump pits or wells lacking a water-tight casing. Of the 41 groundwater samples taken from wells with construction flaws, 13 had atrazine concentrations above 0.01 ug/l. None of the six wells that met the construction criteria contained atrazine. This suggests that spillage during preparation of the pesticide for field use could be the source of contamination.

The conclusion of the study of Management Area II shows point sources frequently result in nitrogen contamination of nearby stock and domestic wells. While some of the N from these sources

does infiltrate to the aquifer through the unsaturated layer, the large numbers of poorly constructed wells augment the problem. The limited availability of groundwater supplies and still more limited supplies of good quality groundwater have led to the formation of rural water districts. While this new source provides the residents with good quality drinking water, it has resulted in the abandonment of many wells. These wells should be plugged to prevent direct contamination of the aquifer and their use as receptacles of waste materials.

While the study of this management area sufficiently acknowledges pollution problems of the aquifer, much more data is needed to examine further the boundaries and available water supply. Such studies should include a modeling analysis similar to the study of the stream aquifer system near Cook (Management Area #I).

Presently the District will continue its groundwater monitoring program and seek to expand it to increase data for future analysis of maintaining reservoir life goals.

MANAGEMENT AREA #III (Remaining Area of District)

When excluding the areas selected as Management Areas #I and #II, the remainder of the District has many of the same physical features when considering geology, soils, elevations, etc. However, basically the area is void of any aquifer of significance. Wells are scattered with a general potential of securing groundwater near the river system drainageways. The amount of available water is varied with some wells capable of producing sufficient quantity for either irrigation or rural water district systems. The remainder of the management area is generally void of sufficient quantity of water. In addition many of the wells are highly mineralized or contaminated with nitrates, chemicals, etc. These two major features have resulted in the establishment of rural water systems utilizing water from the two previously discussed management areas or from wells located near the Missouri River flood plain.

The lack of existing information requires the District to initiate a data gathering program. Efforts will be initiated to budget the necessary funds in 1986 to accomplish this task. Efforts will be directed to:

1. Install a recording well within the management area with the assistance of the Division of Conservation and Survey and the U.S. Geologic Survey Service. Water level readings will be taken every fifteen minutes during the summer months and every thirty minutes during the winter months. Data collected will be made available to the state and federal agencies as desired.

2. Initiate a program of study similar to the effort accomplished in Management Area I. The study will be performed with the assistance of a graduate student at the University of Nebraska.

a. Schedule irrigation wells for measurement.
b. Conduct two to three mass water level measurements, one before an irrigation season, one after, and one before the next season.
c. Measure groundwater contributions to streamflow by conducting one or more seepage runs in the Little Nemaha River.
d. Obtain field cropping patterns from ASCS aerial photographs.
e. Collect soils information.
f. Collect water use information.
g. Collect climatic information.
h. Collect streamflow information.
i. Develop groundwater model.
j. Develop maps of hydrogeologic parameters to show several water level maps, transmissivity, storage coefficients, base of aquifer, and base of confining layer.
k. Develop predictive model
l. An explanation of the recharge and discharge areas of the principle aquifer.
m. An explanation of the principle stresses on the aquifer, e.g., evapotranspiration, irrigation
n. A discussion of the potential for groundwater degredation.
o. Two maps showing the range of estimated water level declines at a point in the future (2020).
p. A chart showing possible baseflow declines in the Big Nemaha River at a point in the future (2020).

The District will continue to consider implementation of groundwater management policies and assist in addressing critical problems as they become known in this management area.

GROUNDWATER RESERVOIR LIFE GOALS

An aquifer is generally considered to be a water-bearing stratum of rock or sediment capable of yielding supplies of water. When an aquifer is overlain by a low permeability layer or layers in which pressure head will force water to rise above the aquifer in which it is contained, it is called a confined aquifer, and if it flows at the surface, an artesian aquifer. An unconfined (or water table) aquifer is one in which the hydraulic pressure is equal to the atmospheric pressure. A perched aquifer contains water separated from an underlying body of groundwater by an unsaturated zone. Another term, principal aquifer, has been used to define the aquifer or combination of related aquifers in a given area that is the important economic source of water to wells. Any other aquifer in the area of the principal aquifer is considered to be a secondary aquifer. A secondary aquifer may have potential use, special use, or may be used singly or in combination with the principal aquifer. Examples of secondary aquifers are (1) perched aquifer overlying the principal aquifer, (2) thin sand units below significant thickness of fine grained material, and (3) water bearing bedrock formations of varying age underlying the principal aquifer. Another term that is used by hydrologists and which now appears in Nebraska statutes is groundwater reservoir. A groundwater reservoir is defined as the subsurface storage space between the water table (or piezometric surface in the case of a confined aquifer) and the base of the principal aquifer. A groundwater reservoir may include one or more aquifers and any associated fine grained materials (silts and clays). More broadly defined, a groundwater reservoir can include a dewatered zone or an area with potential for storage above the regional water table in an area.

The District is directed to establish reservoir life goals for which the management policies would be determined to achieve the goals.

Because though the District has limited groundwater resources, the establishment of reservoir life goals becomes critical for the health and well being of the residents of the District.

The lack of abundance of water supply coupled with contamination from point and non-point sources degrading water quality places a heavy burden upon the District as it attempts to develop policies and make management decisions to protect this vital resource.

The present water supply within the District, although abundant in Management Area #I and limited in Management Area #II and very limited in some areas of Management Area #III, leads the District to recognize the future expanded use of groundwater must be guarded and monitored to protect existing supplies from overuse, contamination, and waste.

The District's well water level monitoring program initiated in 1978 clearly shows a decline of water levels during the peak consumptive use period each summer. Generally this time occurs when irrigation is underway on our rural farms. Likewise the consumptive use within the urban municipalities also peaks as

water demands increase for lawns, gardens, street cleaning, etc. To date each year results in water levels returning to the elevation experienced prior to the high consumptive use period. The amount of recharge is apparently very responsive to precipitation even though much more data needs to be obtained on the recharge capabilities within each of the three identified management areas. Considering only the Cook area, the return to normal water levels has varied approximately 2.30 feet from 1981-1984 based upon December readings of the recording well. In contrast the summer declines have ranged from three years of drawdown of 27.3 to 27.8 feet and one-year decline of 44.2 feet (1981). Water levels are not constant as shown by the monitoring program. The District can only determine whether use of water is resulting in a "mining" effect based upon average readings taken over an extended period of time.

RESERVOIR LIFE GOALS POLICY

It is the policy of this District to manage the groundwater supplies in the three management areas to be maintained at the present water level based upon the 1981-84 four-year average. Such water supplies shall be available for present and future needs with increased usage or withdrawal permitted which will not adversely affect the groundwater levels based upon the District's well monitoring program. When the well monitoring program clearly provides sufficient data to adequately reflect a definite decline of water levels on a sustained basis as determined to be a result of activities by water users rather than reflect upon climatic conditions such as precipitation, action may be taken. It is recognized the District may experience natural periods of drought over several years which would not necessarily reflect groundwater declines having a major adverse effect on the reservoir life goal. When the groundwater levels decline during or following a period of sufficient precipitation and when a definite adverse trend can be recognized, the District will obtain necessary authorities or implement stringent policies specified in this plan to maintain and protect the groundwater resources.

POLICIES

The District is required to develop and maintain management objectives and policies to achieve groundwater reservoir life goals. In addition due to degredation of water quality, policies are necessary to permit water quality standards to be complied with as set forth by the Safe Drinking Water Act.

It is recognized the areas of concern addressed in this groundwater management plan can be accomplished with either voluntary or mandatory constraints; therefore, the District has grouped identified policies into two major categories:

1. On-Going Policies: These policies adopted by the District shall serve to guide the District and water users to apply conservation efforts to promote and maintain groundwater life goals. Many of the policies will be pursued on a voluntary

approach of education and proper planning for wise use of the water resources. It is the District's conviction the implementation of these policies will maintain the reservoir life goals and water quality standards. The District will initiate and pursue the implementation of many of these policies upon adoption of this plan.

2. Stringent Policies: In the event on-going policies are not fully successful in maintaining reservoir life goals and water quality standards, the District will initiate decisions and actions to implement stricter policies which may require the use of mandatory programs to achieve the objectives to maintain water supply and good water quality.

Although not all of the identified policies in either category will be implemented at the same time, the District will address the specific problems on a case-by-case basis and determine which policies will be the most effective in achieving the desired results. Policies implemented in one management area may or may not be implemented in the remaining management areas. The Board of Directors have not accepted stringent policies for all areas of concern as stated within this plan since the adopted on-going policies will provide guidance and direction for good, sound management to protect and maintain the groundwater resources.

As additional studies and research information becomes available, the stated policies herein will be reviewed and may be deleted, modified, expanded upon, or new policies added in order to achieve total resource management.

The District upon developing on-going and stringent policies recognizes its responsibility to "conserve, protect, develop, and manage the natural resources of this state" (Nebraska Statutes 2-3201). In addition purposes are clearly defined in Section 2-3229, R.R.S., as follows:

> **2-3229. Districts; purpose.** The purposes of natural resources districts shall be to develop and execute, through the exercise of powers and authorities contained in this act, plans, facilities, works, and programs relating to (1) erosion prevention and control, (2) prevention of damages from flood water and sediment, (3) flood prevention and control, (4) soil conservation, (5) water supply for any beneficial uses, (6) development, management, utilization, and conservation of ground water and surface water, (7) pollution control, (8) solid waste disposal and sanitary drainage, (9) drainage improvement and channel rectification, (10) development and management of fish and wildlife habitat, (11) development and management of recreational and park facilities, and (12) forestry and range management.

Utilizing the authorities and present statutes, the District will implement this plan upon adoption by the Board of Directors of the Nemaha Natural Resources District. All citizens, federal agencies, state agencies, counties, municipalities, and political subdivisions shall be encouraged to cooperate and assist the District implement these policies either through informational,

educational programs or through use of existing authorities, regulations, and ordinances.

The District will not exert its authority over any local, state, or federal agency which has and is performing specific responsibilities and statutory authorities for various programs which impact the groundwater resources. Some proposed on-going and stringent policies in this plan will encourage responsible political entities or state agencies to utilize existing statutory authorities. In addition the District may seek or support additional authorities for state agencies, county boards of commissioners, municipal governing bodies, or the District in order to carry out programs to resolve natural resource problems affecting the quantity or quality of groundwater.

GROUNDWATER PHYSICAL PROPERTIES

Even though water quality is generally considered to be very good in Nebraska, the quality of water particularly for domestic purposes is of special concern to the Nemaha NRD and its citizens.

Many studies and reports have been prepared on the subject of water quality and its relationship to human, livestock, and wildlife purposes. Intent has been to understand quality problems and determine solutions which can be implemented to safeguard the water quality for the future.

To understand groundwater quality and its associated problems requires a recognition of the sources of groundwater within the District and also the interrelationship between water quality problems of both groundwater sources and surface flow.

The primary source of groundwater in the District is saturated sand and gravel deposits of Pleistocene age. Some groundwater is obtained from bedrock aquifers of Pennsylvanian and Permian age.

Most readily available groundwater is stored in alluvial deposits in stream valleys and buried bedrock valleys. The District's groundwater reservoirs are small compared to others in the state as they account for about 0.4 percent of all groundwater stored in Nebraska. Because of this small quantity of usable groundwater, only approximately 268 registered irrigation wells are located in the NRD. However, due to the small amount of groundwater availability, water quality becomes of major importance and concern.

The saturated deposits of Pleistocene age contain water of good quality with dissolved solids content generally less than 700 milligrams per liter. Water obtained from the Pennsylvanian and Permian aquifers generally is highly mineralized.

According to data collection and studies by the Nebraska Conservation and Survey Division, the following chemical constituents of groundwater within the Nemaha NRD area were identified. The constituents were chosen on the basis of availability of data, relative abundance, public health significance, and aesthetic considerations. All constituents are naturally occurring, although in places their concentration has been changed by irrigation and other land use activities.

Dissolved Solids: The major constituents of dissolved solids are calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, and silica. The total amounts of these and of minor constituents depend on the quality of infiltrating water, the characteristics and compositions of unsaturated material infiltrated by water en route to storage, the characteristics and chemical composition of the storage medium, and the chemical equilibrium of the various constituents in solution at any time during the recharge and storage phases.

Within the NRD dissolved solids concentrations are very high. Approximately 0.65 percent of the District exceeds 1,000 milligrams per liter and in some locations reaches upwards to 3,000 milligrams per liter as found in wells tapping Permian, Pennsylvanian, Devonian, and Cambrian aquifers as well as water derived from aquifers in glacial drift.

Dissolved solids concentrations provide a measure of the salinity hazard of water used for irrigation. Most crops can tolerate water with concentrations of 500 milligrams per liter or less dissolved solids without adverse effect; and if leaching or drainage is adequate, concentrations of 500 to 1,500 milligrams per liter are not likely to be harmful. Water with a concentration of 1,500 milligrams per liter or more dissolved solids has a high salinity hazard and is harmful to most crops.

High dissolved solids within the District have not as yet proven to be detrimental due to four factors. First, the extent and number of irrigation wells are only numbering 220, which is small compared to NRD area. Second, irrigation in the District has not existed for many years. Third, irrigated crops of corn and grain sorghum have medium tolerance to salt. Fourth, the soils in the District generally allow for good drainage.

Hardness: Hardness of groundwater reported as calcium carbonate ranges within the NRD from approximately 180 milligrams per liter upwards to amounts exceeding 360 milligrams per liter.

Calcium and magnesium are the primary components of hardness, although small amounts of strontium and barium as well as a divalent form of iron and manganese may be a part of the total hardness.

Both calcium and magnesium are common in igneous rocks. Calcium is a major constituent of plagioclase feldspar, and magnesium is derived from such minerals as olivine and pyroxene. Sedimentary rocks such such as limestone are also important sources of calcium and magnesium.

Groundwater in the NRD is considered as Hard (120-180 mg/l as $CaCO_3$) or Very Hard (180 mg/l as $CaCO_3$). Such very hard water is derived from bedrock aquifers or from aquifers in glacial drift.

Regulations of the Environmental Protection Agency (EPA-1975) covering drinking water do not include a recommended limit for hardness because no serious health problems are known to result from the consumption of hard water. However, the insoluble residues that collect in kettles and water heaters, the curd that forms when soap is used to produce a lather, and the stiffness that is added to laundered towels and other fabrics are among the aesthetic problems resulting from hardness.

Sodium Plus Potassium: Both sodium and potassium are alkali metals, and both are very abundant in the earth's crust. Both occur in igneous rocks especially high in feldspar and mica and are released into solution when the rocks are weathered. Potassium is commonly adsorbed or incorporated into clay minerals and normally occurs in much smaller amounts in groundwater than

does sodium, which ordinarily tends to remain in solution. Sodium is adsorbed by some clay minerals which when dispersed in water may release sodium into solution and adsorb calcium and magnesium. This often accounts for increases of sodium in groundwater beneath land irrigated by surface water.

Within the District concentrations of sodium plus potassium exceed 200 milligrams per liter because the thick deposits of glacial drift contain substantial amounts of sodium.

The drinking water regulations of the Environmental Protection Agency include no recommended limits for sodium or potassium. Although high concentrations of sodium can be harmful to some person with heart disease, water containing injurious amounts is so unpalatable that its use for drinking or cooking is unlikely.

High concentrations of sodium (Na) are harmful both to plants and to soil. Application of irrigation water containing large amounts of sodium increases soil pH and reduces soil permeability. Such soil deterioration normally takes place over a period of years, and soils so affected are rendered worthless.

Alkalinity: Alkalinity is defined as the capacity of water to neutralize acid. In groundwater the principal source of alkalinity is bicarbonate ions. Bicarbonate is formed either by the reaction of carbon dioxide dissolved in infiltrating water with basic material in the soil or by the weathering of some igneous or silicate rocks. Where the pH of water is greater than or equal to 8.3, measurable concentrations of carbonate as well as of bicarbonate exist in solution. Alkalinities in water samples from aquifers in and at the base of glacial drift within Nemaha and Richardson Counties exceed 300 milligrams per liter. Dissolution of carbonaceous material or limestone detritus from the drift probably accounts for these high concentrations.

Some alkalinity in public supplies is desirable, especially if the water is chlorinated. If alkalinity is less than 25 milligrams per liter, chlorination may produce corrosive water that attacks metallic parts of water systems.

Sulfate: The principal geologic sources of sulfate are metallic sulfides in igneous and sedimentary rocks. Sulfate concentrations greater than 1,000 milligrams per liter are associated with water from bedrock aquifers within the NRD.

A limit of 250 milligrams per liter sulfate was recommended by the U.S Public Health Service for drinking water supplies. Although it is not known to cause any health problems, sulfate has a laxative effect on some people when concentrations greater than 250 milligrams per liter are first ingested. Concentrations of sulfate exceeding 400 milligrams per liter may also affect the taste of water.

Even though sulfate in irrigation water does not affect crops directly, concentrations of sulfate exceeding 500 milligrams per liter may render water unfit for irrigation by contributing to high salinity.

Chloride: Although found throughout the District except for an area along the Missouri River, chloride concentrations are generally less than 100 milligrams per liter.

Evaporate rock undoubtedly is the most important source of chloride, but marine shales are also a source. Chloride enters into relatively few chemical reactions; and once dissolved in water, it generally remains in solution unless precipitated by evaporation.

In much of southeastern Nebraska, the chloride concentrations of groundwater range from 11 to 100 milligrams per liter. Small amounts of naturally occurring salts in the water bearing sediments or in the materials infiltrated by water recharging those sediments are sources of the chloride in the water. However, in some of the areas where a large part of the land is now irrigated, the chloride concentration may have been less than 11 milligrams per liter prior to irrigation but has since increased.

Because human and animal wastes contain considerable chloride, well water having a chloride concentration significantly higher than the average for any given area may under certain circumstances indicate contamination of the water by sewage. Waste materials from some industries can also be a source of higher than normal concentrations of chloride in groundwater. A limit of 250 milligrams per liter chloride in drinking water was recommended by the U.S. Public Health Service. Because water containing that concentration of chloride may be offensively salty to the taste, the standard is based solely on aesthetic considerations.

Fluoride: Fluoride concentrations ranging from 1.0 to 8.4 milligrams per liter occur in water from wells in several different areas in Johnson, Pawnee, and Richardson Counties. These higher fluoride concentrations probably result from dissolution of fluoride in shale layers that are interrelated with the water producing Paleozoic rocks tapped by the wells.

The Environmental Protection Agency recommended upper limits for fluoride in drinking water which are inversely related to mean annual maximum daily air temperatures. For Nebraska with an average maximum daily air temperature of around 50 degrees Farenheit, the upper limit for fluoride is 1.7 milligrams per liter. Concentrations of fluoride greater than 1.7 milligrams per liter are known to cause mottling of teeth; however, lesser concentrations are beneficial in the prevention of tooth decay in children.

Silica: Silica is present in most rocks and minerals. Most igneous rocks are composed at least in part of silicate minerals. Some silicate minerals such as quartz are highly resistant to solution by water, but chert and some of the iron-magnesium minerals are less resistant. Chemical breakdown of these rocks probably accounts for most of the silica in groundwater.

Within this District is the lowest observed concentrations of silica in Nebraska. Silica is not known to be harmful to animals or plants.

Boron: Whereas Boron is found throughout Nebraska, the highest concentrations are found generally within the Nemaha NRD where wells that tap the Paleozoic aquifers yield highly mineralized groundwater. Boron is probably solubilized from shale beds in these aquifers.

Boron, in the quantities occurring in groundwater, is not known to have toxic effects on humans. Boron in small quantities is an essential nutrient for all crops, but even a slight excess over the essential amount is toxic to some. Boron within the Nemaha Basin is found to exceed 330 micrograms per liter; but since found in only eight percent of the analyzed samples, crop problems relating to excess boron in groundwater are unlikely.

Iron: Sources of iron in groundwater include minerals such as pyroxene, amphibole, and olivine in igneous rocks and iron oxides and iron sulfides in sedimentary rocks. The amount of iron dissolved in groundwater depends upon its availability in both the saturated and unsaturated zones and on the chemical environment within the saturated zone.

Iron concentrations higher than 100 micrograms per liter characterize water from wells in western Johnson County, almost all of Pawnee County, and the western side of Richardson County. These higher concentrations can be attributed to available iron minerals in combination with the lack of oxygen in the zone of saturation, thereby finding ferrous iron soluble in water.

Iron is an objectionable constituent both in domestic and in industrial water supplies. When present in excessive amounts, it produces brown stains on laundered goods and results in a bitter taste to beverages. Iron precipitates may cause clogging of well screens and distribution valves. Clogging is sometimes the result of bacteria that require iron for their nutrition, which convert soluble iron to insoluble ferric hydroxides and in the process form gelatinous substance. The U.S. Public Health Service recommended that the concentration of iron in drinking water should not exceed 300 micrograms per liter.

Manganese: Manganese has not been sampled in the Nemaha NRD resulting in insufficient data available to determine whether this mineral is of sufficient concentrations to pose a hazard to plants and domestic use.

Selenium: Selenium tests within the NRD have not been made to the extent to determine whether Selenium concentrations are of the magnitude to pose a hazard to the groundwater used for plants and domestic use.

Phosphorus: Insufficient data have been collected within the Nemaha NRD for this mineral. Phosphorus has been reported by the Environmental Protection Agency as having no harmful effects on humans.

Nitrate: Nitrate is the highest oxidation state of nitrogen and is the most stable form of nitrogen occurring in groundwater. Other forms of nitrogen occurring commonly in groundwater include nitrite, ammonia, and organic nitrogen. These transitional forms may ultimately be oxidized to nitrate if oxygen and certain bacteria occur with them.

Nitrate in groundwater is derived from a variety of sources. Natural processes such as bacteria activity and the growth of certain plants remove nitrogen from the air and fix it in soils. The various forms of fixed nitrogen then are oxidized to nitrate by other bacteria activity, and some of that nitrate reaches the groundwater. Additional potential sources of nitrate include barnyards and abandoned feedlots, septic systems, fertilizers, and waste from grazing animals to include livestock and wild animals. Nitrate probably is not derived from rocks and minerals except in very small quantities. Buried soils and loess of Pleistocene age, some occurring at depths of 50 feet or more, also may be significant sources of nitrate in groundwater. Some sources of nitrate are considered to be non-point -- that is, dispersed over wide areas -- and are very difficult to distinguish from other sources. Nitrogen existing naturally in the soil and commercial fertilizers applied to agricultural lands are both examples of non-point sources of nitrogen in groundwater. Natural soil nitrogen can be leached from the soil by intensive irrigation and added to the groundwater by deep infiltration. The high use of nitrogen fertilizers on irrigated corn fields in the District may contribute some nitrate to the groundwater reservoir.

In contrast to non-point sources of nitrogen, point sources generally can be qualitatively identified if anomalously high concentrations of nitrogen occur adjacent to and down gradient from an observable source. Such sources include barnyard and feedlot wastes as well as septic tank and sludge nitrogen. Although well managed feedlots are not believed to contribute significant amounts of nitrogen to groundwater, nitrogen from abandoned feedlots and barnyards percolates downward and probably adds significant amounts of nitrate to groundwater in various localities within the District. Excess nitrate in groundwater may occur in areas where septic tanks are too closely spaced and where the water table is shallow. In addition the high precipitation within the District may provide higher concentrations as rain runoff flows over areas such as barnyards, and cropland has had large amounts of nitrogen available or applied. Movement of nitrogen may also result in these higher concentrations moving from higher elevation to low lying areas where the nitrogen will have access to water table areas and to the groundwater aquifer.

Concentration of nitrate in groundwater varies widely with respect to season, depth to water, location of wells or springs, type of soil, kinds of sediment in the unsaturated zone, precipitation, runoff, and available sources of nitrate. Because of this variability it is impossible to portray zones of nitrate within the District without further detailed study. From all indications concentrations of nitrate in the District are increasing as groundwater supplies are developed and as

agricultural productivity is increased through improved farming practices; however, research is needed to justify this determination.

Potential sources of nitrate in groundwater in the District are summarized as:

1. Hog & cattle feedlot and confinement operations
2. Dairy Operations
3. Fertilizers applied to cropland
4. Septic systems in both urban and rural areas
5. Runoff into poorly constructed domestic wells

The Environmental Protection Agency retained the 10 milligrams per liter limit previously set by the U.S. Public Health Service as the maximum allowable concentration of nitrate-nitrogen in drinking water. A known health hazard associated with ingestion of high-nitrate water is methemoglobinemia, which can occur in infants. In this malady the ingested nitrate is reduced in the stomach to nitrite which is absorbed by the blood and inhibits the blood's oxygen carrying capacity resulting in brain damage or death from oxygen starvation. The most common symptom of methemoglobinemia in an infant is a blue tinge of the skin and tissues giving rise to the term, "blue baby".

High concentrations of nitrate in water also affect animals, particularly swine. The most common symptom of high nitrate in swine is a swayed back condition caused by the nitrate destruction of Vitamin A.

Nitrogen

Nitrogen availability is essentially unlimited because it is supplied from the atmosphere and from the breakdown of vegetation. Nitrogen moves from one form to another between locations in an environmental cycle. Sources and deposition sinks of nitrogen are temporary. Residence times and conditions may change at any stage of the cycle. Even nitrogen trapped in deep sediments will be released within geologic times. Nitrogen thus moves between the atmosphere, the soil, plants, and water. Observing the flow of nitrogen traffic from any of these potential resting places in the cycle helps us understand how this basic nutrient can become a pollutant.

Nitrogen moves from the atmosphere to the ground in soluble forms, nitrite (NO_2), nitrate (NO_3), and limited by ammonia are generated by electrification (lightning) or photochemical fixation during plant growth. Plant or animal tissue is an organic form of nitrogen that is not available for plant growth. It must be altered by decomposition and bacteria action into an available (soluble) form.

Soluble forms exchange in the cycle by oxidation and through bacteria from moderately soluble ammonia through the short-lived nitrite (NO_2) to the soluble, and highly mobile nitrate (NO_3). Soluble forms, available for use by plants and animals, are applied as fertilizer, residues, or animal waste for growth stimulation. The hydrologic cycle is the mobility vehicle for

the available nitrogen forms. Water carries nitrate from the soil in runoff or by leaching to ground water. Organic nitrogen forms are not soluble and move through the environment either as residue washed from the field or sorbed to soil particles moved downstream by erosion. Movement of available forms also occurs where nitrogen is removed from the soil by plant growth. Such nitrogen transfer is measured as plant yield. Its use for food by animals allows its organic form to become transferred through digestion to available forms that are made available through elimination. Soluble forms are also returned to the atmosphere through volatilization when they are reduced by bacteria to a gas under anaerobic conditions. Denitrification rates are high when soils are saturated, which limits oxygen, and when warm temperatures increase bacterial action. The release of nitrogen from soil to air obviously does not produce water pollution, but it is an important concept in the efficient use of nitrogen as plant growth stimulation. It may also be a mechanism by which excess nitrogen can be removed from an environment niche.

Water pollution because of nitrogen compounds can occur both when it becomes a toxic for fish or humans or when it impairs water use.

Free, un-ionized ammonium (NH3) becomes toxic to some aquatic species at about .2 mg/l, and the cold water fish are very susceptible. The toxic ammonia form (NH3) is present in water in equilibrium with the ionized ammonium (NH4), and its concentration is related to pH and temperature. Greater concentrations exist at higher temperatures and pH. At such time there is a greater opportunity for fishkill. A water quality criteria of .02 mg/l has been set to represent a safety factor. Calcareous aquatic environments, natural or man-made (fish rearing ponds) have a greater hazard for ammonia toxicity during the summer months because of higher temperatures and low flow conditions.

The criteria (Redbook EPA) of 10 mg/l of nitrate-nitrogen has been set for domestic water supply. The presence of nitrate above this level has been found to produce a condition wherein the body produces nitrite in the gastrointestinal tract limit the ability of the blood to transport oxygen. This condition is most hazardous for small babies that are bottle fed on the high nitrate waters. The very mobile nitrate can accumulate in groundwater and produce concentrations in excess of the nitrate criteria.

Other pollution from nitrogen primarily results from its use as a growth simulator for plants and animals. The buildup of aquatic plants such as algaes can limit the use of the water for recreation and produce unsightly conditions. Where nitrogen is the limiting growth stimulant, aquatic communities can remove dissolved oxygen through respiration leading to the death of the organisms.

<u>Phosphorus</u>

Phosphorus is not in essentially unlimited supply like that of nitrogen in the air, but is obtained from earth materials. The availability of phosphorus for agricultural use depends on man's

ability to obtain it, either naturally by erosion or else through mining, and apply it on the field. The cycle moves from a geologic sediment or as an organic detritus to a new deposition site where it becomes available in the future.

Phosphorus cycling, in the broad sense, is relatively slow; but, like nitrogen, it occurs throughout the environmental system as it moves from source to a deposition center. It is taken up by plants along with nitrogen as a growth stimulator and is sorbed to the soil. Its nutrient properties make it important in agriculture or other organic systems. Phosphorus is critical in every energy transformation system and in the maintenance of life forms. Phosphorus, with limited availability because of its sources, frequently is the limiting nutrient in aquatic environments. Its strong retention because of sorption in the soil-plant system fortunately preserves it for use. If it were as mobile as nitrogen, this scarcer nutrient would move more rapidly through the system; and its availability would be severely limited.

Phosphorus-like nitrogen must be in the dissolved form to be used by plants and animals. It has both organic and inorganic forms which interrelate through plant and animal growth as they move through the cycle. As a nutrient it is characterized by a low water solubility and a high potential for sorption.

Generally dissolved available phosphorus is less than 10 percent of total phosphorus. Total phosphorus is made up of three components: a dissolved phosphorus sometimes referred to as phosphate of PO4-P and a particulate or sediment phosphorus form of which part is adsorbed and the other may become available for plant use. The available part of the sediment phosphorus (labile phosphorus) has been estimated to be 5-40 percent of the sediment phosphorus depending upon the chemical and physical environment where it occurs. (A.W. Taylor and A.W. Kunishi (1971), "Phosphate Equilibria on Stream Sediment and Soil in a Watershed Draining of Agricultural Region." Jr. Ag. and Food Chem. 98: 827-931).

Biologically available phosphorus (dissolved plus labile phosphorus), is the amount of dissolved phosphorus plus about 20 percent of the total phosphorus minus the amount of dissolved phosphorus. (G.F. Lee, (1973) Role of Phosphorus in Eutrophication and Diffuse Source Control, Water Research 7: 111-128). Sources of the available phosphorus include natural background amounts from geologic sources, leaching from green plants or residues, culturally generated fertilizers, and animal wastes.

The effects of phosphorus on water quality that cause it to become a pollutant are principally related to growth stimulation. Receiving water bodies may be characterized by their aquatic environment through the concept of their trophic state. Clear water bodies with a lower level of enrichment have limited aquatic productivity but are aesthetically pleasing. They are free from organic loads that produce deleterious conditions affecting their uses. Such lakes are called oligotrophic. When a lake becomes so nutrient rich that plant production prevents a

desired use, and it is aesthetically displeasing, it is called eutrophic. There is also an intermediate stage known as mesotrophic.

The available phosphorus (or in some cases nitrogen) is the limiting growth stimulator. It generates organic production proportional to the amount of nutrient loading in the receiving water. Plant production is by photochemical reaction, and light penetration through the water is a measure of the driving energy for the reaction.

The enriched (eutrophic) lake frequently produces an organic growth which interferes with recreational use. In absence of sufficient sunlight, such as on overcast days or nights, oxygen production would be depressed or terminated.

The respiration of the resident animal communities may cause extensive reduction of dissolved oxygen from the receiving waters that will become too depleted for fish to survive. The decay process contributes to the oxygen debt.

The sedimentation of the phosphorus, sorption to bottom sediment, and stratification tend to rapidly tie up the phosphorus in the lower level of the stratified lake. The lower lake levels (hypolimnion) become anaerobic and reduction of the organic phosphorus compounds occurs allowing dissolved phosphorus to accumulate. The use of phosphorus by plants and animals in the upper lake strata -- epilimnion also removes dissolved phosphorus from the waters. The period of toxicity because of oxygen deficit and the restricted use from organic growth ends. However, higher animal communities such as fish may have been eliminated or depleted during the time of stress.

Mixing of the lakes due to seasonal overturn redistributes available phosphorus; and in areas of light penetration, growth recurs. In mixed lakes the stratification would not occur, and the lake condition is a function of the biologic use and sorption of phosphorus by sediments. The time of persistence of these conditions is a seasonal function of phosphorus availability and climatic elements.

Nutrients

The chemical form of a nutrient determines its mobility and the pathway it would take to be a water pollutant. Dissolved phosphorus is plant available and is the form that most often causes environmental degradation. Particulate or sorbed phosphorus forms also contribute to the problem because they are convertible to available forms (labile phosphorus) by biological processes. Concerns about phosphorus pollution must consider both dissolved and particulate phosphorus.

The form of nitrogen is important to its effects on water quality. Nitrate is plant available, very soluble, and very mobile. Ammonia is limitedly available to plants, sorbed to soil, and converts readily to nitrate for plant use. Nitrite is a mobile, short-lived product of the transition between ammonia and nitrate. Where present and in sufficient concentration, it is reactive and biologically active. Organic nitrogen forms are

not usually and directly available for plant use. They are converted to available forms microbiologically. The rate of conversion is such that polluting concentrations are seldom attained from this pathway alone. The ability of a nutrient to become a pollutant depends on its form during the processes of availability, detachment, transport, and integration into receiving streams. Available nutrients are needed in the earth-water-plant system. More plant available nutrients are added such as by fertilizer when we modify the growth system to increase agricultural production. Soluble forms of the nutrient leave their source sites by dissolving in water and traveling downstream in solution. Forms of the nutrient which are attached to the soil such as organic material must be detached by erosion and move with their host. Nutrient transportation, whether attached or dissolved, is by water. Nutrient effects on water depend on their form as they move to and through the fluvial system to a deposition location. Sediment particles containing attached nutrients may be trapped enroute by water bodies or vegetation. Dissolved nutrients may be retained in a water body for a particular residence time before reaching a final destination. The biological communities in these water bodies respond to the presence of the nutrient.

There is an opportunity for use and control of nutrients at each point in these processes of availability, detachment, transport, and integration. Management, vegetative, and structural practices are all used throughout these processes to prevent the nutrients required for good agricultural production from becoming a water pollutant.

Fertilizer management is a practice by which the optimum amount of nutrients are provided the plant without wastage and at the time that they are needed. This practice includes managing the amount, method, type of application, and type of fertilizer. The amount of fertilizer used should cause optimum plant growth for the least cost. This cost is not only for the material but also for its application. Nutrient needs are based on soil capability, crop use, soil moisture, and present fertility. These needs should be established through soil testing and experience. Only the amount of nutrients needed to meet yield goals should be applied because excess leads to pollution. Computer modeling results indicate that losses of nitrate-nitrogen were increased 70 percent when the amount applied was twice that required (Robillard, Paul D., M.F. Walter, and L.M. Bruckner, 1981, "A Planning Guide for the Evaluation of Agricultural Nonpoint Source Water Quality Control." Final project report R804925101. U.S. Environmental Protection Agency, Athens, Georgia). Such nutrient losses have both economic and water quality consequences.

The method of application is important in fertilizer management because it relates to the amount of soluble nitrogen that could be removed from the soil by solution and subsequent transfer in runoff. The depth of soil that reacts with runoff is usually less than 1 cm (Logan, Terry J. and John R. Adams, 1981, "The effects of Reduced Tillage on Phosphate Transport from Ag. Land Lake Erie Waste Water Management Study" and Ahuja, L.R., and O.R. Lehman, (1983)--Journal of Environmental Quality, Volume 12,

No. 1). Therefore, the incorporation of the fertilizer into the soil would minimize the amount of nutrients available for removal either by runoff or attached to eroded soil because they are in the root zone.

The timing of the application is part of management. Nutrients are needed only when desired for plant growth. Proper management places just the right amount and form of the nutrient where it is available to the plant for growth. Selection of the form, method, and timing of nitrogen application are all parts of the management considerations. Early applications of a soluble nitrogen (nitrate) fertilizer can be leached to groundwater or transported on solution during runoff before the plant can use them. Incorporation of plant available nutrients will usually minimize losses, especially if the application is split into the root zone where the plant can easily use them. It prevents accumulation of large amounts of nutrients at the soil surface where it may be lost to runoff. Split applications minimize the amount of nutrients available for loss at any one time but makes them available during the growing season.

Incorporation can't be used with some crop and tillage combinations; and a mobile, available nutrient form is required to meet fertility requirements. When this form is used, timing the application to apply only the needed amount at time of plant use is desirable. This optimizes the amount available to the plant but minimizes the amount that can be lost to become a water pollutant.

Nutrient management can also be part of a program of irrigation water conservation. The amount of nitrogen can be applied through the system to provide for plant growth without causing excessive leaching to groundwater or loss in runoff, or with sediment. Soil moisture control through irrigation permits management of fertilizers for optimal growth and minimum pollution. It allows opportunities to manage the application time and form of nutrient.

Many vegetative practices are effective in reducing losses of dissolved and particulate (solid phase) nutrients. They prevent detachment and transport as well as increase infiltration rates to limit runoff and prevent erosion.

Conservation cropping systems (crop rotations) make use of changes in both availability and detachment processes to affect water quality. Multiple crops in sequence improve soil structure and increase the potential for infiltration. They provide a more stable cover to retard the detachment of soil particles having attached nutrients. Legumes may be used in the rotation to minimize applied chemical fertilization. Legumes and grasses are also green manures that provide nutrients in less mobile forms that convert to available forms for crop use. Model studies show that reductions in nitrogen and phosphorus movement from fields by using this practice may be reduced 25 to 80 percent depending on the type and form of nutrient (Robillard et al., 1981).

Cover crops may be used to consume available nutrients to prevent loss before periods of cash crop growth. The cover crop is then

converted from organic to available forms later when crops are grown. The cover crop also provides protection to reduce the erosion of nutrient-bearing soil.

Conservation tillage systems produce various effects depending on the degree of land disturbance and the amount of residue on the soil surface. These effects vary with the type of tillage equipment used and the extent the soil is worked. They also depend on the chemical programs used as part of the production method. The increased amount of residue on the surface and degree of surface roughness affect the amount of surface water storage and the rate and amount of infiltration. These hydrologic changes decrease runoff with its dissolved nutrients and the amount of erosion of nutrient-bearing soils.

Residue left on the field supplies organic nutrients which slowly break down into available forms. Methods that minimize tillage may reduce the amount of nutrient brought to the root zone and the chance for loss of the dissolved forms increases. When tillage is minimized, erosion is sharply reduced; but runoff may not be proportionally lessened. The runoff is able to pick up dissolved phosphorus without the buffering effect of the sediment. In that way a greater amount of biologically reactive phosphorus becomes available to the water environment (Logan and Adams, 1981). Availability of the dissolved phosphorus is also increased, especially for no-till systems, because the nutrient form used is generally water soluble and surface applied. Where fertilizer encounters soil, much of it becomes attached and may become unavailable to the plant (Logan and Adams, 1981). The great amount of surface residue limits the opportunity for fertilizer-soil contact. In addition the residue itself is a source of nitrogen and phosphorus that adds to the total nutrient pool. In time some of these organic nutrients will be converted to available forms. This larger amount of mobile, available nutrients from the surface applied fertilizer and residue becomes available for transport downstream to aquatic communities through runoff. If nutrient pollution, especially from dissolved phosphorus, is potentially a problem, limited tillage by itself may not provide the best overall solution. However, total phosphorus, dissolved and particulate phosphorus combined, will be reduced. Methods of placing the fertilizer within the root zone of the soil are needed to avoid the loss of the dissolved materials in runoff.

Vegetation in field borders, filter strips, and strip cropping also reduces nutrient pollution because it lessens detachment and interrupts transport. The more stable cover reduces the opportunity for erosion which prevents the movement of nutrient with the soil. The vegetated areas also use the trapped nutrients to stimulate their own growth. They are temporary nutrient sinks until harvested for forage or die back at the end of the growing season. The die-back period may release dissolved nutrients more slowly to the streams through runoff, but it generally occurs at a time of year when contributions from other sources have diminished. It may also delay cultural man-induced eutrophication of the water bodies until period of peak recreation are past.

Structural practice such as ponds, terraces, and water-and-sediment control basins interrupt nutrient transport. The interruption provides an increased residence time for the waters on the land surface. There it provides an opportunity for infiltration into the soil or use by biological communities. These structures also trap sediment particles that carry attached nutrients. Increased infiltration can result in a greater quantity of nutrient leaching to groundwater. Structural practices can produce very effective reductions in movement of both dissolved and particulate nutrients.

Available nutrients trapped in water bodies such as lakes or ponds become available to their biologic systems. The bioavailable nutrient forms stimulate plant growth that removes the nutrients from the water, although producing significant organic matter. This growth could itself be a pollutant. Harvest of this organic growth removes the nutrients from the aquatic environment, and they can be recycled as a fertilizer. In most of the nation, dissolved phosphorus is the key growth stimulant although available forms of nitrogen can be limiting in some areas.

Phosphorus from municipal waste systems is a dominant point source because almost all is converted to bioavailable forms (Black, A., 1980, "Experience with phosphorus removal of existing Ontario municipal waste water treatment plants, " pp. 329-353 in R. C. Loehr et al. (ed.). Phosphorus management strategy for lake, Ann Arbor Science, Ann Arbor, MI). Inorganic fertilizers are probably the dominant nonpoint source of dissolved phosphorus is estimated to be particulate. The volumes of sediment by source and the efficiency of ways to control phosphorus from any source (Sonzogni, W. C., Chapra, S.C., Armstron, D.E. and Logan, T.J. 1982--Bioavailability of phosphorus inputs to Lakes, Journal of Environmental Quality, volume 11, No. 4). Also important are the characteristics of receiving waters with regard to their ability to react to aquatic communities. Deep reservoirs are usually more effective traps for particulate phosphorus than shallow ponds that offer opportunity for reentrainment of phosphorus into their waters.

The integration of nutrients into receiving streams can cause pollution. The great loads associated with nonpoint agricultural sources generally preclude any opportunity for dilution to be an effective process in extensive agricultural areas. However, the consumption of nutrients by the biological communities can result in cleanup of downstream waters. This natural process has a finite capacity to keep water quality acceptable.

POLICIES: Nutrients (Nitrates), Pesticides, Chemicals

The following policies are established as on-going procedures and objectives of the District's management of groundwater as pertaining to Nutrients (Nitrates), Pesticides, and Chemicals. The extent and scope of each is to be carried out subject to legislative authorization, promulgated rules and regulations, financial capability, and/or available personnel and resources.

1. Continue to emphasize and expand an educational program to promote voluntary use of agricultural best management practices and provide information on the effectiveness, cost, and selection of these practices. This program would be revised as necessary and continued as a long-term effort.

BEST MANAGEMENT PRACTICES

Pesticides

a. Use less pesticide -- if less pesticide is used, less is available as a pollutant.

b. Use a lower persistence pesticide -- the longer the time required to degrade, the longer the pesticide is toxic at a high rate.

c. Use a lower toxicity pesticide.

d. Incorporate the pesticide when feasible. Incorporation leaves the pesticide less available to be detached and removed over the surface, either attached to soil particles or dissolved in the runoff waters.

e. Install conservation practices such as waterways, grass filter areas, etc., to reduce runoff water velocity.

f. Use biological control where possible to suppress pest problems such as insect parasites and predators to decrease size of pest problems sometimes to the point where pesticide applications are not needed.

g. Use cultural control which involves the physical alteration of the crop ecosystem such as changing the planting and harvesting dates. The planting and harvesting dates are often changed in conjunction with altering irrigation schedules and selecting plant varieties. Crop varieties with shorter maturity periods can significantly reduce the need for insecticides. Crop rotation may also be used since many pests require the continuous presence of the host crop to complete their life cycle.

h. Crop selection is a successful procedure to reduce the use of pesticides through the use of pest resistant plant varieties.

i. Timing of pesticide application will be important when avoiding windy conditions and applying just before a rain. Application should be delayed until a more complete crop canopy develops whenever this is possible.

j. Containers should be triple rinsed into the sprayer and then disposed of in one of the following ways:

1. Place in an approved sanitary landfill.
2. Bury singly on site as regulations allow.
3. Burn containers
4. Return empty, rinsed containers to pesticide manufacturers.

k. Structural practices are quite effective in trapping absorbed pesticides such as:

1. Sediment basins built to remove sediment from runoff. All pesticides absorbed to sands and to most silts will be trapped. Pesticides absorbed to clay particles will probably not be trapped unless the residence time is quite long.

2. Terraces not only control erosion by reducing the length of slope but also reduce the flow velocity, thus trapping sediment and absorbed pollutants. If terraces with underground outlets are used, 90 percent or more of the sediment reaching the channel is trapped. Very little of the soluble fraction of the pesticide would be trapped, however.

<u>Nutrients</u> (Ammonia, Nitrate, & Nitrite)

a. Fertilizer management

1. Apply the proper amount
2. Apply the proper type
3. Apply at the right place (incorporate)
4. Apply at the right time

b. Use legumes and grasses in rotation.

c. Use cover and green manure crops.

d. Design and develop adequate structured methods along with proper management of animal wastes.

e. Develop conservation systems to reduce erosion and runoff of nutrients.

f. Construct structural improvements such as water and sediment control basins.

g. Apply conservation practices of terraces and waterways on erodible land.

2. Encourage support and cooperation of the Department of Environmental Control to assist in implementing educational programs to promote consideration of water quality programs to urban and rural groundwater users to reduce groundwater pollution.

3. Support legislation to require backflow preventative devices on groundwater irrigation systems through which fertilizers and pesticides are applied. Legislation (Chemigation Act) under consideration should be enacted and implemented by the

District with required assistance from the Department of Environmental Control.

4. Encourage authorization to allow Nebraska State Laboratory facilities to be available on a "no-charge" basis for analysis of water samples to determine chemical pollutants.

5. Strongly encourage the Department of Environmental Control to implement protective measures such as use restrictions on pesticides classified as having "unacceptably high potential" for contamination under ordinary usage.

6. Encourage the Department of Environmental Control to establish pesticide product registration requirements reporting requirements on those products having significant effects upon groundwater contamination in critical areas such as groundwater quality control areas.

7. Encourage the Department of Environmental Control to establish and implement regulations on fertilizer applicator certification within groundwater quality control areas to include training and guidance on fertilizer usage by the University of Nebraska Extension Service.

8. Request the Department of Environmental Control to assist the District in developing and implementing ambient groundwater quality monitoring system based upon sale and use information, cropping patterns, presence of nitrate sources, and area physical land and water characteristics.

When the District determines that stringent policies need to be applied to correct problems adversely affecting reservoir life goals and acceptable state water quality standards, the following policies may be applied as allowed by legislation, rules and regulations, and other means.

1. Encourage state statues to be modified to provide the District to establish groundwater quality control areas if groundwater quality parameters approach or exceed recommended safe drinking water limits. The procedure for the establishment of groundwater quality control areas within the District should be similar to the procedure for establishment of groundwater quantity control areas provided in the Groundwater Management Act. A program to monitor the groundwater quality in a control area would be established. Within the defined areas, the use of irrigation water and to some extent the use of fertilizer, pesticides, and other chemicals could be regulated. These regulations could include one or more of the following provisions:

   a. Permits for the installation of any new irrigation systems, including the construction of new wells to meet well drilling specifications

   b. Meters or other measuring devices on groundwater wells and stream diversions

   c. Well spacing requirements

d. Limits on the total amount of irrigation water applied

e. Limits on the length of fields served by gravity irrigation systems

f. Minimum standards for irrigation systems

g. A requirement that each irrigator complete an acceptable training course on irrigation scheduling

h. A requirement that each irrigator in the area purchase and use soil moisture measuring equipment

i. A requirement that each irrigator implement an irrigation scheduling program that will to the extent possible schedule the application of water in amounts which will not move below the root zone

j. Restrictions on the application of nitrates or other chemicals of particular concern during the fall and winter months

k. A requirement that the District provide each landowner or operator with copies of current University of Nebraska fertilizer guidesheets

2. When the District has determined from reports of the Nebraska Department of Health that an urban community has unsafe drinking water due to chemicals such as nitrates (nutrients) or other chemicals, the District will

a. Assist in determining point sources of the pollutant by developing a procedure of data collection, visual observation, and other means to determine origin of pollutants.

b. Assist urban communities and rural water districts in selection of alternative for new sources of safe drinking water.

c. Assist in coordinating efforts between agencies, political subdivisions such as communities, rural water districts, and others to cooperate in merging water systems and other alternatives to provide safe drinking water.

AGRICULTURAL WATER USE EFFICIENCY

Agricultural water use efficiency techniques are designed to increase the efficiency with which both precipitation and irrigation water are used. Improved water use efficiency does not always mean a corresponding reduction in withdrawal of groundwater. Water which is "saved" on one field, for instance, can sometimes be used to irrigate another field. A reduction in withdrawal can, however, mean a local, on-site water savings and result in less water used.

Agricultural techniques designed to increase efficiency of water used include:

Reuse Systems - Reuse pits are generally used on groundwater irrigated lands to capture water which would otherwise run off the end of a field. The system usually consists of a pit or collection reservoir located below the irrigated area, a pump, and a pipeline to deliver water either back to the distribution system or to irrigate additional lands.

Land Shaping - Land shaping is a technique to reshape the surface of a field to either control or increase the water flow. It can involve increasing slopes, flattening slopes, or the construction of terraces, grassed waterways, or other conservation structures.

Shorter Rows - By shortening the length of run, less water need be applied with each irrigation due to a reduction in infiltration at the top of the field.

Irrigation Scheduling - Irrigation scheduling is the practice of determining as accurately as possible the precise water needs of a crop and then controlling the amount and timing of water application to meet those needs without overwatering. Irrigation scheduling does not employ deficit irrigation, that is, applying less water than the crop requires.

Flow Management - Flow management devices can be used to control and measure the amount of water delivered and applied to a field. Examples of farm water control and regulating structures are checks, drops, divider boxes, and reservoirs. Examples of flow measurement devices include Parshall flume wiers, orifice plates, and flow meters.

Residue Management - Residue management involves the use of tillage practices which leave residue on the land surface or in some cases the application of mulches onto the land surface.

System Modification - System modification refers to changes made within existing irrigation systems to improve the efficiency of those systems.

System Conversion - System conversion refers to changing from one irrigation system to other. The two main methods of irrigation application in the Nemaha NRD are gravity flow and sprinkler. Other methods include drip, subsurface, and drop nozzle systems.

Windbreaks - Windbreaks are designed to minimize the effects of the wind on crops. They generally include trees planted in rows or strips of annual grass. Wind shelter can significantly reduce ET, especially during periods of strong winds accompanied by warm temperatures. Also soil moisture in the spring may be increased because of captured snow.

Alternative Cropping and Hybrid Selection - Alternative cropping involves the use of a crop type with a lower ET (evaporation/transpiration) requirement than other crops. Hybrid selection refers to choosing a less water intensive variety of the same crop.

POLICIES: AGRICULTURAL WATER USE EFFICIENCY

The following policies are established as on-going procedures and objectives of the District's management of groundwater. The extent and scope of each is to be carried out subject to enacted legislation, financial capability, and required personnel.

1. Encourage state, federal, and others to increase and expand research and educational efforts related to improving water efficiency. This policy would enable the development of new techniques and the refinement of existing techniques through research and promote the adoption of existing education and demonstration programs.

2. The NRD may provide either economic incentives for installing efficient water use techniques or disincentives for excessive use of water. Water use efficiency practices available for cost-share financial incentives include reuse pits, terrace construction, windbreaks, water impoundments for purpose of recharge and irrigation, and land shaping.

3. The Nebraska Soil & Water Conservation Program (SWCP) provides additional financial support to the NRD with funds appropriated by the Legislature to financially assist in encouraging water and related land resource conservation measures on privately owned land. This fund administered by the Natural Resources Commission permits landowners working with the Nemaha NRD to receive up to 75 percent cost sharing on eligible soil and water conservation practices. In conjunction with Policy 2, the NRD may designate a portion of or all available cost-share incentive funds to be dedicated to funding more water use efficiency practices. The environmental impacts of implementing this policy would be variable. In areas where overland runoff is the primary source of stream flow, water quality may be improved although the total stream volume may be diminished. There may be a greater potential for stream bank erosion because reduced sediment loads increase the potential energy of the stream flow. If windbreaks are planted, habitat diversity will increase.

4. Investigate artesion flow systems to determine minimum flow requirement and methods to restrict flows of those systems not used for beneficial purposes.

When the District determines stringent policies need to be applied to correct problems adversely affecting reservoir life goals, the following water use efficiency policies may be applied as allowed by legislation, rules and regulations, and other means.

1. Groundwater Management and Protection Areas - Establish groundwater control areas pursuant to Section 46-656 to 46-674.01 R.R.S., Nebraska Statutes, when the District has determined following evaluation of relevant hydrologic and water quality data, history of developments, projection of effects of current and new development, that the reservoir life goals are adversely impacted by withdrawal of groundwater for agricultural irrigation purposes and that there is inadequate groundwater supply to meet present or reasonably foreseeable needs for beneficial uses of such water supply. In addition the District may consider such action when it has determined a dewatering of an aquifer resulting in a deterioration of the quality of such groundwater sufficient to make such groundwater unsuitable for the present purposes for which it is being utilized or pollution of groundwater has occurred or is likely to occur in the reasonably foreseeable future.

   Pursuant to the establishment of a groundwater control area, the District shall by order adopt one or more of the following controls for the control area:

   (a) It may determine the permissible total withdrawal of groundwater for each day, month, or year and allocate such withdrawal among the groundwater users;

   (b) It may adopt a system of rotation for use of groundwater;

   (c) It may adopt well spacing requirements more restrictive than those found in Sections 46-609 and 46-651;

   (d) It may require the installation of devices for measuring groundwater withdrawals from wells;

   (e) It may require water users to implement irrigation scheduling programs to schedule to the extent reasonably possible the application of water in amounts which will not move below the root zone; and

   (f) It may adopt such other reasonable regulations as are necessary to carry out the intent of this act.

AGRICULTURAL RUNOFF

Nonpoint Sources

Pollutant contributions by nonpoint sources are usually highly correlated with precipitation events, especially high intensity rainfall and snow melts. The potential impact of nonpoint sources becomes even more significant when precipitation is an average of 5.29 inches above normal throughout the basin, as was true in the Nemaha Basin during 1977 (Table 2).

Sediment is the primary pollutant related to agricultural runoff. Through the physical process of water erosion, soil particles are dislodged and transported by water with a fraction of the particles reaching surface waters and being subsequently identified as sediment. Sediment can interfere with the feeding and reproduction of aquatic organisms. It can reduce light penetration into the surface water thereby disrupting the photosynthetic process and reducing vegetative and oxygen production. It can also cause a scouring effect which can damage aquatic plants and organisms existing in a stream. Sediment also acts as a transportation medium for pesticides and fertilizer nutrients that become attached to the soil particles. These chemicals can make the water unfit for its intended uses. Sediment can also reduce the hydraulic efficiency of a stream and increase its potential for flooding.

In the District sediment affects water quality in almost all areas. The problems vary in kind and severity depending on the soil type, precipitation, type of stream affected, land use near the stream, and the various uses made of the water itself. These problems will continue.

The two predominant agricultural land uses which occur within the Nemaha Basin are cropland (70 percent of total land area) and rangeland or pasture (17 percent of total land area). The majority of the range, pasture, and cropland (48 percent) have not been adequately treated to prevent soil loss or sediment yield to the streams. Soil losses from the basin's croplands average 8.9 tons/acre/year, whereas losses from pasture and rangeland are 3.7 tons/acre/year. The State Erosion Hazard Map shows soil loss potential of Basin uplands is greater than 25 tons/acre/year while in the valley bottomlands the soil loss potential is less than 5 tons/acre/year. Soil conservation needs data show that 11 percent of the basin's soil loss occurs on Class II land, 64 percent on Class III land, 16 percent on Class IV land, and 8 percent on Class VI lands. (Numeric values from the Nemaha Basin 208 Nonpoint Source Fact Sheet, March, 1978).

Agricultural runoff is a source of water pollution, especially when consideration is given to the intensive agricultural practices and development of new croplands. Frequently, this cropland development results in the conversion from dryland farming or rangeland into center pivot systems used for row crops. In many instances, this development has occurred on marginal lands where "Best Management Practices" have not been utilized.

In addition to the concern of sediment loading in streams is the potential impact of agricultural chemicals (pesticides, herbicides, etc.) which may adhere to soil particles and likewise degrade the water quality.

POLICIES: AGRICULTURAL RUNOFF

The following policies are established as on-going procedures and objectives of the District's management of groundwater as related to Agricultural Runoff. The extent and scope of each is to be carried out subject to legislative authorization, promulgated rules and regulations, financial capability, and/or available personnel and resources.

1. Continue to emphasize and expand an educational program to promote voluntary use of best management practices to include:

   a. Conservation tillage
   b. Construction of siltation traps on grade stabilization structures
   c. Development of windbreaks
   d. Incorporation of crop rotation systems
   e. Contour farming practices
   f. Conservation cropping systems
   g. Installation of underground outlets
   h. Development of grass waterways
   i. Establishment or maintenance of filter strips
   j. Crop residual management
   k. Maintaining and developing permanent vegetative cover

2. Promote Special Project Areas within the hydrological boundaries of the following identified watersheds:

   a. Squaw-Camp Creek Watershed
   b. Upper Little Nemaha Watershed
   c. Middle Big Nemaha Watershed
   d. Turkey Creek Watershed
   e. Lower Little Nemaha Watershed
   f. Big Muddy Watershed
   g. Lower Big Nemaha Watershed
   h. Peru-Brownville Watershed

   This concentrated effort to promote the application of best management practices would be of great benefit to water quality by increasing the amount of land treated in these high need areas. The implementation would rely upon available PL566 Small Watershed Program funding as well as State funding.

3. Encourage use of "Sodbuster Bill" to provide a disincentive to landowners to plow highly erodible land that should remain in permanent vegetative cover to reduce erosion runoff.

4. Encourage authorization for the NRD to require conservation planning and implementation in water quality problem areas upon guarantee of 75 percent cost-share and establish State cost-share fund for practices needed to protect surface and

groundwater from pollution due to agricultural activities. This policy objective would be based upon the District identifying areas which would be confirmed by the Department of Environmental Control to have specific water pollution problems. Within these areas landowners or operators would receive 75 percent of actual costs to apply conservation practices to protect surface and groundwater as identified in a required conservation plan.

5. Seek authorization for implementation of a Sediment and Erosion Control Act as considered by the Legislature in the form of LB474 (1985). The bill as proposed would provide the Director of Natural Resources would assist the Natural Resources Commission and other state and federal agencies and require the program to be carried out by the NRD's. The State would develop guidelines to consider of conservation standards for various soils and land uses including criteria, techniques, and methods for the control of erosion and sediment. The NRD would establish a soil loss limit and develop a program to include promulgating rules and regulations to require landowners to employ soil and water conservation practices and bring soil losses to tolerable levels. The regulatory action would be initiated by a written complaint from a landowner or occupant being damaged by sediment or by the NRD itself if a watershed or flood control structure was being damaged by sediment. Once the complaint was received and notice to the landowner, the NRD would inspect the land to gather evidence on whether the District's soil loss limits were being violated. If after a hearing the Board of Directors determined there was a violation, it could order the landowner to take appropriate action to correct the problem. If the plan required construction projects involving the removal of vegetative cover, the violator would have five days to commence work on remedial measures and 30 days to complete the work. The violator would also have six months to commence work and one year to complete implementation of necessary practices. Variances in these time limits could be obtained from the NRD Board if the work could not be performed due to reasons beyond control of the landowner. Cost-share is available from the Soil and Water Conservation Fund, which would have to set aside five percent of its total fund for these purposes. The landowner would have access to 75 percent cost-share assistance and technical assistance in implementing the plan. There are various appeal processes available to the landowner, and the NRD could take action in court if any landowner failed to implement conservation practices.

IRRIGATION RETURN FLOWS

Irrigation return flows include water diverted from a stream to irrigate cropland that returns to a stream or seeps to the groundwater aquifer and excess well irrigation water that flows to a stream or seeps into the groundwater aquifer. Salts, nutrients, pesticides, sediment, bacteria, and floating debris may be contained in surface return flows in greater concentrations than the original water supply. These materials can affect surface water usage in many ways. Drainage water that moves through the soil profile may contain higher concentrations of salts and nutrients and pesticides than in the original water supply. It should be pointed out, however, that irrigation return flows have become an expected water source for some uses.

Irrigation development within the District has continually increased. A reported 26,000 acres (1.5 percent of land area) were irrigated in 1976. As of October, 1985, approximately 268 irrigation wells had been registered in the District with an undetermined number of acres of land irrigated each year from surface water sources of the Nemaha River and its tributaries.

County	# of Registered Irrigation Wells
Johnson County	119
Otoe County*	30
Gage County*	30
Lancaster County*	37
Nemaha County	33
Richardson County	17
Pawnee County*	2
Cass County*	0

* Only a portion of County within Nemaha NRD

The impacts of the resulting irrigation return flows have not been quantified. However, the potential for water pollution exists and is of major concern to not only surface water in the form of sediment, nutrients, salts, and pesticides, but also through percolation and leaching of nitrates, salts, and pesticides into groundwater.

POLICIES: IRRIGATION RETURN FLOWS

The following policies are established as on-going procedures and objectives of the District's management of groundwater as related to Irrigation Return Flows. The extent and scope of each is to be carried out subject to required legislative authorization, promulgated rules and regulations, financial capability, and/or available personnel and resources.

1. Encourage the cooperation of the Department of Environmental Control and the University of Nebraska to assist the District in an expanded educational program to promote the voluntary use of best management practices to include effectiveness, cost, and alternatives to allow for irrigation return flows which do not degrade groundwater quality.

2. Encourage legislation which would regulate return flows from surface water which would increase pollution of the groundwater through the build-up of chemicals.

3. Seek legislation which would require a permit for drilling an irrigation well. Such legislation should require the denial of a permit if it is determined that the irrigation development would adversely affect surface water quality because of increased erosion or would adversely affect groundwater quality because of anticipated leaching of chemicals. When such adverse effects could be eliminated by management practices, the permit could be issued but could establish conditions for the development and operation of the irrigation system.

4. Continue implementing District rules and regulations for runoff controls for groundwater irrigation. These rules and regulations allow for reduced groundwater withdrawals for irrigation by preventing irrigation tail water runoff and requiring reuse of irrigation tailwater. The runoff controls are administered on a complaint basis. A landowner may notify the District of irrigation runoff coming onto his land. The District will check to verify whether improper irrigation runoff has occurred. If so, the District will notify the irrigator that he has violated runoff regulations. The irrigator is given an opportunity to make corrective action such as constructing an irrigation reuse pit or other means. If the irrigator refuses to cooperate, the District, after a hearing has been held to determine whether runoff regulations have been violated, can issue a cease and desist order. If the irrigator refuses to comply, the cease and desist order can be enforced by court action.

When the District determines stringent policies need to be applied to correct problems adversely affecting reservoir life goals and water quality standards, the following Irrigation Return Flows policies may be applied as allowed by legislation, rules and regulations, and other means.

1. Establishment of Groundwater Management and Protection Areas as described as a stringent policy in Agricultural Water Use Efficiency will permit the implementation of controls to reduce or eliminate irrigation runoff wastes.

ANIMAL WASTES

Animal wastes which enter our waterways have been rightly described as "a resource out of place." Since livestock and poultry wastes can have a number of beneficial uses ranging from fertilizer to energy production, they deserve to be considered a resource. Their role as a resource is lost, however, when they are allowed to move into streams, lakes, and other waterbodies. At that point the resource becomes a bona fide waste.

It is important for us to recognize that more than half of all the livestock wastes produced each year are not being recovered and utilized as a resource. In fact the wastes from more than half our farm animals, particularly those on pasture and rangeland, cannot be effectively recovered. These wastes are classed as economically non-recoverable.

With this fact in mind, we approach the question of how to control animal waste pollution from the standpoint of the type of waste involved -- that is, recoverable or non-recoverable. For the purpose of simplicity, we will consider the economically recoverable and non-recoverable wastes to be, respectively, those from confined animals and those from animals on pasture or rangeland.

A word of caution is needed, however, before proceeding. Although the wastes from all pastured and rangeland animals are considered to be economically non-recoverable, the wastes from some small confinement operations may also fit into this category. For such operations the annualized costs for waste management, including the costs for equipment, maintenance, labor, etc., would not exceed the annual value of the manure as fertilizer -- or its value for any other beneficial use. Nevertheless, controls for all confinement operations will be discussed together regardless of the economic recoverability of the wastes.

Pollution control should be an integral part of every waste management plan. Sometimes the control practices will be incidental to other parts of the plan; at other times they may be the only elements involved. Regardless of their importance relative to other components, practices for pollution control are an essential part of every waste management plan.

Whether the animals are in confinement or on pasture, a number of practices are available to control pollution. These can generally be classed as structural, vegetative, and management practices.

PASTURED ANIMALS (NON-RECOVERABLE WASTES)

Pastured animals can seriously affect water quality, especially when the animals have direct access to a stream or other waterbody. To reduce or prevent pollution, the owner has three broad options: (1) he can completely remove the animals from the affected watershed (totally preventing availability of the wastes for pollution); (2) he can place the animals in confinement so the wastes can be collected and appropriately utilized; or (3) he

can prevent the animals from having access to the affected water body and then control any polluted runoff.

Option No. 1 may be required for especially sensitive waters such as those designated as Wild and Scenic Rivers, etc. But this option is usually unnecessary.

Option No. 2 provides the owner better control over the wastes and allows him to utilize it as a resource. Once removed from pasture, a different approach to pollution control is required as discussed in the next section on confined animals.

Option No. 3, sometimes called livestock exclusion, may be the most practical. A number of specific practices or combinations of practices are available to properly exercise this option.

The objectives of livestock exclusion are twofold; the first is to prevent deposition of the wastes directly into or near the water; the second is to interrupt or extend the transport process allowing time for pollutants to settle, volatilize, or infiltrate into the soil. It would be difficult to prevent detachment of wastes which are spread diffusely over the landscape and which are so exposed to rainfall and runoff. Likewise, preventing availability would be virtually impossible for pastured animals except by employing Option 1. Thus the practices selected for livestock exclusion will usually focus on the principle of interrupting the transport process. Some specific practices are noted below:

<u>Fencing and Filters</u>: Fencing livestock out of a stream or other waterbodies is an effective way to reduce pollution. However, fencing should be used in combination with a grass filter to be most effective. The filter includes both the soil matrix and a healthy stand of vegetation. Together they provide for the settling of pollutants onto the soil surface as the grass slows runoff; infiltration of soluble substances and bacteria into the soil profile; screening or filtering of bacteria within the top few inches of soil; uptake of nutrients by the grass; adsorption of phosphorus and ammonia onto; volatilization of certain compounds such as ammonia and sulfur; and denitrification of NO3 when the soil is saturated.

Grass filters 10 to 25 feet wide on flat slopes; and sandy soils can reduce nitrogen, phosphorus, suspended solids, and fecal coliform concentrations to levels typical of those in runoff from grassland or cropland. Filter strips on steeper slopes and tighter soils may require a much greater width to accomplish the same results. In some cases a serpentine waterway or switch back terrace may be used to provide the needed treatment and to carry the polluted water safely down a hillside. However, as a general rule wastewaters released over a broad area through a narrow strip are usually treated more effectively than those which pass through a long narrow waterway.

In either case maintenance of the filter is important. Grass should be cut and removed on a regular basis. This will promote the uptake of more water and nutrients. Vegetation that is cut and allowed to lay on the filter will decay and add nutrients to

the runoff water. In addition the filter should not be allowed to develop rills or channels; these allow untreated wastewater to shortcut the filtering mechanisms.

Rotational Grazing: This is an important management practice which is effective in reducing pollution. Continuous grazing reduces the vegetative cover. Consequently, more polluted runoff is transported off the field without benefit of the interruptions and subsequent treatment provided by the grass.

Settling Basins: In some situations a settling basin can be appropriately placed to collect polluted runoff. This practice may be used where the animal density is relatively high and the existing pasture grass fairly sparse. This situation may occur where rotational grazing is not used.

In addition to the pond-type settling basin, other less traditional settling basins can be used. For instance, a storage terrace with underground outlet could be used to provide settling of solids and dewatering.

Transport Extenders: The term "transport extenders" refers to those practices that extend the distance between the waste source and the waters that are being protected. They include practices which encourage livestock to congregate as far from the waterbody as possible. Feed bunkers, watering points, and shade areas are examples of places where livestock congregate.

If livestock are excluded from a natural waterbody, a source of drinking water is necessary. Spring development, pumping from the stream, and windmills have been used to provide the necessary water. Placing the watering point and all other transport extenders as far from the waterbody as possible will help prevent pollution from non-recoverable wastes.

CONFINED ANIMALS (RECOVERABLE WASTES)

Confined animal feeding operations include feedlots, hog houses, poultry buildings, and the like. These operations differ in many ways besides just in the type of animals involved. Hog facilities can include buildings with totally slatted or partially slatted floors over a pit or a lagoon, open concrete lots with partial cover, waste flushing systems, recycling of flush water from a lagoon, scraping and hand washing, etc. But all confinement facilities have three major elements in common. These are (1) collection, (2) treatment or storage, and (3) land application. Water pollution can occur at any of the points in the system.

Collection

Wastes are collected in a number of ways. Scraping, washing with a hose, and automatic flushing are common methods of collecting wastes. On open lots rainfall becomes an important part of collection.

The key to controlling pollution at the collection point is in controlling all sources of unnecessary clean water. This can be accomplished with structural and management practices; some examples are listed below:

Management Practices

-- Reduce the volume of water used in hose-washing operations

-- Reduce the flow to automatic flushing devices (i.e., tipping buckets, automatic siphons, etc.)

-- Recycle wastewater as flushwater in certain situations

-- Control leaking or ineffective waterers and misters

Structural Practices

-- Use diversions, waterways, etc., to divert the runoff from outside drainage areas away from areas contaminated with manure

-- Use gutters and downspouts to divert roof water away

Treatment or Storage

Waste treatment and waste storage have two distinctly different purposes, although a single waste management system could have both practices. The differences between the two systems should be clearly understood since a poor choice could add to water quality problems.

1. Waste Treatment

The purpose of waste treatment is to reduce the concentrations of nutrients and other potential pollutants. The principal mechanisms for accomplishing these reductions include settling, biochemical oxidation and reduction, volatilization, and detention. Other mechanisms are also involved when land application is part of the treatment system. These mechanisms will be discussed under Land Application.

Waste may be treated with lagoons, settling basins, grass filters, composting, and various modifications and combinations of these practices. The lagoon, however, has been the mainstay of most treatment systems.

The following is a brief discussion of the treatment mechanisms which occur in a lagoon:

a. Settling - Manure that is more dense than water will settle to the bottom of the lagoon, thereby, reducing the concentration of total suspended solids in the lagoon effluent. Not all animal wastes settle at the same rates. A large portion of swine wastes will remain suspended in the lagoon supernatant. The wastes from dairy and beef cattle may have both settleable and floating matter. Dairy wastes with a lot of bedding will often form floating mats which create problems when the lagoon is pumped out.

Settling accounts for large reductions in phosphorus and potassium. Aproximately 80 to 90 percent of the phosphorus and 60 to 70 percent of the potassium can be

"lost" through settling. In addition 60 to 90 percent of the nitrogen can be lost as a result of settling and volatilization.

Since the sludge layer at the bottom of the lagoon will have high concentrations of nutrients, especially phosphorus, appropriate measures should be taken to avoid disturbing the bottom sludge where a low level of nutrients is desired for land application. Extremely high levels of phosphorus can accumulate in soils where lagoon sludge is applied to the land over several years. In these instances the chance for increased levels of phosphorus in runoff also increases.

b. Biochemical oxidation and reduction - microorganisms convert various chemical compounds from one form to another. For example organic nitrogen is converted (oxidized) by bacteria to ammonia nitrogen under aerobic conditions. Under anaerobic conditions nitrate will be converted (reduced) to nitrite and N2 gas.

c. Volatilization - wastes that are driven from the liquid to the gaseous phase are said to be volatilized. Much of the waste that settles into the sludge layer is subject to being converted by bacteria to a gaseous form which can be lost to the atmosphere. A large part of the ammonia in a lagoon and that spread on the land can be volatilized. Volatile solids are generally considered to represent the organic fraction (60 to 70 percent) of total solids. A large part of the volatile solids will be converted to methane gas (CH4) and carbon dioxide (CO2).

d. Detention - This is not so much a physical or biochemical mechanism as it is the necessary ingredient which allows the other mechanisms to work. It is also the means by which fecal bacteria and pathogenic organisms are destroyed.

2. Waste Storage

Unlike waste treatment, the function of waste storage is to conserve nutrients. The destruction of any other pollutants is not a goal of waste storage.

Waste can be stored for short periods in a number of ways. Barnyard wastes may be simply stored on the open lot in a manure pile. Or the wastes may be scraped, washed, or pumped to a waste storage pond or to a concrete pit or other type of fabricated structure. The storage time will typically be from 60 to 120 days, although shorter or longer periods are often used. However, for longer detention times, the storage facility becomes more like a waste treatment lagoon in which large quantities of nitrogen are lost.

For all waste storage systems, it is assumed that all of the stored waste will be removed from the facility at specified

intervals. Therefore, the wastes will not be as subject to the loss mechanisms associated with lagoons.

3. Treatment versus Storage

Ideally, wastes should be collected and spread on the land daily to gain the maximum benefit from the manure as a resource. But daily hauling and spreading is not only impractical, it is frequently undesirable from a water quality standpoint.

Waste storage provides greater flexibility to the operator than daily spreading. In addition it provides good conservation of nutrients; that, of course, is the goal of waste storage. But maximum conservation of nutrients may not be desired if land area is inadequate to properly utilize the nutrients. If the wastes must be spread on limited acreage to a crop that cannot fully utilize the applied N, P, and K, pollution problems could easily occur. In such cases a waste treatment system may be desirable.

The choice between a waste treatment and a waste storage system will depend on other factors as well. These include such factors as manpower requirements and available labor, distance to land application sites, equipment available, and other economic factors. It also includes the desire of the operator to carry out an intensive waste utilization plan.

As mentioned earlier, resource recovery may not be economically feasible in some situations, especially for small livestock operations. In these cases the value of the manure as fertlizer is less than the costs of applying it to the land. Here a waste treatment system may be more appropriate than a full-scale waste storage system. If such is the case, an inexpensive and cost effective means must be selected for applying any excess wastewaters to the land.

The discharge of wastewaters from either waste treatment or waste storage facilities is unacceptable. The concentration of pollutants from storage facilities is generally higher than from treatment facilities; yet the concentrations of nearly all pollutants from a lagoon (the typical treatment practice) are much higher than either untreated municipal wastewater or raw domestic sewage.

Land Application

Land application usually refers to conventional practices of applying animal wastes to crops to obtain maximum beneficial use of the manure nutrients. However, land application can also include the application or discharge of wastewaters to a vegetative filter or to other vegetated areas for the primary purpose of waste disposal. In this case waste utilization or resource recovery is incidental.

A number of factors should be considered if pollution is to be controlled at conventional land application sites. These include land area, type of crop, method and timing of applications, distance between the application site and a

waterbody, soil type, land slope, and tillage methods at the site. These factors are discussed briefly below:

a. Land Area -- the size of the application site should be adequate to receive the amount of waste or wastewater applied. If land area is limited, a lagoon or other treatment system may be needed to reduce nutrient levels.

b. Type of Crop -- It is important to know the nutrient requirements of the crop receiving the wastes. The nutrient levels in the wastes should not exceed the nutrient requirements of the crop.

c. Method of Application -- wastes can be applied as solids, liquids, or slurries. They can be applied to the soil surface with no incorporation, or they can be injected below the surface or be surface applied and plowed under. Surface applications with no incorporation provide the greatest pollution hazard. If wastes are injected or plowed under, the detachment of pollutants is virtually eliminated. In addition volatilization of nitrogen is greatly reduced, thus conserving this important nutrient for plant use.

d. Time of Application -- wastes should be applied just prior to or during periods of maximum crop nutrient uptake. Grasses receiving wastes should be cut and removed regularly to encourage maximum uptake of nutrients and wastewater.

   Fall and winter applications of wastes should be discouraged. Up to 50 percent of the total nitrogen in fall-applied wastes can be lost through decomposition and leaching, and up to 86 percent of the nitrogen and 94 percent of the phosphorus applied during the winter can be lost in a single rainfall or during snowmelt.

e. Distance between Application Site and Stream -- applying wastes to fields that are as far removed from a stream as possible increases the transport process and thus helps reduce potential pollution. When the field is near a stream or waterbody, vegetative filters should be installed and the wastes incorporated into the field.

f. Soil Type -- nutrients are more easily lost from sandy soils than from clayey soils. Positively charged amonium ions (NH_4^+) readily adsorb to negatively charged sites on clay soils. A large fraction of the applied phosphorus will chemically combine with iron (Fe) and other positively charged elements normally associated clay soils; however, these interactions are a function of soil pH. On sandy soils practically all of the nitrogen can be lost within days after application due to leaching and volatilization. Therefore, wastes should be applied to crops on sandy soils only when the crops are actively growing. In addition, several small applications would be preferable to one large application.

g. Land Slope -- applying wastes to steep slopes should be avoided, especially on clay soils. Wastes applied to sloping soils should have a good vegetative cover.

h. Tillage Method -- wastes are best applied to lands having good conservation practices. Since ammonia, nitrogen, and phosphorus readily adsorb to clay particles, the loss of these nutrients in surface runoff can be reduced if good soil conservation practices are in use. If wastes must be applied to frozen ground, the land receiving the waste should be contoured and have a good cover of crop residue or mulch. The residue or mulch is more important in controlling pollution from nutrients on frozen ground than the contour plowing.

Waste can also be applied to non-conventional land application sites for the purpose of providing or extending waste treatment. These sites include filter strips at the edge of pasture, grassed waterways, switch-back terraces, and the like. Although the vegetation can be cut and utilized, crop production is not the primary function of non-conventional land application.

The Department of Environmental Control has issued 26 NPDES permits to feedlots within the Nemaha Basin which upon inspection appeared to have a pollution potential. These feedlots make up only approximately six percent of the feedlot permits issued in the State. The primary concern with confined animal lots is in regard to the number of small lots which do not have adequate management practices to prevent runoff into streams. Although the singular effect of each small operation may be minimal, the cumulative effect of all small lots when coupled with other bacteria sources may preclude the attainment of the "Swimmable" portion of the P.L. 92-500 Goal.

POLICIES: ANIMAL WASTES

The following policies are established as on-going procedures and objectives of the District's management of groundwater. The extent and scope of each is to be carried out subject to enacted legislation, financial capability, and required personnel.

1. Encourage the University of Nebraska Extension Service and USDA Soil Conservation Service to assist in the development of designs and plans for individual landowners needing to control pollution from animal wastes.

2. Encourage the use of best management practices to control or reduce pollution of the surface and groundwater supplier as caused by animal wastes.

MUNICIPAL WATER USE EFFICIENCY

Municipal water use is divided into distribution and residential uses. To improve water use efficiency in the first category, upgrading of the distribution system (control of underground leakage) has the advantage of being cost effective in that it reduces both pumping and water treatment costs.

The following methods are available to improve water use efficiency in the residential category:

1. Toilet Flushing Control
2. Showering Control
3. Laundry & Cleaning Controls
4. Plumbing Maintenance
5. Dual or Recycling Systems
6. Lawn Irrigation Scheduling
7. Landscaping Practices

Industrial Water Use Efficiency

Industrial water use can be divided into three major classifications:

1. Non-Contact Cooling
2. Process and Related Uses
3. Sanitary or Miscellaneous Uses

Industries vary greatly in water requirements, both among types of industries and within the same industry. Therefore, it is difficult to say that a product requires a specific quantity of water. However, the greatest opportunity for improved industrial water use efficiency occurs where recycling of the water may be possible.

Industrial water use within the Nemaha NRD is limited to those industries which obtain water from two principal sources:

1. Groundwater
2. Missouri River Surface Flow

Major groundwater industrial usage is presently by the Campbell Soup Company in Tecumseh which secures water from the major Cook aquifer. Additional or increased industrial needs from this aquifer will result in major impact upon the present source and depending upon the quantity needed for each potential industry, may result in significant impact upon maintaining NRD groundwater reservoir life goals.

Municipal Water Needs

Approximately 47,179 Nebraska citizens (1980 Census) within the District depend on public water systems as their sole source of supply for drinking water, sanitation, fire protection, and lawn and garden watering. In addition those citizens residing on homesteads and farms and visitors to southeast Nebraska depend on these public sources of drinking water for short periods of time. The availability and safety of drinking water is, therefore, essential to the well-being of the resident population and their guests.

POPULATION OF NEMAHA NRD ACCORDING TO 1980 CENSUS

Cass County	294
Gage County	1,018
Johnson County	5,285
Lancaster County	2,686
Nemaha County	8,367
Otoe County	14,679
Pawnee County	3,535
Richardson County	11,315
TOTAL	47,179

Most municipal water systems consist of a source of supply, minimal storage, and distribution to the point of use. A number of small water systems have found it advantageous to purchase water from another system. These decisions have been based on both quantity and quality considerations. The practice was initiated in the 1970's when rural water districts (RWD's) began purchasing water from existing municipal systems. The Falls City, Nebraska City, and Tecumseh systems make water sales to RWD's which in turn sell at bulk rates to other districts and to municipal systems within their service areas.

As shown below, primary systems provide water to the secondary systems, which in turn provide water to the tertiary system.

Primary System	Source	Secondary System	Tertiary System
Falls City	Groundwater	Richardson Co. RWD #2 Rulo	
Johnson Co. RWD #1	Groundwater	Pawnee Co. RWD #1 Crab Orchard	Burchard DuBois Lewiston Steinauer Virginia
Lancaster Co. RWD #1	Groundwater	Bennet (Partial) Panama	
Nemaha Co. RWD #2	Groundwater		
Nemaha Co. RWD #2	Groundwater	Johnson (Partial)	
Nebraska City	Groundwater	Otoe Co. RWD #1 Otoe County RWD #2	 Julian
Otoe Co. RWD #3	Groundwater	Unadilla Avoca Douglas Otoe Palmyra (Partial)	
Tecumseh	Groundwater	Johnson Co. RWD #1 (North Part) Elk Creek	

Consolidation of systems can be expected to continue especially in the NRD area as groundwater quality deteriorates and as

localized shortages of groundwater are experienced. These shortages are anticipated from municipal wells in the small communities of the District located either outside of the major Cook aquifer or those communities located near the flood plain of the Missouri River. Generally communities near the Missouri River experience water quality problems even though water quantity is sufficient. Larger municipalities such as Nebraska City and Falls City find this source sufficient to meet present and future needs so long as their treatment plants are able to process the amount of water pumped from the groundwater table near the river.

There are few if any municipal water systems in the NRD that are without problems associated with management, operation, maintenance, or replacement of the system or with the quantity and quality of the water supply source. In numerous instances the problems are not recognized as such and continue to multiply in both magnitude and number.

Identified problems are grouped to reflect those associated with (1) source of supply, (2) operation and maintenance and replacement of systems, and (3) those that affect financing and evaluation of municipal water service provided to consumers.

Source of Supply Problems

A. Municipal water use is not recognized by statute of Constitutional reference in the preferences system for ground or surface water.

   1. Water distributed and sold through municipal systems is usually the sole source of supply for the system subscriber and may be used for any number of purposes. This delivered water is dedicated to uses which include domestic, industrial, lawn and garden watering, recreation, and the maintenance of aesthetic values. The mix of uses experienced by any municipal system is dependent upon and contributes to the social and economic character of the community served. The combination of uses accommodated by a municipal system is not recognized under Nebraska law as a classified entity receiving equal consideration with other established uses.

B. Municipal wellfields inducing groundwater recharge from stream seepage are not recognized in the statutes as having surface water rights.

C. Existing or future legal and institutional constraints may prevent cities from effectively using surface waters.

   1. Use of surface water for public supply in Nebraska may increase in the future especially in the more heavily populated eastern part of the state. Treated surface water may be an economical alternative to those towns or consolidated systems with limited or poor quality groundwater available. Future problems could arise as cities attempt to obtain additional surface water

supplies. Flows may be fully appropriated with streams regularly depleted during periods of peak demand. Adequate appropriation rights of sufficiently high preference must be available for a reliable supply of drinking water. Under present law diversion rights cannot be acquired or combined except by using preference provisions.

D. Municipalities are encountering increasing resistance from competitive users relative to developing new and expanded sources of water supply. These competitive uses also affect the quality of raw water available for municipal use.

1. The nearly total reliance of municipal water systems within the District of groundwater as a source of supply for drinking water establishes reason for concern over the continued availability of this source. From the standpoint of quantity, the municipalities in most cases can be expected to compete for the available supply. This is because the value of water for community use far exceeds the economic return that can be realized from other uses. However, seasonal water level interference will continue to affect a community's ability to utilize water. The quality requirements for public supply are also much more stringent than for other uses and the combined cost of source development and treatment to remove contamination could become the deciding factor in the continuation of acceptable municipal water service. Based on the assumption that all but the smaller systems can acquire needed amounts of water, quality parameters become elevated to a position of greater importance.

E. Groundwater supplies are being contaminated by man's use of the overlying land surface. There has been reluctance at both state and local levels of government to exercise land use control as a tool in protecting groundwater resources.

1. Man's activities to develop and utilize the resource base exert a significant influence on the quality of groundwater. Agricultural practices, the disposal of waste material, and even the rates of withdrawal practices by those utilizing the groundwater reservoir have increased the rate of quality deterioration. The geological setting of Nebraska contributes to the rapidity of man's influences on the quality of groundwater. The permeable nature of many surface soil structures encourages the percolation of precipitation to the groundwater. This increases those problems associated with the use of land as it influences the quality of groundwater. Soluble material placed on the land or in the upper soil strata without proper precaution will likely reach the groundwater reservoir eventually and cause quality deterioration of the resource. Development of these unsuitable soils by private enterprise can result in water quality deterioration or erosion problems that society must deal with generally at public expense.

2. With the absence of land use controls, municipal wells are particularly vulnerable to groundwater contamination and pumping interference effects by nearby development. Controlling the land surrounding municipal wells is the best assurance a community can have of minimizing quality deterioration and pumping interference effects.

F. Inefficiency of agricultural management practices contributes to groundwater pollution and water level declines.

1. Without question agricultural practices can have an impact on municipal water systems. Excessive application of water, fertilizers, herbicides, and pesticides results in groundwater pollution.

G. No enforceable design standards exist for construction of wells serving other than public supply.

1. Poorly constructed wells that permit accelerated entrance of surface water to the underground reservoir also contribute to localized contamination. Excessive withdrawal of groundwater by single wells and in areas of intensive development increases the flow of water through the aquifer and over a period of time encourages the movement of local contamination into otherwise unaffected areas. Wells that penetrate two or more aquifers present a potential for contamination by permitting water of low quality to mix with higher quality water. This mixing action can be controlled by proper well design and construction and by applying adequate precautions when such wells are abandoned.

Operation & Maintenance & Replacement of Systems

A. Additional problems occur for the publicly owned water systems, the existing condition of municipal water systems and the costs associated with rehabilitation, the need and cost for treatment to remove harmful contaminants, and the public reaction to improved water service and their desire to pay for this service.

Such problems, although not found in every municipality, include:

1. Obsolete and sometimes conflicting authorities and requirements exist in the statutes regarding acquisition, management, and operation of public water systems.

2. The municipal user fails to appreciate the economic value of water delivered by municipal systems. Many consumers have demonstrated reluctance to pay the price necessary to assure the long-term delivery of a quality product.

3. There is an absence of fiscal accountability for operation and management of municipal water systems as self-supporting utilities.

4. Many water systems in the District are in a deteriorated condition. Considerable funding will be required for rehabilitation. Locating such funding will be a significant problem.

5. Water treatment facilities will need to be constructed by a number of municipal systems found to be in violation of the contaminant levels established by the Safe Drinking Water Act.

6. A continuing need for water system consolidation has been demonstrated. An apparent lack of public interest and financial support for such consolidation has been encountered.

   A number of water systems have found it advantageous to purchase water from another system due to quality or quantity considerations. Limited groundwater supplies particularly in the southeastern part of the state and poor quality led to the development of rural water districts. There remains great potential for additional consolidation. Merging of operations and management by small communities could increase efficiency. Shared operators, a central "pool" of spare parts and maintenance equipment, and central billing and record keeping procedures can reduce the cost of delivered water. With adequate sources of funding and a supportive institutional framework, this will be a viable alternative for small water systems encountering water quality deterioration and localized shortages of supply.

7. Numerous municipal systems experience greatly reduced or negative water pressure during fire fighting operations. A potential for backflow or backsiphonage and the resulting contamination of the water supply exists under reduced pressure conditions.

<u>Problems in Financing & Evaluation of Municipal Water Service Provided to Consumers</u>

A. The public water system surveillance program (Safe Drinking Water Act) is being restricted in scope as federal and state funding is reduced.

B. Developing and maintaining laboratory capability necessary for identifying and measuring contaminants in drinking water is a continuing, difficult task.

C. A need exists for the continuing collection and refinement of water use information.

D. Federal sources of financial assistance to municipal water systems are being reduced to the point of extinction. In the absence of subsidy, at least half of the smaller systems cannot finance needed improvement to assure an acceptable quality of service to their customers.

Municipal Water Needs Policy

The Natural Resources District recognizes that municipal water needs require consideration in the development of this groundwater management plan. Many of the District's towns and rural water districts are dependent upon the Cook aquifer with remaining community water systems generally in need of improvement of quantity and quality.

Although many problems have been identified in municipal water needs, the NRD can only address those which are related to groundwater supply. Other problems will have to be resolved by the municipalities when considering the operation, maintenance, and replacement of systems and required financing and evaluation of water service.

POLICIES: MUNICIPAL WATER NEEDS

The following policies are established as on-going procedures and objectives of the District management of groundwater. The extent and scope of each is to be carried out subject to enacted legislation, financial capability, and required personnel.

1. Encourage the State Legislature to recognize municipal water use in the Constitution and Statutes as having a preference equal to or secondary only to domestic use.

   Municipal use should only mean the use of water supplied through a distribution system by a municipality or other public entity for any beneficial purpose, the intent of which is to promote the life, safety, health, comfort, and business pursuits of the municipality and its inhabitants. It does not include the irrigation of crops where the area to be irrigated exceeds two acres or the use of water outside the zoning jurisdiction of the municipality for any purpose other than domestic purposes except where a municipality or other public entity furnishes water to another municipality, Natural Resources District, or Rural Water District for the same purposes and with the same limitations.

2. Encourage legislation to authorize cities and villages to apply limited zoning and land use controls to areas within a prescribed distance of their water supply sources in addition to existing authority within designated distances from their existing corporate boundaries.

   The District recommends this action for the protection of both water quality and quantity. Such legislative action would allow municipalities to zone in areas beyond their boundaries. Such legislation should carefully specify the distances involved and the land use activities which may pose a direct hazard to the municipal water supply. Such action should not be used for any purpose other than the protection of the municipal water supply.

3. Adoption of miscellaneous actions that would serve to improve and protect the quality of groundwater used as a source of municipal drinking water.

Although related to agricultural programs and resulting policies by this District, the following four miscellaneous actions should be required policies to improve and protect groundwater used for domestic purposes:

a. Irrigation systems with direct withdrawal from groundwater aquifers should not be allowed for the purposes of application of chemicals to include but not be limited to herbicides, pesticides, and fertilizers.

b. Require licensing or certification of well drillers and pump installation systems.

c. Enactment of legislation for standards and permit system for storage of chemicals and petroleum and delegate administration of the system to proper authority.

d. Encourage the enactment of legislation that would require municipal systems to install back-flow prevention devices on industrial and commercial service connections where there is an apparent hazard. Chlorinate or otherwise disinfect water entering the distribution system, and provide for sale of water through meters or other means of volume measurement.

However, we do feel that meters should be required on all service connections. Meters discourage overuse of water, can result in less repair, and delay need for expanding the water system. Chlorination results in fewer health problems at minimal expense and, therefore, should be a system requirement. Main breaks do occur, and there are sometimes associated disease outbreaks. Chlorination can substantially lessen the occurrence of these outbreaks.

4. Require all municipalities to develop a program and include implementation plan to reduce quantity of water used within the municipality. The program or plan shall include lawn watering schedules and other means used to reduce water usage.

When the District determines stringent policies need to be applied to correct problems adversely affecting reservoir life goals, the following water use efficiency policies may be applied as allowed by legislation, rules and regulations, and other means.

1. Encourage legislation to require municipalities to receive approval from the NRD on new expansions which would increase the volume of water to be withdrawn from the principal aquifers of groundwater. Such action would only be required when the NRD has determined any withdrawal expansion could have a significant detrimental effect upon the depletion of aquifer or reduce the reservoir life goal.

IMPROPER OPERATION & MAINTENANCE OF WASTEWATER TREATMENT PLANTS AND INSUFFICIENT OPERATOR TRAINING

The removal of pollutants from wastewater to amounts acceptable for discharge is a relatively complex process. Wastewater treatment systems cannot function correctly without proper operation and maintenance. Therefore, the plant operator must be adequately trained to properly operate and maintain the system. Failure to maintain these systems will result in the unnecessary pollution of streams and rivers and could easily contaminate the groundwater resources.

The District has a total of 63 wastewater treatment plants discharge to its streams. This basin ranks fourth in the total number of discharges among the other basins in the state. System (NPDES) permits are summarized below.

Type of Facility	Number	No. on Final Effluent Limitations
Municipal	36	20 (56%)
Industrial	25	25 (100%)
Miscellaneous Domestic (i.e., trailer parks, schools, etc.)	2	2 (100%)
Total	63	47 (74%)

All of the industrial discharges in the Nemaha Basin are on final effluent limitations.

Seventy percent of the permitted facilities in this basin had discharge monitoring report (DMR) violations. Sixty-two percent of the facilities were in violation due to failure to submit DMR's during the reporting period specified in the NPDES permit. The municipal dischargers in the basin were generally more likely to file DMR's than were the industrial and miscellaneous dischargers.

Operator training and certification needs can often be determined based on permit non-compliance records. Thirty-two of the 36 municipal facilities are in need of some form of training and/or certification. The needs of the industrial permittees are unknown at this time. The miscellaneous domestic dischargers are in need of both training and certification. The voluntary training and certification program does not seem to be providing an adequate solution to the problem experienced in this respect.

Although the Department of Environmental Control has authoritative responsibility over municipalities and wastewater treatment plants, current assessments report many such installations have a high potential for contaminating groundwater.

POLICIES: WASTEWATER TREATMENT PLANTS

The following policies are established as ongoing procedures and objectives of the District's management of groundwater as related to operation and maintenance of wastewater treatment plants. The

extent and scope of each is to be carried out subject to legislative authorization, promulgated rules and regulations, financial capability, and/or available personnel and resources.

1. Promote circuit wastewater treatment plant operators. An adequately trained and certified operator could serve several small wastewater treatment facilities which are in close proximity within the District. This would result in improved operation and efficiency as long as the arrangement was able to deal with the many problems of treatment plant operation. The District with assistance of the Department of Environmental Control and the Southeast Nebraska Development District should promote this concept of sharing an operator.

2. Encourage the modification of state statutes to require all wastewater treatment plant operators to be trained and certified. The level of required training should correspond with the size and complexity of the facility. Such requirement should be under the authority and responsibility of the Department of Environmental Control.

3. Communities with wastewater treatment plant deficiencies causing pollution to surface and groundwater resources shall be encouraged to perform corrective measures. The District within its capabilities of financial and personnel resources shall provide assistance to help the community to correct such pollution problems.

URBAN RUNOFF

Runoff leaving developed residential, commercial, and industrial areas carries with it sediment, fertilizer nutrients, pesticides, heavy metals, and oils. Sediment can adversely impact aquatic organisms and their habitat. The fertilizer nutrients enrich surface water resulting in imbalance of animal and plant organisms coexisting in the surface water. Pesticides can eliminate nontarget plant and animal aquatic organisms. Heavy metals, although not always toxic to smaller organisms in the aquatic food chain, can become concentrated in the tissue of larger aquatic organisms becoming toxic in some cases, and resulting in such abnormalities as stunted growth and lack of reproduction. Other uses of surface waters such as recreation, agriculture, industrial, and water supply are also adversely affected by pollution from urban runoff.

Urban runoff is not known to be a major concern in the communities within the District; however, as an existing or potential contributor to the pollution of surface water and groundwater, policies are herein established.

POLICIES: URBAN RUNOFF

The following policies are established as on-going procedures and objectives of the District's management of groundwater. The extent and scope of each is to be carried out subject to enacted legislation, financial capability, and required personnel.

1. Cities and counties are encouraged to periodically evaluate the potential for water pollution from urban runoff in their jurisdictions. Areas that should be reviewed include street cleaning practices, open storage of materials such as pesticides, petroleum products, paper and solid waste, industrial and commercial activities, and construction activities. (Construction activities are specifically addressed under "Construction Site Runoff".) The cities and counties could request assistance in this evaluation from the Department of Environmental Control. The entire hydrologic system for storm water runoff should be included in this evaluation. If a significant pollution potential becomes evident, the following items may need to be developed or improved to reduce pollution from urban runoff to an acceptable limit.

   a. Street cleaning
   b. Anti-litter laws or ordinances
   c. Open storage regulations
   d. Erosion control regulations
   e. Zoning ordinances
   f. Building codes

   Construction of stormwater detention facilities or other modifications in the stormwater runoff system could also be needed.

2. Encourage the Department of Environmental Control to conduct informational programs to help city officials and employees,

consulting engineers, and also the general public be more aware of the effects of urban runoff on water quality. The various methods to reduce the urban runoff waste loads should be included in these informational programs.

3. Encourage the Department of Environmental Control to prepare and promote model ordinances applicable to cities, villages, and counties as a step to assisting in uniform procedures in controlling urban storm runoff. These ordinances could include the following:

   a. Anti-litter laws
   b. Regulations for open storage of pesticides
   c. Oil and lubricants
   d. Paper
   e. Solid waste
   f. Erosion and sediment control regulations
   g. Zoning laws
   h. Building codes
   i. Other regulations that would reduce urban runoff to acceptable limits

   The Department of Environmental Control would make local governmental units aware of these model ordinances and urge them to adopt them.

When the District determines stringent policies need to be applied to correct problems adversely affecting reservoir life goals and water quality standards, the following urban runoff control policies may be applied as allowed by legislation, rules and regulations, and other means.

1. Seek adequate authority for the Department of Environmental Control to require a mandatory urban runoff control program to be enacted to require each community to prepare and submit an urban runoff control plan for approval by the Department of Environmental Control. These plans would include (a) a description of the physical system including storm sewers, detention basins, etc., (b) street cleaning and catch basin cleaning program, (c) a description of the community's use of deicing salt, and (d) an education program directed at community residents. Requirements which would insure the reduction of pollutant loads to an acceptable level could be established. The Department of Environmental Control would approve the local plans if they met minimum requirements taking into account local conditions. A penalty including fines could be established and imposed for noncompliance. Each community would be required to have an approved plan. Smaller communities may be exempt; communities not near surface water may also be exempt as some feedlots are exempt from the runoff control requirements.

RESIDUAL WASTE DISPOSAL SITE CONTAMINATION OF SURFACE AND GROUNDWATER AND LAND APPLICATION OF WASTEWATER EFFLUENT AND SLUDGE

Water disposal is one of the most widespread potential sources of groundwater pollution in the District. Within the District are 30 known solid waste disposal sites, 2 licensed, 18 approved, and 4 unapproved sites. Fifty-seven percent (57%) of these sites are considered to have water pollution potential.

Communities with licensed sites:

1. Falls City
2. Otoe County Landfill

Communities with approved sites:

1. Adams
2. Auburn (private)
3. Bennet
4. Brownville
5. Burr
6. Eagle
7. Elk Creek
8. Humboldt (with Table Rock)
9. Johnson
10. Nemaha
11. Pawnee City
12. Peru
13. Salem
14. Shubert
15. Table Rock (with Humboldt)

Communities which transfer wastes to approved or licensed sites:

1.	Barada	Goes to Falls City
2.	Crab Orchard	Goes to Auburn
3.	Dunbar	Goes to Otoe County Landfill
4.	Firth	Goes to Lincoln
5.	Julian	Goes to Auburn
6.	Lewiston	Goes to Auburn
7.	Lorton	Goes to Otoe County Landfill
8.	Nebraska City	Goes to Otoe County Landfill
9.	Panama	Goes to Lincoln
10.	Preston	Goes to Falls City
11.	Stella	Goes to Falls City
12.	Sterling	Goes to Auburn
13.	St. Mary	Goes to Auburn
14.	Talmage	Goes to Otoe County Landfill
15.	Tecumseh	Goes to Auburn
16.	Verdon	Goes to Auburn
17.	Palmyra	Goes to Otoe County Landfill
18.	Syracuse	Goes to Otoe County Landfill
19.	Unadilla	Goes to Otoe County Landfill
20.	Otoe	Goes to Otoe County Landfill
21.	Cook	Goes to Auburn

Communities with no sites or unknown sites:

1. Brock
2. Union
3. Vesta

Communities with unapproved sites:

1. Douglas
2. DuBois
3. Rulo
4. Steinauer

Sites with identified water pollution potential:

1. Burr
2. Douglas
3. DuBois
4. Elk Creek
5. Johnson
6. Rulo
7. Salem
8. Shubert
9. Table Rock

Not only do ground and surface water pollution potentials exist in twelve (12) identified sites, but many rural citizens permit pollution to occur due to dumping solid wastes, chemical containers, and other toxic contaminants in gullies, draws, and other eroded areas which with surface runoff, the contaminants flow into tributaries to flowing streams and the Nemaha Rivers.

Within the District it is presently unknown the quantity and types of toxic pollutants which result from improper waste disposal, but generally assumed major pollution results from improper waste disposal.

The Department of Environmental Control's authorities regarding waste disposal are presently incomplete and inconsistent. Current law regarding liability for pollution resulting from improper waste disposal is unclear, does not provide adequate private incentives to avoid pollution, and does not clearly establish liability for the costs of remedial action and liability for damages caused.

Metropolitan cities and cities of the first class must obtain Department of Environmental Control permits to operate a solid waste disposal facility. Cities of the second class and villages are not subject to Department of Environmental Control solid waste disposal facility regulations unless they are disposing of hazardous wastes or are polluting water of the State. Many of these unregulated sites are at times unsupervised and unsecured which makes them potentially susceptible to illegal dumping of hazardous wastes. (Designated hazardous substances will be covered in another section of this groundwater management plan.)

Wastewater lagoons are also of concern when considering potential groundwater and surface water pollution. The Department of

Environmental Control has promulgated rules and regulations over wastewater lagoons to help assure protection of surface water resources; however, assessments of lagoons show many such facilities may have a high potential for contaminating groundwater in the District.

Considerable quantities of sludge are produced by conventional wastewater treatment. The sludge is normally buried in landfills or spread on agricultural land or incinerated. Wastewater effluent is also applied to land by a small but growing number of communities. Land application of sludge or effluent if done properly is not only an environmentally sound method of disposal but also a method of resource recovery. Surface and groundwater quality problems can result if the site is not carefully selected, if the rate of application is too great, or if the waste is not properly incorporated into the soil. The pollutants of concern include organic material, nutrients, bacteria, and heavy metals in sludge and suspended solids, bacteria, and biochemical oxygen demand in effluent.

Another environmentally sound method for recovery of this resource is composting, which results in a stable material with qualities similar to black dirt. An excellent soil amendment, it is also used in reclaiming strip-mined areas as landfill cover; and when simply disposed of in a landfill, it does not create problems that sludge-slurries cause.

Residual waste disposal problems will increase in the future due to increasingly effective treatment processes that produce more sludge and competition from other land uses for suitable disposal or reuse sites.

There are two power plants in this District. The Cooper Nuclear Station located near Brownville, Nebraska, discharges some 710 MGD of once-through cooling water. This facility has undergone considerable scrutiny by the Nebraska Public Power District in their attempt to define any effects of this plant's operation on the Missouri River. This plant and the Fort Calhoun Plant in the Missouri Tributaries Basin were the subject of a five-year study involving eleven state and federal agencies designed to evaluate the thermal effects of these plants on the Missouri.

The Nebraska City Power Station is a new coal-fired plant on the Missouri River. The plant has started operation and discharges some 450 MGD of once-through cooling water into segment NE-10. The wastewater control systems at this power station were designed to recycle and reuse as much water as possible, thereby decreasing the amount of discharge from the plant. The power district has undertaken a number of studies at this facility in an effort to predict any possible effects of plant operation.

POLICIES: WASTE DISPOSAL, WASTEWATER EFFLUENT & SLUDGE

The following policies are established as on-going procedures and objectives of the District's management of groundwater. The extent and scope of each is to be carried out subject to enacted legislation, financial capability, and required personnel.

1. Encourage the Legislature to provide the Department of Environmental Control the regulatory and licensing authority over solid waste sites managed by villages and second class cities in the State.

2. Encourage communities with unapproved sites such as Douglas, DuBois, Rulo, and Steinauer to close solid waste sites and make arrangements for the transport of solid wastes to approved sites.

3. Encourage the Department of Environmental Control to study and evaluate each of the identified twelve sites with identified water pollution potential and required remedial actions to either close or have preventative measures taken to assure the groundwater and surface water is not polluted.

4. Urge the Department of Environmental Control to develop a landfill classification system on the types and quantities of wastes to be handled at each facility within the District. This will permit regulations and requirements to vary according to these different landfills with respect to design, siting, site control, and monitoring. It must be emphasized that solid waste landfills and wastewater lagoons can only be considered sound waste management approaches if the materials going into them are known and carefully controlled. While regulatory measures may be relaxed for landfills and lagoons receiving materials with little potential to contaminate the environment and groundwater, very strict controls would be established for facilities authorized to accept hazardous wastes. Penalties must be strengthened to ensure that site operators are discouraged from allowing disposal of wastes at facilities not authorized to receive them.

5. The Department of Environmental Control is encouraged to develop and institute management practices which emphasize resource recovery and waste utilization practices specific to each type of facility. This should include the identification of substances and materials which should not be landfilled or otherwise land disposed. A method and place of disposition of such substances and materials should also be designated within the District.

6. Communities and villages with approved sites will be encouraged to either provide trained site operators to monitor the operation of solid waste disposal sites or consider moving solid waste disposal operations into licensed county landfill or approved sites where operators are provided.

7. Encourage urban and rural citizens to cease indiscriminant dumping of solid wastes and chemicals in gullies, eroded areas, etc., in rural areas and county road right-of-ways where a potential of contaminating surface and groundwater exists.

8. Encourage the Department of Environmental Control to evaluate all waste water lagoons in the District identifying those

with high pollution potential of the surface and groundwater. Evaluation should result in identifying those factors which lead to groundwater contamination and corrective measures to be required.

9. Encourage the Department of Environmental Control to develop and instigate an initiative for wastewater and sludge utilization. Greater emphasis should be given to current industrial pre-treatment programs as a means of providing high quality, low pollution potential wastewater and sludge materials. With this quality assurance, the commercialization of land based utilization programs for these materials would be encouraged and fostered while protecting the groundwater and surface water quality.

When the District determines stringent policies need to be applied to correct problems adversely affecting reservoir life goals and water quality standards, the following Residual Waste Disposal Site Contamination of Surface and Groundwater and Land Application of Wastewater Effluent and Sludge policies may be applied as allowed by legislation, rules and regulations, and other means.

1. Seek legislation to prevent communities from operating solid waste disposal sites which do not have a trained operator on duty when facility is open.

2. Seek legislation to prevent the operation of any solid waste disposal site or wastewater treatment plant which permits the pollution of the groundwater and/or surface water.

3. Encourage appropriate legislative action to require appropriate agencies and law enforcement officials to enforce laws or regulations prohibiting the disposal of solid wastes and toxic chemicals at any location not approved by the Department of Environmental Control.

CONSTRUCTION SITE RUNOFF

The major pollutant stemming from construction site runoff is sediment. Through the physical process of water erosion, soil particles are dislodged and transported by water with a fraction of the particles reaching streams, lakes, and other surface water and being subsequently identified as sediment. Along with adversely affecting aquatic organisms and their habitat, other impacts due to sedimentation include loss of reservoir capacity, reduced recreation demand, increased drainage maintenance costs, and reduced capacity of waterways.

Presently construction site runoff does not appear to be a major concern within the District since many of the communities are basically rural in nature. It should not be ignored since all communities are continuing efforts to encourage industrial development which would also result in increased construction of plants, factories, warehouses, and corresponding residential expansion with supporting businesses to provide services for expanding population.

Expansion of industrial facilities is of major emphasis in Nebraska City and other major communities to include Auburn, Falls City, Humboldt, Pawnee City, Syracuse, and Tecumseh. Smaller communities within the District also seek expanded development to help offset the general decline of population and business.

POLICIES: CONSTRUCTION SITE RUNOFF

The following policies are established as on-going procedures and objectives of the District's management of groundwater as pertaining to Construction Site Runoff. The extent and scope of each is to be carried out subject to legislative authorization, promulgated rules and regulations, ordinances, financial capability, and/or available personnel and resources.

1. Encourage city and county governments to adopt rules and regulations and/or ordinances to require developers and owners to submit and implement sediment and erosion control site plans in order to control construction site runoff and limit sedimentation to acceptable limits. Sediment control plans could be required for all developments that require grading and excavation except for minor activities, agricultural activities, or sites covered by the National Pollutant Discharge Elimination System. Cities and counties could take the following action:

    a. Review the sediment control plans or contract with the District to review them.

    b. Approve the plans if requirements were met.

    c. Make periodic inspections of the construction sites.

    d. Provide enforcement if required.

The construction site runoff control program could be tied to existing procedures such as subdivision approval where such action is presently required.

2. Encourage the Nebraska Natural Resources Department to meet with the Association of General Contractors, Land Improvement Contractors Association, Home Builders Association, and consulting engineers to inform them that many of the known conservation measures have been identified as best management practices and that they should apply these measures to areas and projects they are working on.

When the District determines stringent policies need to be applied to correct problems adversely affecting reservoir life goals and/or water quality standards, the following construction site runoff policies may be applied as permitted by legislation, rules and regulations, and other means.

1. Encourage legislative authority to require construction site runoff control plans to be prepared and subject to approval prior to any construction site development. Such authority would require city or county governments to adopt rules and regulations to conform to this legislation. Developers and owners could be required to submit to the city or county government a sediment and erosion control plan for each construction site. Each plan must be determined as adequate before building permits are granted. Each construction site with an approved erosion control plan would be subject to inspection during the course of construction.

SEPTIC TANK SYSTEMS

Septic tank systems, when properly constructed, located, and maintained, can be a satisfactory means of treating wastewater from single family dwellings. However, all too often the proper precautionary steps are not taken; and water quality and public health may be affected. An improperly constructed, located, or maintained septic tank system can discharge viruses, bacteria, chlorides, nitrates, and detergents to surface or groundwater. These pollutants may cause water quality degradation and make water unsafe for human consumption. Detergents can be carcinogenic; nitrates can cause methemoglobinemia; bacteria and viruses can lead to many diseases.

In the District numerous septic tank systems are improperly located thereby adding to the poor water quality experienced at specific site locations.

It is also very likely some water wells presently providing drinking water for domestic and animal consumption are contaminated beyond safe drinking water limits. There is a tendency with many rural areas if the water looks good, tastes all right, and doesn't make the user sick that it is safe to drink. Wells are often located near septic tank drainage or leaching fields. Although wells did not originally experience contamination, with time due to extensive saturation of the soils resulting from improperly placed septic tank locations, wells eventually become contaminated.

Several communities within the District such as second class cities and villages allow for septic tanks, i.e., Peru. Soil conditions often do not support a heavy concentration of septic drainage fields in areas where the soils are heavy and clayey in nature.

POLICIES: SEPTIC SYSTEMS

The following policies are established as on-going procedures and objectives of the District's management of groundwater. The extent and scope of each is to be carried out subject to enacted legislation, authorities, rules and regulations, financial capability, and required personnel.

1. To encourage an expansion of an educational program to promote voluntary use of best management practices to allow for the proper site location and installation of septic systems to consider reducing pollution of surface and groundwater resources.

   The University of Nebraska Institute of Agriculture and Extension Service should assume leadership responsibilities in consultation with the Department of Health, Department of Environmental Control, USDA Soil Conservation Service, and the District.

2. State statutes could be modified to require septic tank manufacturers, installers, and pumpers to be licensed. To be licensed, these people would have to demonstrate sufficient

knowledge and ability to practice their trade without creating a potential for surface or groundwater pollution. They would have to be knowledgeable of (a) existing rules and regulations regarding septic tank systems and disposal of solid and liquid wastes, and (b) the possible effects on water quality and public health of faulty manufacture or installation of septic tank systems or improper sludge disposal. Individuals who install their own septic tank systems would not have to be licensed but would have to follow the minimum standards.

The Nebraska Department of Health with necessary legislative authorization should be responsible for the licensing of the septic tank manufacturers, installers, and pumpers.

3. Municipalities are encouraged to require permits to be issued for the installation of a new tank system or to modify an existing septic tank system. Ordinances and rules and regulations should be promulgated in those communities which permit septic tank systems. Construction permits could be issued after plan review if minimum standards are met. All tank systems should require compliance with published standard soil survey limitations. The septic tank systems with permits would be subject to on-site construction inspections.

4. Encourage the Department of Environmental Control and Department of Health to provide technical assistance to recreational developers and private owners in adequate installation of septic tanks with drainage field systems along lakes, streams, and rivers within the District.

5. Discourage the installation of septic tanks with drainage field systems within the flood plains of rivers, streams, and lakes within the District.

6. Discourage the installation of any septic tank system with drainage field near any groundwater well. Locations would be dependent upon soils information revealed by the standard soil survey.

7. Seek legislation to prohibit any septic tank system with drainage field from being installed or modified without necessary installation measures which will prevent contamination of the ground and surface water resources.

When the District determines stringent policies need to be applied to correct problems adversely affecting reservoir life goals or water quality standards, the following Septic Tank policies may be applied as allowed by legislation, rules and regulations, and other means.

1. Encourage legislation be enacted to allow for corrective measures to be required for existing systems when pollution of water resources occurs.

SITING, DRILLING, CASING, SEALING, AND PLUGGING OF DOMESTIC, STOCK, IRRIGATION, AND INDUSTRIAL WATER WELLS

Wells and test holes provide potential sources of groundwater contamination by providing a direct conduit for pollutants to reach groundwater aquifers. In addition water wells are constructed in areas where groundwater quality may be of questionable safety for the designated use(s). These are areas within the District especially along the flood plain of the Nemaha River system where shallow hand-dug wells are contaminated. When such wells are deepened, the lower groundwater supplies may become contaminated through improper drilling, casing, sealing, thereby allowing dissolved contaminants and other pollutants to migrate from one aquifer into another of different quality of water.

In addition the District has hundreds of abandoned wells which permit dissolved contaminants and other pollutants to migrate into groundwater supplies. Similar problems are associated with improperly constructed water supply wells.

Presently Nebraska Statutes do not allow for restrictions or requirements in locating, drilling, and minimum construction standards for water wells other than public supply wells or for private wells which have applied for Federal Housing Administration, Farmers Home Administration, or Veterans Administration loan assistance. Consequently, private wells, either for potable supply or irrigation, are occasionally located too close to sources of contamination, are cased with nonsealed joints, or are packed with only gravel throughout the depth of the well. Practices of this type can result in groundwater contamination and a potential future health hazard. As more wells are installed, this possibility increases.

Statutory well abandonment has weak enforcement and compliance provisions. Several state agencies have specific authorities for certain types of wells such as:

Department of Water Resources: Authorities to set regulations for high capacity wells such as for irrigation purposes. However, enforcement depends primarily on voluntary compliance; i.e., individuals abandoning their wells must notify the Department.

Department of Environmental Control: Authorities to regulate mineral exploration holes. However, DEC has not exercised its more general groundwater protection authorities to regulate water wells or test holes both of which provide groundwater pollution potentials at least equal to that of mineral exploration holes.

Health Department: Authorities to regulate construction of public water supply system wells such as municipal and rural water district wells.

The Nebraska Well Drillers Association and Conservation and Survey Division have established domestic and irrigation well construction standards, but compliance is voluntary.

It becomes obvious to the District that the management and authorities of well drilling, siting, casing, sealing, and plugging is scattered among too many state agencies resulting in confusion and lack of enforcement of authorities by those respective agencies.

POLICIES: WELL CONSTRUCTION & ABANDONMENT

The following policies are established as on-going procedures and objectives of the District's management of groundwater. The extent and scope of each is to be carried out subject to enacted legislation, financial capability, and required personnel.

1. Encourage the Legislature to require that all wells be installed in accordance with minimum standards and that well drillers and pump installation contractors be certified and licensed to assure they are knowledgeable of well construction practices to protect water quality.

2. Encourage the Legislature to grant required authorities to conduct this program to the Nebraska Department of Health since it has been designated as the implementing state agency responsible for the Safe Drinking Water Act in Nebraska.

3. Encourage the development and enforcement of regulations for all well construction and well abandonment standards to include

   a. Irrigation
   b. Industrial
   c. Private domestic

   These regulations should be developed by the Department of Health in cooperation with the Conservation and Survey Division of the University of Nebraska and the Well Drillers Association.

4. The District would cooperate and assist the Nebraska Department of Health conduct this program at the local level as regulations and authorities permit.

5. Request the Nebraska Congressional offices to require the appropriate federal agencies to take necessary action to properly close and prevent potential water pollution of all former military missle silos within the NRD since almost all missle silos extend into the groundwater aquifers. Such action should include all abandoned facilities such as underground operations centers, living quarters, and missle launching areas since many contain contaminated water and are also a safety hazard to District citizens.

ROADSIDE EROSION

The major pollutant stemming from roadside erosion is sediment. Through the physical process of water erosion, soil particles are dislodged and transported by water with some of the particles reaching bodies of water such as the groundwater aquifer. Roadside erosion is accelerated by removing the ground cover for maintenance or construction or by cultivation. Sediment with attached nutrients, pesticides, and other chemicals can make the receiving water unfit for fish and wildlife, recreation, and other intended uses.

The roadside erosion problem will continue on roads that do not have the proper backslope or have not been stabilized with vegetation. Although few new roads are being built, more existing roads will need to be constructed in the foreseeable future.

Within the District are located many rural county roads with many located every mile. The counties have had difficulties maintaining each due to limited financial resources. Generally such maintenance is directed toward maintenance of the road surface with little concern on how the road ditch is maintained. In addition due to available "free-seed" from the Game & Parks Commission, the seeding of road right-of-ways is limited to whatever "free seed" is available without regard to soil conditions, etc. The seed is available to help promote wildlife habitat and cover along the roadways. In some areas especially within the northwest region of the District (Lancaster and Gage Counties), landowners are often permitted to direct flows from terrace systems into the road right-of-way to serve as a waterway. Other areas of the District have resulted in farming operations being permitted in the road ditches.

Road right-of-ways need to be properly maintained to eliminate potential safety hazards as well as reduce water quality problems.

POLICIES: ROADSIDE EROSION

The following policies are established as on-going procedures and objectives of the District's management of groundwater as related to roadside erosion. The extent and scope of each is to be carried out subject to required legislative authorization, promulgated rules and regulations, financial capability, and/or available personnel and resources.

1. Encourage modification of state statues to clearly prohibit agricultural cultivation and planting of row crops in rural road drainage way.

2. Encourage cooperation between the counties and landowners when mutually agreeable to allow waterway drainage and diversion systems to be placed upon county road right-of-way when the county allows the landowner to maintain the system and when design of such system will prevent occurrances of erosion as designed by the Soil Conservation Service.

3. Encourage the Nebraska Board of Public Roads Classifications and Standards to change its design standards for back slopes on rural roads. The standards, which currently state that the back slope is variable, could recommend a minimum back slope for rural road construction. The minimum needs to be different for different soils and counties or areas of the state. Compliance by counties and townships would be on a voluntary basis because in some cases this standard would be unfeasible. It is believed the recommended back slope would give leverage to counties and townships in their dealings with landowners to acquire adequate right-of-way for road construction and reconstruction.

4. Request the Nebraska Board of Public Roads Classifications and Standards to change its minimum design standards for rural roads to require seeding of all disturbed areas during the reconstruction of a road or construction of a new road. Seeding should provide for using established species for various soils, types, and conditions and specify reseeding measures in the event new seedings do not become established. When the counties seed native grass species, preventative measures such as cover crops should be required to prevent erosion while the native species becomes established.

5. Encourage counties that have a need to purchase roadside seeding equipment such as narrow grass drills, hydroseeders, and mulching equipment on a voluntary but coordinated basis. The equipment could then be shared by cooperating entities to their best advantage. The District, in cooperation with counties, would encourage such arrangement and may become a cooperating agency in such program.

STREAMBANK EROSION

Streambank erosion is a natural process which is often accelerated by channel straightening or realignment or by clearing of protective cover from banks. Soil particles dislodged from the streambank become sediment in the stream. This sediment can cover the bottom of the stream interfering with feeding and reproduction of aquatic organisms. It can cause a scouring effect which can damage aquatic organisms existing on the stream bottom. It can reduce light penetration into the stream, slowing photosynthesis and reducing vegetative and oxygen production. Other impacts due to sedimentation include loss of reservoir capacity, reduced recreation demand, increased drainage maintenance costs, reduced capacity of waterways, and increased potential for downstream flooding.

The District has approximately 1,278 stream miles subject to various degrees of streambank erosion. This District has tremendous erosion along the stream banks of the North and South Forks of both the Little Nemaha and Big Nemaha Rivers. In almost all instances notable erosion of the streambank has occurred and is adding to the sediment load of the rivers. Much of this is due largely to efforts in the 1920's when major projects were undertaken to realign or straighten these rivers. In subsequent years due to high velocity, the river beds eroded with river stream banks sloughing. Natural shifting of the stream channel has resulted along with accelerated bank erosion due to the channelization.

Although natural shifting of a channel is expected, farming to the edge of stream and river banks increases the instability of streambanks resulting in accelerated streambank erosion. The clearing of trees and placing of them in debris piles adjacent to the stream and river beds often helps increase streambank erosion due to high runoff carrying the trees into the water course. These trees also help redirect channel flow sometimes reflecting the velocity into the streambank increasing erosion thus degrading water quality.

The highly erosive soils contribute more than five tons per acre of sediment annually from cropland without sediment control. Erosion and sedimentation volumes are estimated to occur at an annual volume of about 12 million tons of soil with about 2 million tons reaching the Missouri River. Streambank erosion comprises a relatively small volume of total erosion although it is a serious problem in portions of the District.

POLICIES: STREAMBANK EROSION

The following policies are established as on-going procedures and objectives of the District's management of groundwater as related to streambank erosion. The extent and scope of each is to be carried out subject to required legislative authorization, promulgated rules and regulations, financial capability, and/or available personnel and resources.

1. Encourage landowners to participate in the existing habitat program administered by the District with financial

assistance from the Game & Parks Commission. The purpose of this program (WHIP - Wildlife Habitat Improvement Program) is protection and development of wildlife habitat, but it also serves to protect riparian lands and reduce streambank erosion. Preservation of existing habitat and conversion of marginal lands would be included. This could help to preserve a vegetative strip along streams and rivers that would provide additional protection against streambank erosion.

2. Encourage state statutes be amended to include consideration of potential downstream effects on water quality and flood hazard that may result from proposed channel modifications. The present Department of Water Resources floodplain permit program authorized by Section 2-1506.15 - 1506.27 provides for a review of proposed channel modification to assess the potential flood hazard to upstream and adjacent lands. Channel modifications, particularly realignments, present other potential erosion and flood problems which could be considered before state permits are issued. Realignments generally involve decreasing the original length of a given stream reach, which causes the velocity to increase. Increased velocities often result in bank and channel erosion. These problems continue upstream as the altered channel slope stabilizes. This material is transported and deposited downstream where velocities are lower. Potential flooding is also caused by channel realignment because channel storage is reduced.

   The amendments could be accomplished as part of a state assumption of the Section 404 permit program or if Section 404 program assumption does not occur, by amending the Department of Water Resources floodplain authority. If the latter route is taken, assessment of the water quality impacts should be provided by the Department of Environmental Control prior to issuance of the LB 108 permit by the Department of Water Resources.

3. Promote the development and funding of the PL566 Small Watershed and Flood Prevention Act to provide benefits of land treatment and watershed protection to streambank erosion control. Additional technical measures to assist in streambank stabilization could be included in this vital program well suited to this District.

   It should be noted various studies by the U.S Army Corps of Engineers have revealed the most economical and feasible approach to reducing streambank erosion is by continuing the implementation of the PL566 Small Watersheds and Flood Prevention Program.

   Sufficient funding for planning and development of non-operational watersheds in the District is of utmost importance to reducing flooding and subsequent streambank erosion.

4. Encourage adequate funding for the Agricultural Conservation Program (ACP), Rural Clean Water Program, and Nebraska Soil &

Water Conservation Program (NSWCP) to enable acceleration of conservation land treatment practices to be applied. Additional technical measures to assist in streambank stabilization could also be included in these programs.

5. Discourage land clearing and cultivation near streambanks to preserve a vegetative strip along streams. A vegetative strip would provide protection against streambank erosion.

6. The practice of placing dead trees and other vegetation in stream channels and immediately adjacent to the channel would be discouraged as it results in damage to structures in the channel and contributes to streambank erosion. Removal of dead trees and other vegetation from the area adjacent to the stream would be encouraged to prevent this material from eventually reaching the stream and contributing to structural and erosion problems. The proper utilization or disposal of these materials could be encouraged.

7. Encourage counties to replace bridges with road structures to reduce flooding, erosion, high maintenance costs of bridges, and stabilize stream channels. The District will continue to assist in the design and cost-share program for construction of road structures and encourage adjacent landowners to cooperate in this program.

When the District determines stringent policies need to be applied to correct problems adversely affecting reservoir life goals and water quality standards, the following streambank erosion policies may be applied as allowed by legislation, rules and regulations, and other means.

1. Encourage counties and cities to develop and adopt a riparian land zoning ordinance to control development and use along streams and rivers in areas within the District where streambank erosion is a problem or serious potential problem. Best management practices that could be used on riparian lands could be identified.

2. Encourage legislation to require all wildlife habitat monies available for preservation and development of new habitat to be used for easements for a buffer vegetative strip along and adjacent to where streambank erosion is occurring or a potential for streambank erosion exists.

POLLUTION FROM TRUCK WASHES, FERTILIZER AND PESTICIDE WASHDOWN FACILITIES

The Department of Environmental Control currently has an ongoing program which regulates these activities on a complaint basis. Because agriculture is the primary basis for Nebraska's economy, there are many facilities requiring washdown of equipment. Examples of these facilities are truck washes, elevators, cooperatives, aerial applicators, and custom mixers and applicators of herbicides and insecticides. The major waste product of environmental concern is wash water from these facilities. Tanks containing herbicides and insecticides are washed out prior to reuse on a daily basis. Many of these facilities are located in small communities and wash either into a road ditch, alley, or other areas in close proximity to their operation. Because of this public health becomes a major concern as well as the pollution aspects. Many of the complaints involve damage to neighbors' lawns, gardens, and trees.

Manpower is currently inadequate to handle this problem on any basis other than complaints. Annually approximately 12-15 complaints of this nature are controlled on a case-by-case basis. It is suspected that there are a large number of such facilities still in need of environmentally sound wash water practices.

POLICIES: WASHDOWN FACILITIES

The following policies are established as on-going procedures and objectives of the District's management of groundwater. The extent and scope of each is to be carried out subject to enacted legislation, financial capability, and required personnel.

1. Encourage the Department of Environmental Control to expand their existing programs from operation on a complaint basis to a uniform program to control the wash water from these facilities. Guidelines need to be developed for the control of wash water discharges. To properly address this problem within the District would require a compilation of a complete list of trucking, insecticide, and herbicide companies and farm elevators requiring or using wash down facilities.

2. Encourage the Department of Environmental Control and the Extension Service, University of Nebraska, to implement an educational program to those utilizing chemicals and other potential pollutants to be knowledgeable of proper washdown procedures.

STORAGE OF CHEMICALS & PETROLEUM

The storage of chemicals and petroleum products in the vicinity of water supply wells presents a significant threat of contamination of the water source. The Department of Health has documented several instances of contamination of the groundwater by petroleum products in the State. Detection of petroleum contamination is relatively simple because of the pronounced taste and odor associated with this type of contamination. Contamination by other products such as agricultural chemicals and fertilizers is not as readily detected but could be more hazardous to human health.

The Department of Health has the authority to regulate the siting of proposed public water supply wells and can usually prevent the location of such wells in the vicinity of bulk chemical or petroleum storage. Once a well is constructed, the Department has no authority to prevent the installation of storage facilities in the vicinity. The only recourse is to require abandonment of the well in the event contamination occurs.

The State Fire Marshal has authority to require that accidental discharge from storage facilities be prevented from reaching waterways (natural watercourses, public sewers, or drains). There is no provision for preventing groundwater contamination caused by infiltrating agricultural chemicals or petroleum products.

It is not believed the storage of chemicals and petroleum products present a problem within the District due to insufficient inventory data. The exception may exist due to the oil well field located in Richardson County near the communities of Dawson and Salem. Additional research and information needs to be sought to properly analyze whether such activities are contributing to ground and surface water pollution in the District. Such activities should examine whether runoff near the storage of petroleum sites and petroleum spillage near oil wells have allowed flowage of these pollutants into the watercourses, tributaries, and streams reaching the Big Nemaha River.

Storage of agricultural chemicals and petroleum products used on the farm is of concern to the District. The determination of whether these toxicants are contaminating ground and surface water supplies is unknown. Literally hundreds of abandoned wells and other drilled or dug holes are found throughout the District. These could permit chemical and petroleum products as well as other contaminants and pollutants to migrate into groundwater supplies. Since present authorities do not exist for examination of each agricultural producer, it is unknown whether the pollution of groundwater from these sources on the farm is significant.

POLICIES: STORAGE OF CHEMICALS & PETROLEUM

The following policies are established as on-going procedures and objectives of the District's management of groundwater. The extent and scope of each is to be carried out subject to enacted legislation, financial capability, personnel, and resources.

1. Encourage local industries, municipalities, county governments, and individuals to consider the possible hazards resulting from storage of chemicals especially where they could contaminate wells or streams.

2. Encourage the Department of Health and/or Department of Environmental Control to develop guidelines regarding the storage of chemicals and petroleum especially in areas where it might contaminate wells, streams, or the Nemaha River. Such guidelines should include suggested distances and suggested protective structures and best management practices.

3. Encourage the University of Nebraska Extension Service to promote and inform rural landowners having their own petroleum and chemical storage facilities of the guidelines to protect surface and groundwater from pollution and the hazards of improper handling and storage of these potential pollutants.

When the District determines stringent policies need to be applied to correct problems adversely affecting reservoir life goals and the groundwater quality, the following Improper Storage of Chemicals and Petroleum policies may be applied as allowed by legislation, rules and regulations, and other means.

1. Encourage legislative authorization for the Department of Health or the Department of Environmental Control to develop standards regarding storage of chemicals and petroleum especially in areas where it might contaminate wells, streams, or the Nemaha River. Such standards could include required distances and protective devices and structures such as roofs, walls, levees, and dikes. A permit system could also be developed to give a storage permit to those facilities that meet the standards. It would be illegal to store certain chemicals and petroleum products near wells or streams and the river systems without a storage permit.

SPILLAGE OR LEAKAGE OF PETROLEUM PRODUCTS AND DESIGNATED HAZARDOUS SUBSTANCES

Present regulations concerning spills of oil and hazardous materials cover only the reporting of such incidents and clean-up of those spills which may affect groundwater. Rule 4, Nebraska Water Quality Standards for Surface Waters, requires immediate notification of spills which may enter waters of the State. Rule 5, Nebraska Groundwater Protection Standards, requires notification and clean-up of toxic or taste and odor producing substances which may enter groundwater. These two rules still leave gaps concerning the clean-up in surface water, the specifics as to the responsible parties for clean-up, and the ultimate disposal of such containments.

Current authority for requiring the necessary steps of containment, clean-up, and disposal by the responsible party is contained in the general "Emergency Clause" authority of the Director of the Department of Environmental Control. This is not specific to spills of petroleum products and hazardous materials and leaves some question regarding its adequacy concerning these particular environmental emergencies.

Between January 1 and September 1, 1979, a total of eighty-one spills were reported. There was difficulty in initiating proper clean-up with four of these spills due to lack of rules and regulations. The severity of these four spills was significant. An effective spill program will become increasingly important when hazardous materials are designated in the near future.

It is not known whether spills or leakage of petroleum products and designated hazardous substances has been a problem within the District. However, it is believed future problems will exist due to the underground storage tanks of petroleum and chemicals becoming rusted and in deteriorated condition, thus permitting pollution of surface and groundwater resources.

In addition, transportation corridors, railroad lines, highways, and pipelines are potential sites of accidental spills and leaks of hazardous and other contaminating materials.

In the District are numerous buried gas and oil transportation systems and highways crossing the District. The Burlington Northern Railroad also has two major lines which have undergone extensive upgrading activity to accommodate the accelerated railroad traffic due to coal transportation. Having experienced several railroad derailments in recent years, opportunity exists for potential accidental spills and leaks of hazardous materials. Many of these transportation modes are located near tributaries and other water courses to the Nemaha River systems, thereby increasing the potential for surface and groundwater pollution.

The Cooper Nuclear Power Plant located near Brownville also presents potential pollution hazards although under very close federal observation and monitoring. If an accident occurs contamination would probably result in pollution of the Missouri River bordering the east edge of the District; however, due to

the confining levee dike around the plant, pollution of the groundwater may be possible.

POLICIES: SPILLAGE OR LEAKAGE OF PETROLEUM & HAZARDOUS SUBSTANCES

The following policies are established as on-going procedures and objectives of the District's management of groundwater. The extent and scope of each is to be carried out subject to financial capability and required personnel.

1. Encourage the Environmental Control Council to develop a data base of all industrial facilities in the District to include the following information:

   a. Types and sizes of sites
   b. Locations
   c. Chemical processes used
   d. Types and quantities of chemicals
   e. Materials stored and used at the sites
   f. Information on the characteristics of these materials
   g. Waste and material handling plans and procedures used

   This data would be used to identify industrial sites having the potential to contaminate the environment and underlying water.

2. The Department of Environmental Control and the State Fire Marshal are urged to document and develop a data base on what is known about the transport of hazardous and potentially contaminating material throughout the District. It should include the identification and evaluation of transportation modes and methods and corridors commonly used in this transport relative to their water pollution potential in the event of spills or leaks of materials during transport.

3. Encourage the Department of Environmental Control to develop and biannually evaluate an emergency preparedness plan to protect the groundwater resources from becoming polluted resulting from transportation of hazardous and contaminating materials throughout the District. The District should be informed of such plan and subsequent changes.

4. The Environmental Control Council should adopt regulations governing discharges or emissions of petroleum products and other hazardous materials into the waters, in the air, or upon the land of the District. The Council could consider methods for prevention of such discharges or emissions and the responsibility of the discharger or emitter for clean-up, toxicity, degradability, and dispersal characteristics of the substance.

   With the adoption of such regulations, enforcement would be handled in the routine manner through county courts. Voluntary compliance regarding containment, clean-up, and disposal would be discussed by phone at the time of spill notification. The Department of Environmental Control assists responsible parties in protecting against human or

animal exposure, clean-up, and proper disposal methods. Enforcement and subsequent fines would be levied in cases of willful negligence, intentional spills, or refusal of the spiller to carry out his responsibilities as stated in the regulations.

5. Encourage the reporting of spills or leakage that has occurred to the State Fire Marshall or the Department of Environmental Control. Legislation to be encouraged to require the reporting of accidental spills by the party responsible without penalty.

GROUNDWATER PLAN IMPLEMENTATION

The District has identified specific programs and activities which will be implemented to carry out the policies stated in this groundwater management plan. Although a number of the policies adopted in various areas of concern will require additional authorization by the State Legislature, the District will be able to take specific action within existing authorities and also request others such as local, state, and federal agencies to utilize their agency programs and authorities to assist in carrying out this groundwater plan of work and policies adopted by the Nemaha Natural Resources District.

Specific programs and actions to be implemented as on-going activities by the District will be implemented beginning January 1, 1986. Some of the listed activities will require additional sources of revenue to be acquired before the programs can be successfully implemented. Other programs will be budgeted utilizing local revenue. The District continues to seek the necessary funding required to properly address and implement this groundwater plan and actively pursue the carrying out of the needed programs to achieve sound management of the water resources.

Responsibilities to be carried out are as follows:

1. Expand the District's Well Monitoring Program. The District is presently monitoring approximately 50 wells throughout the Nemaha River Basin. Efforts will be undertaken to explore expanding the monitoring uiltizing the base maps in the Groundwater Management Plan to determine need and location for additional monitoring wells for each management area. The Division of Conservation and Survey will be requested to assist in determining where additional wells need to be monitored.

2. Initiate Groundwater Modeling Programs. Additional information will be needed within Management Area I and Management Area II. Efforts will be made to program the initiation of studies similar to the 1983-85 study performed by Bob Hiergesell, "Analysis of the Stream-Aquifer System Neal Cook, Nebraska, Using a Finite-Difference Digital Groundwater Model." These additional studies will need to be expanded to obtain specific data to further delineate the boundaries of Management Areas I and II.

3. Recording Wells. The District will expand its monitoring program to include at least one recording well to be located within Management ARea II. The Division of Conservation and Survey will be requested to assist in determining the location of the well and the Geological Survey will be encouraged to provide the recorder and monitor the readings with assistance from the Division of Conservation and Survey.

4. The District will explore the testing of water quality samples of groundwater in Nebraska State Laboratory

facilities to enable the establishment of a water quality program specifically addressing nitrates and other water polluting chemicals significant within the District.

5. The District will request all municipalities to develop a program to include an implementation plan to reduce quantity of water used within the municipality. This plan should define actions to be taken by the municipal government in the event of groundwater shortage.

6. Each municipality will be requested to periodically evaluate the potential for water pollution from urban runoff. The cities, towns, and villages will be encouraged to adopt ordinances where applicable to reduce water quality pollution considering erosion and sediment control, zoning, solid waste, storage of chemical, oil, and lubricants, and building codes to protect the soil and water resources.

7. Communities with unapproved solid waste disposal sites will be requested to either perform corrective measure or close their solid waste sites making other arrangements for the transport of solid wastes to approved sites.

8. Request the Department of Environmental Control to study and evaluate the nine solid waste sites identified as having water pollution potential and initiate actions to either close or have preventative measures taken to assure the groundwater and surface water is not polluted.

9. The District will request communities and villages with approved solid waste sites to either provide trained site operators to monitor the operation of the sites or consider moving solid waste disposal operations into licensed county landfill or approved sites where operators are provided.

10. The District will encourage urban and rural citizens to cease indiscriminant dumping of solid wastes and chemicals in gullies, eroded areas, and county road rights-of-way where a potential of contamination to surface and groundwater exists. This will be carried out by news articles, on-site investigation, etc.

11. City and county officials will be requested to utilize the District's technical and professional resources to review construction site designs and plans to assure the soil and water resources are protected from contamination and pollution during construction. The District's information will be provided to planning and zoning commissions or boards prior to considering approval of plans and issuance of permits.

12. Contractors will be encouraged to promote best management practices in site location and installation of septic systems to prevent pollution of surface and groundwater resources. This request will be made during annual contractor workshops and meetings with District officials.

13. Municipalities will be encouraged to require permits to allow for the installation of new modification of septic systems when the installation meets approved standards and specifications to prevent groundwater and surface water pollution. The District will make available technical assistance upon request to determine soil suitability for the septic system.

14. The District will request municipalities and landowners not to construct or develop septic systems and drainage fields within flood plains of rivers, streams, and lakes.

15. The District will develop and informational educational program to alert and request landowners to properly close and seal abandoned wells found throughout the District at abandoned and active farmsted sites and in pastures. The District will provide information on proper procedures to adequately close and seal such wells to prevent contamination of the groundwater resources. When such wells are known, the District will contact the property owner and request action to be taken to properly seal the abandoned well.

16. The District will contact each well driller within the Nemaha NRD and urge well drilling activities be performed in accordance with minimum well drilling standards to prevent groundwater pollution. The District will sponsor a workshop for well drillers to provide information on proper safeguards to prevent groundwater pollution.

17. The District will request county officials to prohibit agricultural cultivation and planting of row crops in rural road drainage ways and to reseed all disturbed areas during the reconstruction of a road or construction of new roads.

18. The District will discourage all stream channelization on the Nemaha Rivers and their tributaries to prevent streambank erosion.

19. The District will investigate a modification of the Wildlife Habitat Improvement Program (WHIP) to permit cost-share funds for habitat areas be restricted to marginal and other areas adjacent to streams to protect and reduce streambank erosion.

20. The District will continue to provide cost-share funds to county governments to replace bridges with road grade stabilization structures to reduce flooding, erosion, and pollution of surface and groundwater resources.

21. The District will request assistance from the Department of Environmental Control to inventory the washdown facilities for trucking, insecticide, and herbicide companies and farm elevators requiring the use of wash-down facilities in order to develop a program to prevent pollution of surface and groundwater resources.

22. The District will prepare an inventory of abandoned military missle silos throughout the District and request the Department of Defense to return to these sites and take necessary actions to seal and prevent these silos from contaminating the groundwater resources since many of the silos extend into the aquifer.

23. The District will request the Department of Environmental Control to assist in the inventory of all industrial facilities which store, use, and dispose of waste materials which have a potential to contaminate the environment and underlying groundwater resources.

24. The District will continue to provide local and available state funds to landowners to apply conservation practices which promote groundwater and surface water efficiency, reduction of soil loss and pollution of the surface and groundwater resources.

25. The District will investigate the expansion of its program to provide irrigation water flow meters to promote water use efficiency.

26. The District will investigate the artesion flow systems to determine minimum flow requirements and methods to restrict flows of those systems not used for beneficial purposes.

27. The District will continue to promote and make available cost-share funds to landowners to reduce soil and water pollution by construction of grade stabilization structures in eroded areas.

28. The District will continue its efforts to promote and obtain adequate funding for the accelerated land treatment program available through PL566 Small Watersheds Program.

29. The District will continue to investigate complaints from landowners damaged from irrigation return flows of adjacent landowners. All complaints will be handled within the rules and regulations adopted by the District to control runoff from groundwater resources.

30. The District will provide assistance to municipalities experiencing groundwater pollution from nitrates and other chemicals when the District either receives requests from the municipalities or when information is provided from the Department of Health and other agencies that a health problem exists with domestic water supplies. The assistance will consist of development of a program to assist in identification of point sources of pollution and selection of location and sources of a water supply that complies with standards for safe drinking water.

31. The District will continue to be responsive to individual and other requests and complaints on activities occurring which adversely impact the groundwater and surface water quantity and quality. All concerns brought to the attention

of the District will be properly investigated and appropriate action taken to resolve viable problems.

32. The District will initiate action to obtain additional data and studies in groundwater quality and water supply supplemental sources to complement present information and supply to meet the groundwater reservoir life goals. Upon receiving this information, the District will make needed adjustments, modifications, and additional policies to this Groundwater Management Plan.

33. Efforts will be made by the District to actively pursue authorization identified in policies to allow for actions to be taken by the District and other agencies which will allow for implementation of programs and activities which will address and resolve problems in surface and groundwater management. The District will work to see such legislative authority be prepared and enacted to adequately address the water problems maintaining local control where possible. Actions of the District will be directed to always obtain cooperation and assistance to correct resource problems prior to seeking legislative authorization.

The District will initiate educational and informational programs utilizing the following methods to implement groundwater management plan policies:

1. Prepare articles and news releases for local radio stations in Falls City, Auburn, Nebraska City, and Beatrice. News releases will be prepared for newspaper publications in Nebraska City, Syracuse, Auburn, Tecumseh, Beatrice, Pawnee City, Humboldt, Falls City, and the "Voice" published by the District.

2. Training sessions and workshops will be either co-sponsored or sponsored by the District for landowners, contractors, city and county officials, and other individuals who have responsibilities for management and operations which directly impact the soil and water resources as presented in the groundwater management plan.

3. Presentations will be made by District officials and staff to individuals, groups, and organizations to provide educational information on groundwater and surface water resources problems, policies, and actions by the District to address problems in groundwater management and total resource management.

4. The District will utilize other methods such as demonstrations, fair displays, tours, and other opportunities to inform the public and those who can provide assistance in correcting specific and general soil and water management as related to groundwater and surface water management.

5. The District will seek cooperation and assistance from local, state, and federal agencies to help provide education, information, resource data, studies, research, and technical assistance. The District will urge these agencies to help

implement voluntary and stringent policies identified in this plan.

Topics to be addressed in the aforementioned educational and informational programs to be implemented by the District will include the following:

1. Proper use, handling, storage, and discarding of pesticides, herbicides, fertilizers, and other chemicals as well as petroleum products.

2. Benefits and use of backflow preventative devices on water systems which will prevent groundwater contamination.

3. Benefits and need for application of best management practices of rural, urban, and industrial lands.

4. Benefits and need for application of soil and water conservation practices to protect the water resources.

5. Identification and control of ground and surface water pollution sources.

6. Annual progress reports of the District's well monitoring program and status of the District's groundwater reservoir life goals.

7. Programs available to reduce and control irrigation return flows to prevent damages and waste of water resources.

8. Proper pasture and range management practices and available programs and assistance to reduce pollution from animal wastes, soil erosion, etc.

9. Best management practices on the application of animal wastes to cropland.

10. Management practices to improve water use efficiency such as irrigation scheduling, soil moisture blocks, conservation tillage, and other farming practices identified to adequately treat the land while protecting water resources.

11. Operation and maintenance of wastewater treatment plants and solid waste sites and impacts of these facilities on surface and groundwater resources.

12. Best management practices to control urban and construction site runoff which can pollute the surface and groundwater resources.

13. Proper methods for siting, installation, and modification of septic systems to prevent ground and surface water pollution.

14. Proper siting, drilling, casing, sealing, and plugging of domestic, stock, irrigation, and industrial water wells.

PUBLIC INVOLVEMENT

This groundwater management plan affects each citizen within the District. It is, therefore, important to seek input from all citizens to understand not only the groundwater resource but also future plans and objectives to protect this valuable resource.

The District Board of Directors recognizing the importance of public involvement developed the following program for preparation of this groundwater plan which would allow concerned citizens to become involved and offer suggestions to manage the resources.

Ad-Hoc Subcommittee

A subcommittee was selected by the NRD Board of Directors to serve as a special subcommittee to formulate the development of the Nemaha Natural Resources District groundwater management plan.

Subcommittee members: James Hunzeker, Chairman
Don Larson
Richard V. Pella
James T. Truscott
Lorin Wusk

Questionnaire

The newly organized Ad-Hoc Subcommittee published a special edition of the NRD "Voice" in June, 1985, to solicit comments and answers to several groundwater concerns. Results of the survey clearly showed a concern that there will be groundwater problems in the future. A tabulation of the questionnaire results is shown on Page 116.

Special Citizens Advisory Subcommittee

Following the preparation of the first draft of the District's groundwater management plan, a special subcommittee was organized to review and submit recommendations on the draft proposal. This subcommittee as selected included:

Dr. Alfred Gigstad, Chairman, Veterinary, Nebraska City
Elaine Wentz, Johnson County Commissioner, Sterling
Ervin Kehlenbeck, Mayor, Syracuse
Charles Hunzeker, Manager, Central Soya Plant, Humboldt
Ruth Ann Schultz, Housewife, Brock
Don Block, Water Department Superintendent, Syracuse
Fred Baumert, Manager, Pawnee County Rural Water District, Pawnee City
Jim Lowe, Plant Manager, Campbell Soup Company, Tecumseh
Bill Brockley, Manager, Nebraska City Utilities
Herman Royal, Farmer, Palmyra
Joy Klaasmeyer, Farmer/Irrigator, Burr
Lester M. Coleman, State Department of Health, Falls City

This subcommittee volunteered its efforts spending four evenings to thoroughly evaluate the draft proposal. Recommendations were submitted to the District calling for omission, changes, and addition to the plan. These recommendations were accepted in total by the NRD Ad-Hoc Subcommittee.

Public Hearings

Two public hearings were scheduled with one in Humboldt on December 10, 1985. The second public hearing on the final draft plan was held in Syracuse on December 16, 1985. Concerned citizens attending the hearing were encouraged to offer testimony on the plan.

FINAL ADOPTION

This plan was adopted on the 19 day of December, 1985, by the Board of Directors of the Nemaha Natural Resources District.

/s/ Richard Lubben

Chairman, Nemaha Natural Resources District

NRD VOICE

Nemaha Natural Resources District
★ SPECIAL EDITION ★
June, 1985

Will we always have plenty of water? Is our water suitable for babies? Are nitrates dangerous in our water? Are agricultural chemicals polluting our water supply? Does our water taste good? Are groundwater controls necessary? Do we have enough water for industry to move into our communities? Should irrigation be allowed to expand?

PUBLIC NOTICE

Public views are urgently needed by the Nemaha Natural Resources District to help identify groundwater concerns in southeast Nebraska. Local citizens are strongly encouraged to respond to this special edition of the "Voice" by completing the following simple questionnaire and mailing or returning it to the NRD office at 125 Jackson, Box 717, Tecumseh, Nebraska 68450, no later than July 15, 1985.

This request for citizen input results from adoption of LB1106 enacted by the Nebraska Unicameral requiring the Nemaha Natural Resources District to have a "Groundwater Management Plan" prepared by January, 1986.

"Every man, woman, child in the NRD should be concerned about our water supply and quality of the water," commented Jim Hunzeker, NRD Groundwater Subcommittee Chairman, adding, "and many communities like Johnson, Adams, Peru, and others have experienced water quality problems." Johnson recently required bottled water for infants. Peru and Peru State College have wrestled with mineral problems for many years, and in some locations good water has to be blended with poor water to yield acceptable water. Is there enough water for everyone?

Please take a couple of minutes and respond to the following questions:

GROUNDWATER MANAGEMENT PLAN QUESTIONNAIRE

1. Do you believe there is or will be in the near future a groundwater problem in the Nemaha Natural Resources District area?

   ☐ Yes ☐ No

2. What do you believe to be the existing or potential problems?

   ☐ Water Table Declines
   ☐ Water Table Inclines
   ☐ Water Quality
   ☐ Other _____

3. Indicate below which are the worst problems in water quality. (Place a priority on the problems with 1 as the worst, 5 as the least concerned problem).

   ☐ Nitrates
   ☐ Insecticides
   ☐ Herbicides
   ☐ Minerals
   ☐ Other Contaminants _____
   _____

4. Indicate what you believe are sources of water contaminants.

   ☐ Abandoned Wells
   ☐ Irrigation
   ☐ Hazardous Waste Sites (Chemical Storage, etc.)
   ☐ Aerial Sprays
   ☐ Other _____
   _____

5. What do you see as necessary methods to control water quality/water quantity problems as identified above?
   - ☐ Well Spacing
   - ☐ Chemical Application Regulations
   - ☐ Fertilizer Application Regulations
   - ☐ Regulations for Abandoning Wells
   - ☐ Conservation by Irrigation Scheduling
     - ☐ Voluntary
     - ☐ Regulated
   - ☐ Limit Construction of New Wells
   - ☐ Create Stricter Regulations for Well Construction

6. I use groundwater for the following purpose.
   - ☐ Household
   - ☐ Livestock
   - ☐ Irrigation of Crops
   - ☐ Industrial Purposes
   - ☐ Other _____

7. Other Comments: _____

I reside in _____ or in _____.
(Town) (County)

****

In order to gain additional input from all areas of the District and special interest groups, the NRD will form a "Citizens Advisory Subcommittee". This subcommittee will assist the NRD in assessing the groundwater concerns, potential problems, and possible management plans for the District.

The subcommittee will be represented by the following:

Cities/Villages/County Boards
Irrigators
Center Pivot Chemigator
Industrial User
Livestock Industry
Individual Domestic User (Dryland Farmer)
Farm Organization Representative
Rural Water District
Center Pivot Non-Chemigator
Gravity Irrigator
Irrigation Dealer
Well Driller
Environmental Organization Representative
Citizens from Conflict Area
(Draw Down During Pumping Season)

I am concerned about future management of groundwater in southeast Nebraska and would be willing to serve if selected on this "Citizens Advisory Subcommittee".

_____ _____
Name Address

_____ _____
Telephone Number Representing (One of the Groups or Interests Listed Above)

PLEASE MAIL THIS QUESTIONNAIRE TO:
NEMAHA NRD
P.O. Box 717 - Tecumseh, Nebr. 68450
(No Later Than July 15)

GROUNDWATER MANAGEMENT PLAN QUESTIONNAIRE

1. Do you believe there is or will be in the future a groundwater problem in the Nemaha Natural Resources District area?

   116 -- YES
   9 -- NO

2. What do you believe to be the existing or potential problems?

   59 -- Water Table Declines
   2 -- Water Table Inclines
   117 -- Water Quality
   13 -- Other

3. Indicate below which are the worst problems in water quality. (Place a priority on the problems with 1 as the worst, 5 as the least concerned problem).

	1	2	3	4	5
Nitrates	85	8	16	4	4
Insecticides	32	35	35	8	2
Herbicides	33	39	26	13	1
Minerals	8	11	4	47	16
Other Contaminants	6	2	3	12	40

4. Indicate what you believe are sources of water contaminants.

	1	2	3	4	5
Abandoned Wells	34	4	5	1	1
Irrigation	51	2	3	2	1
Hazardous Waste Sites	82	5	0	1	0
Aerial Sprays	48	3	3	3	0
Other	42	0	1	0	2

5. What do you see as necessary methods to control water quality/water quantity problems as identified above?

22 -- Well Spacing

95 -- Chemical Application Regulations

92 -- Fertilizer Application Regulations

55 -- Regulations for Abandoning Wells

81 -- Conservation by Irrigation Scheduling

- 21 -- Voluntary
- 57 -- Regulated

28 -- Limit Construction of New Wells

45 -- Create Stricter Regulations for Well Construction

6. I use groundwater for the following purpose:

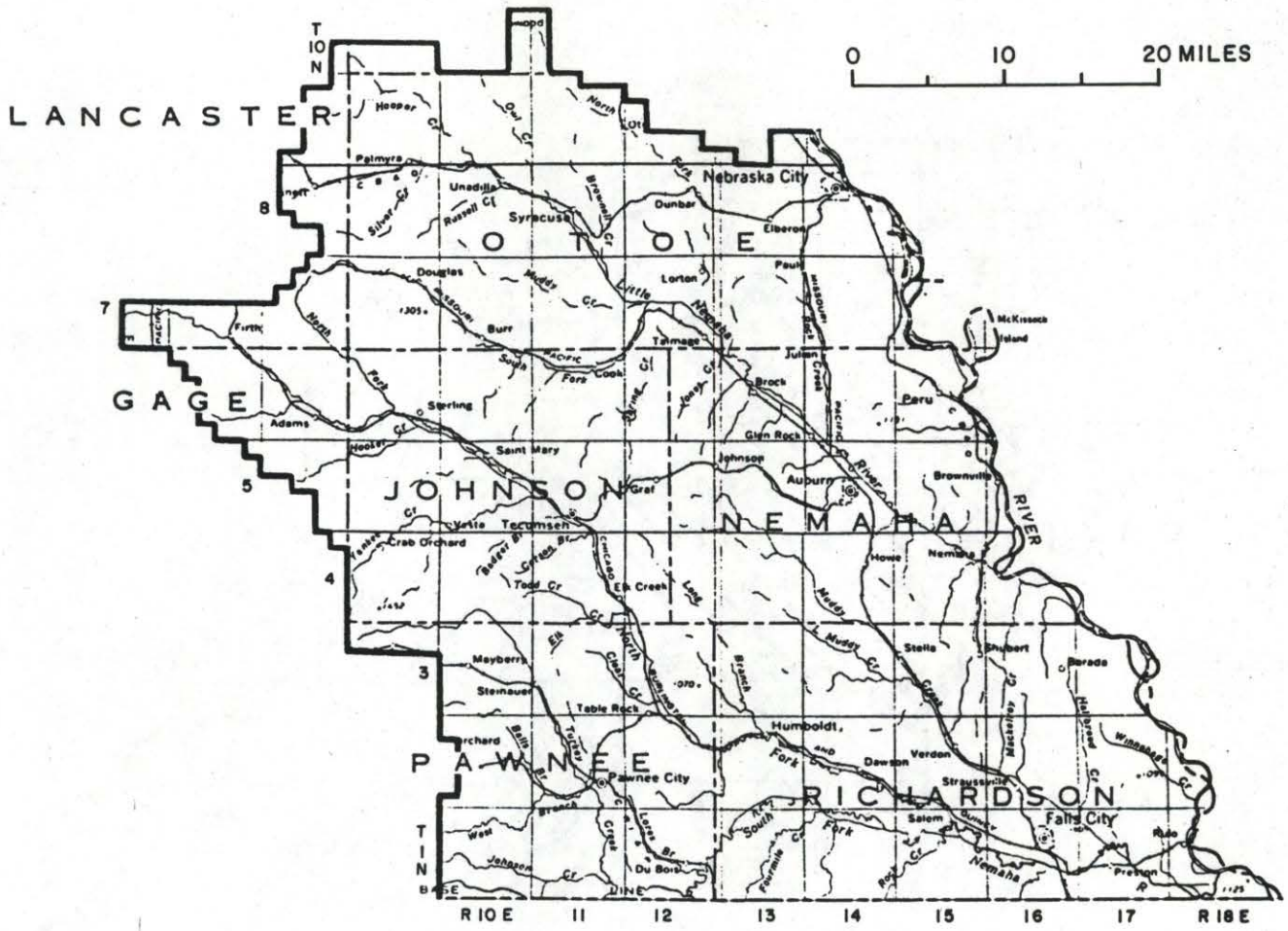
119 -- Household

78 -- Livestock

9 -- Irrigation of Crops

3 -- Industrial Purposes

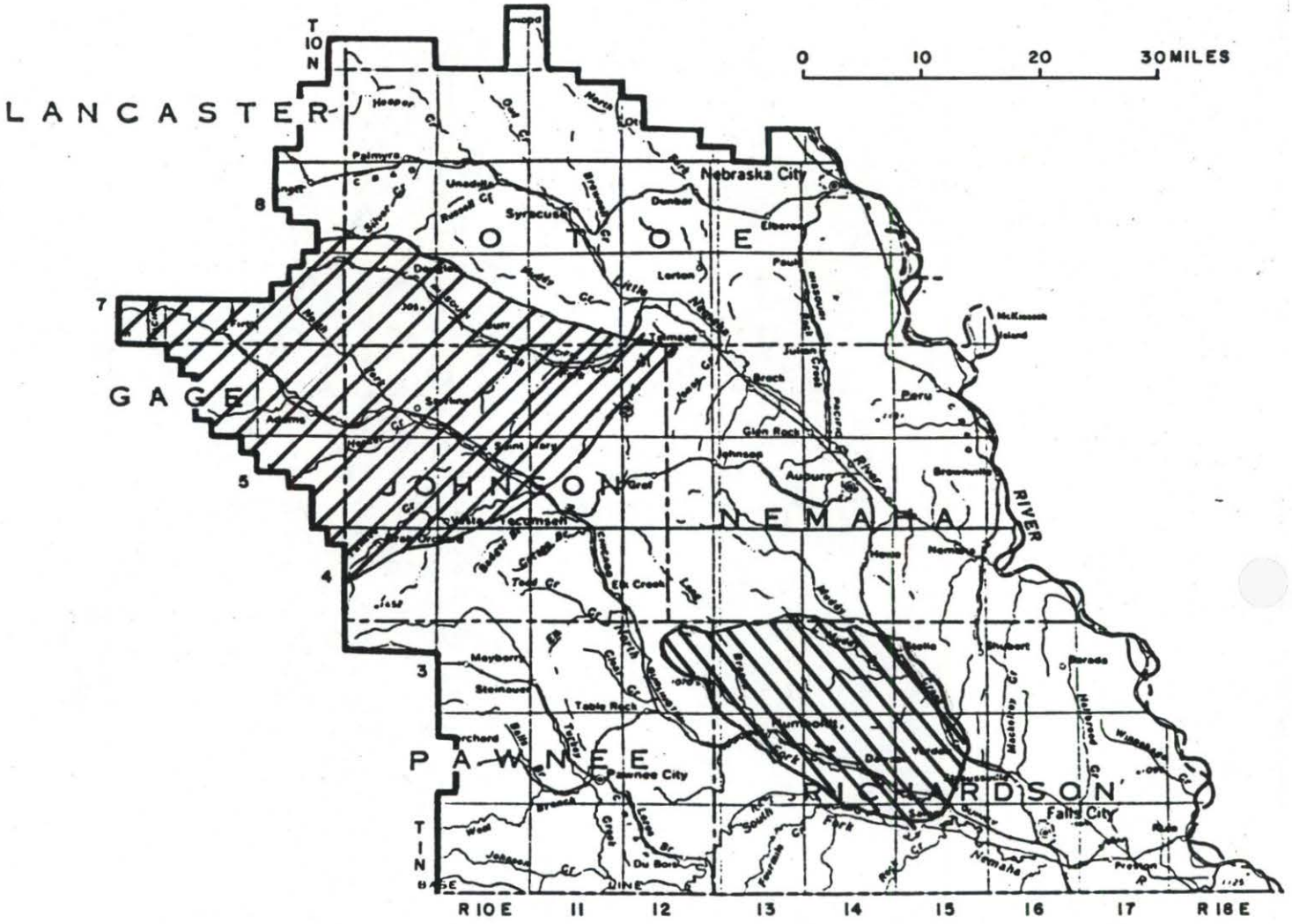
14 -- Other



NEMAHA NATURAL RESOURCES DISTRICT

Figure 1

GROUNDWATER MANAGEMENT AREAS

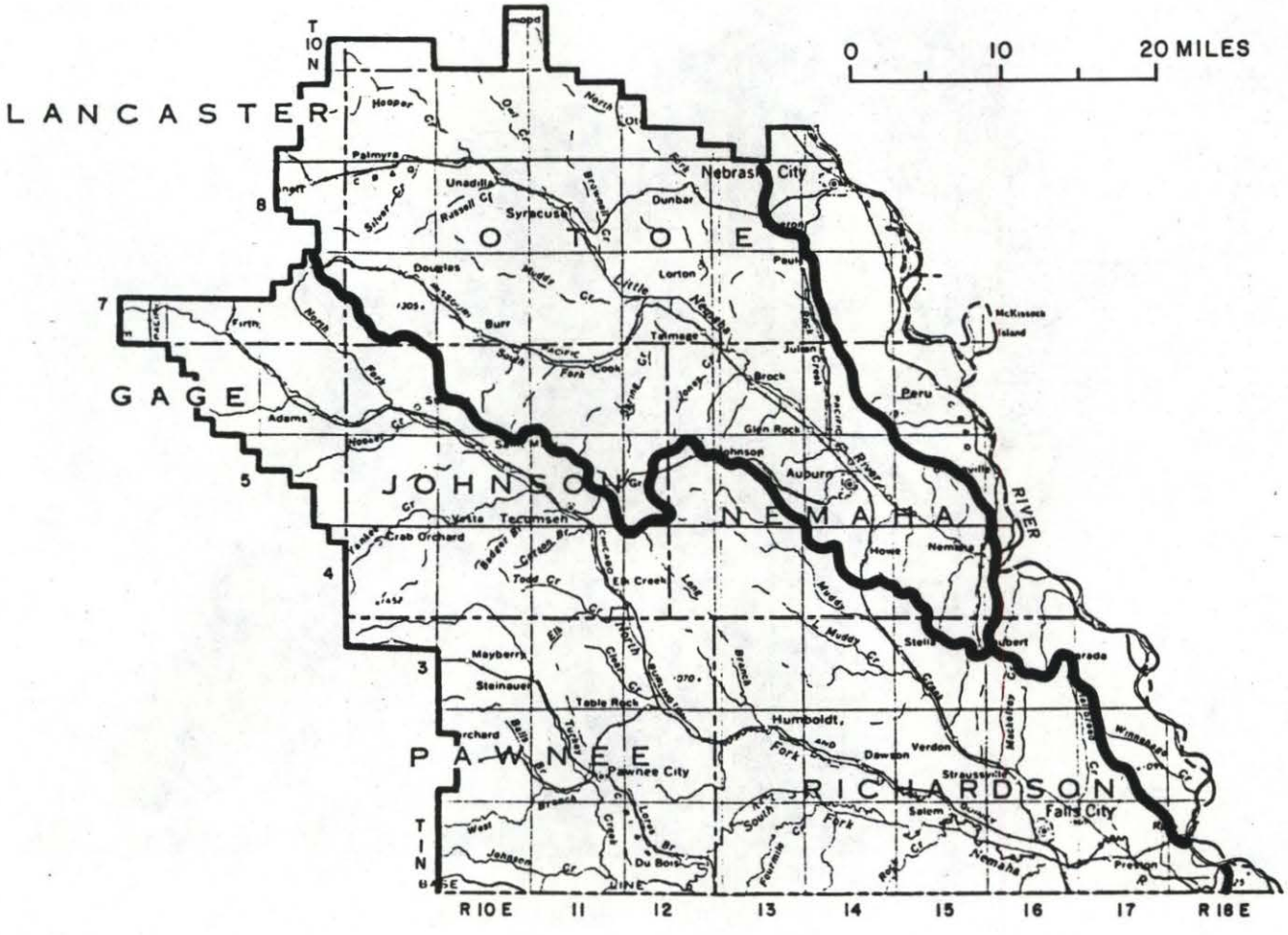


MANAGEMENT AREA I

MANAGEMENT AREA II

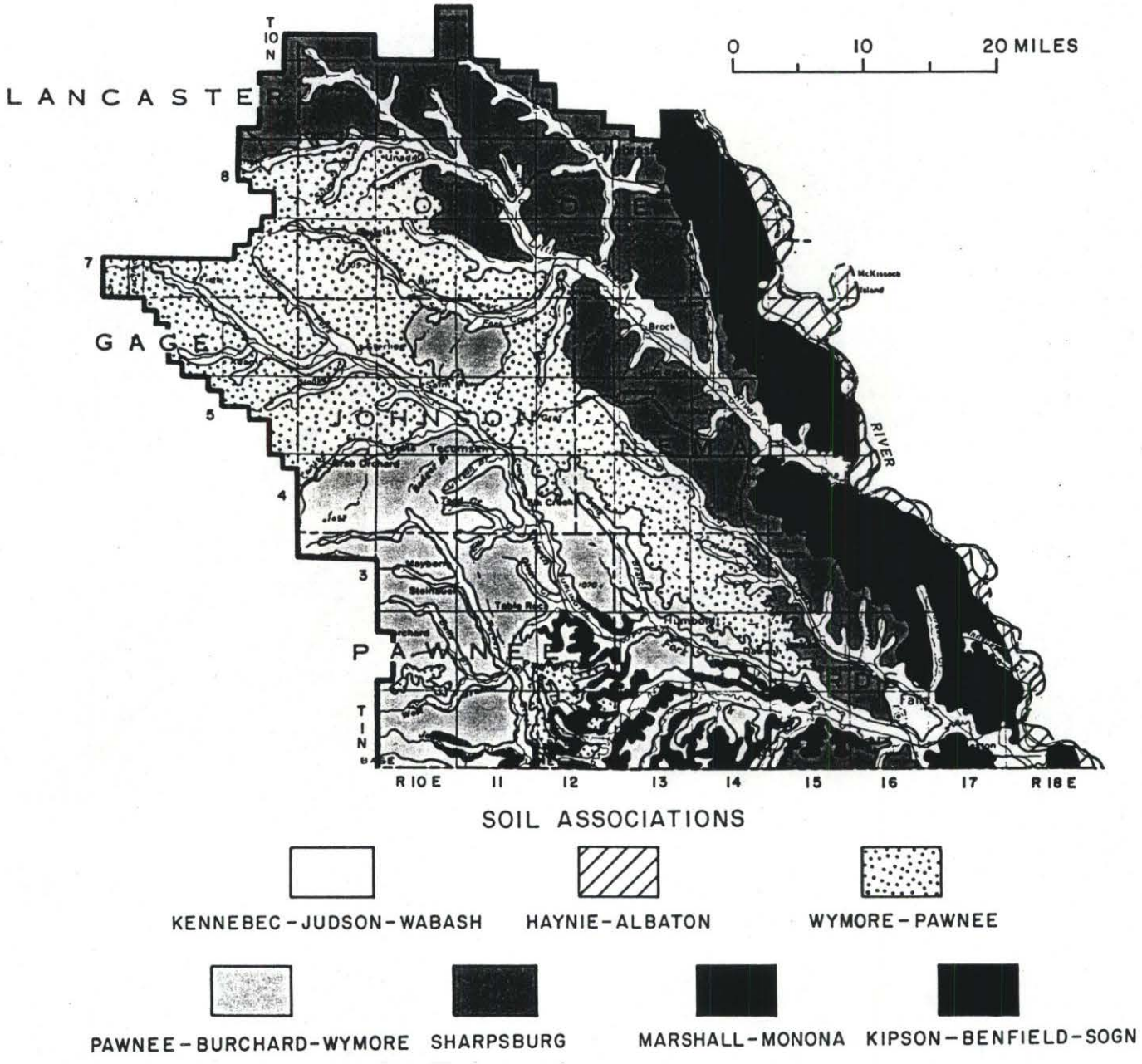
(Remainder of NRD Area) MANAGEMENT AREA III

Figure 2



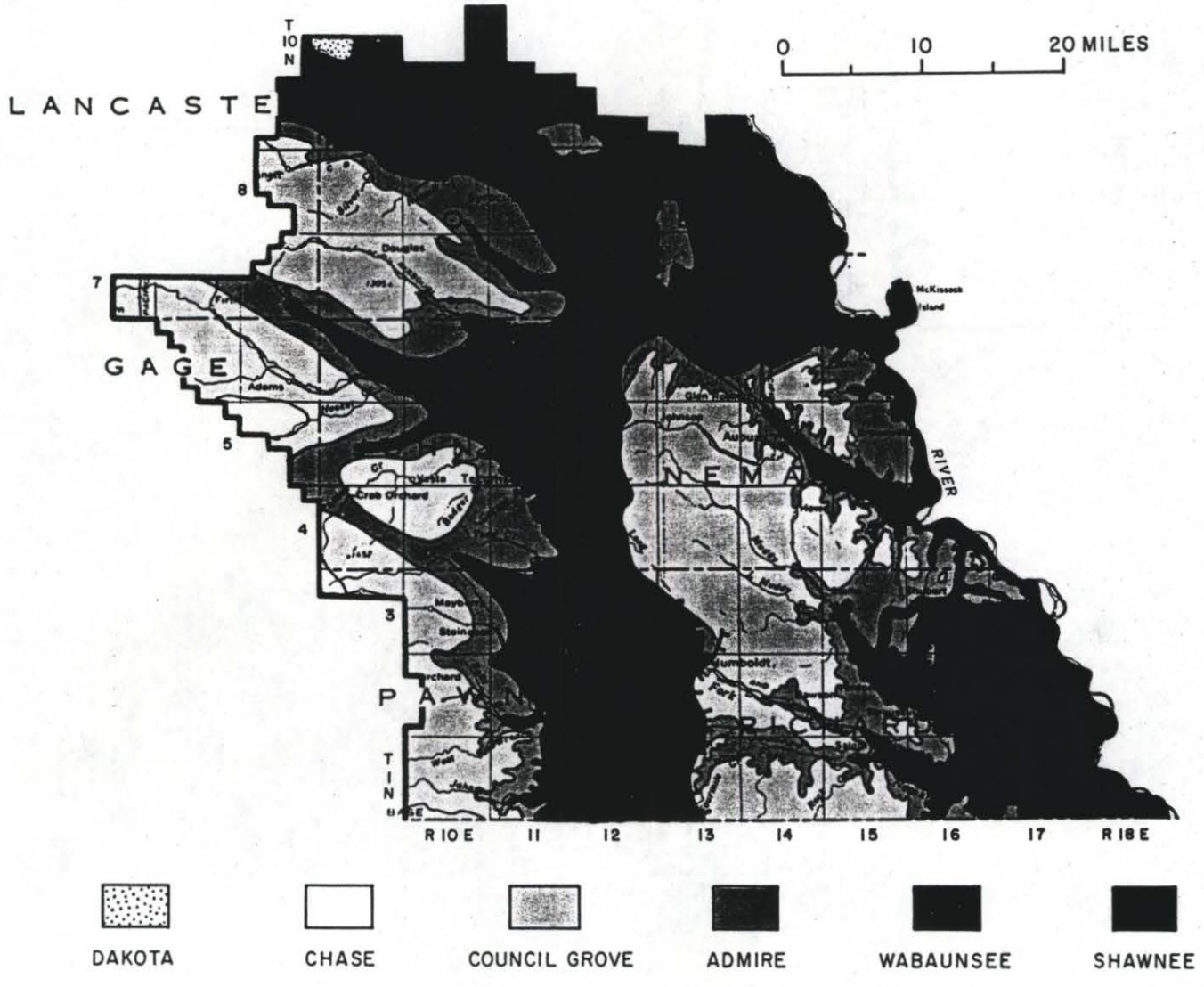
LITTLE & BIG NEMAHA RIVER WATERSHEDS

Figure 3



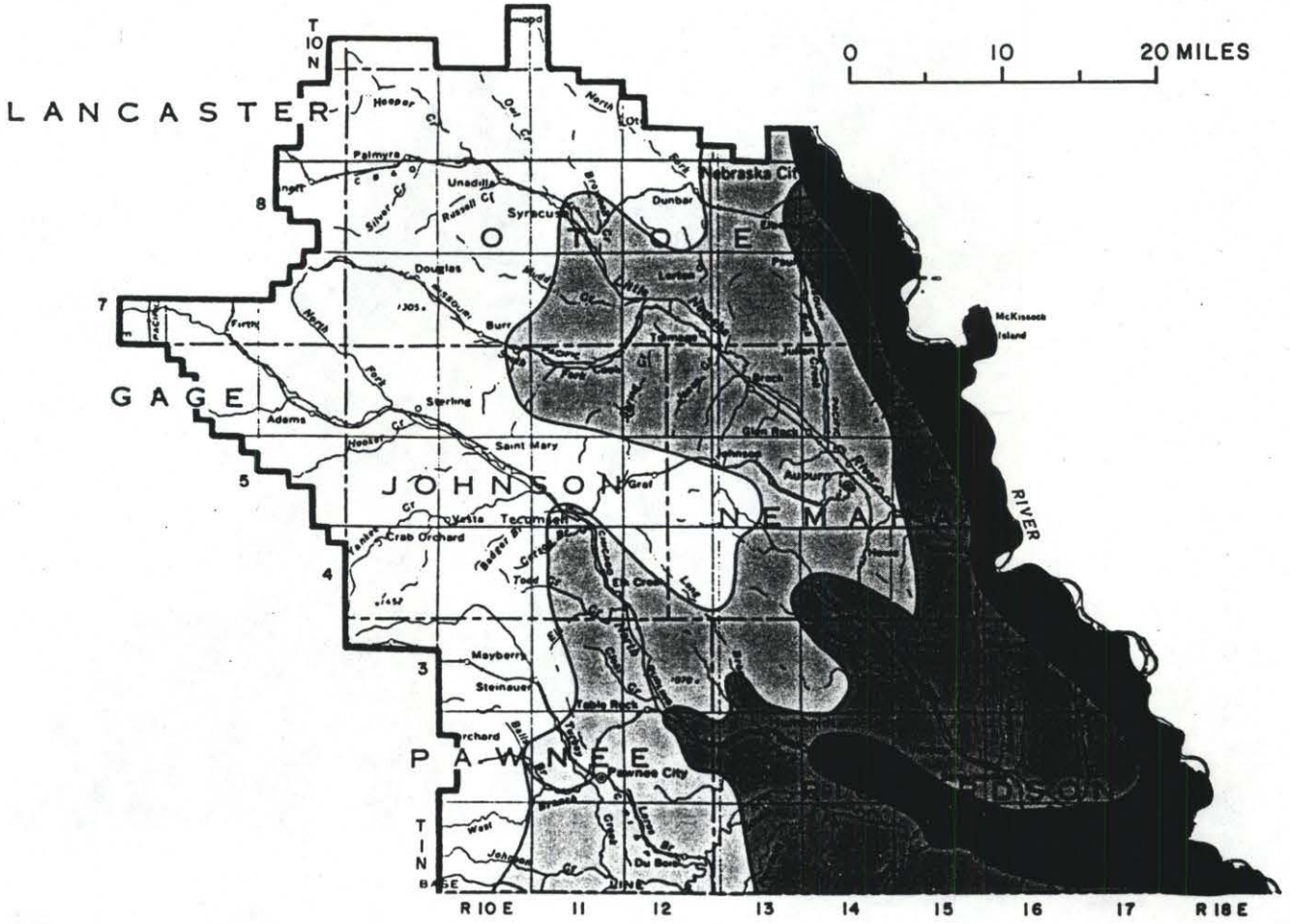
GENERAL SOIL MAP

Figure 4



GENERALIZED GEOLOGIC BEDROCK MAP

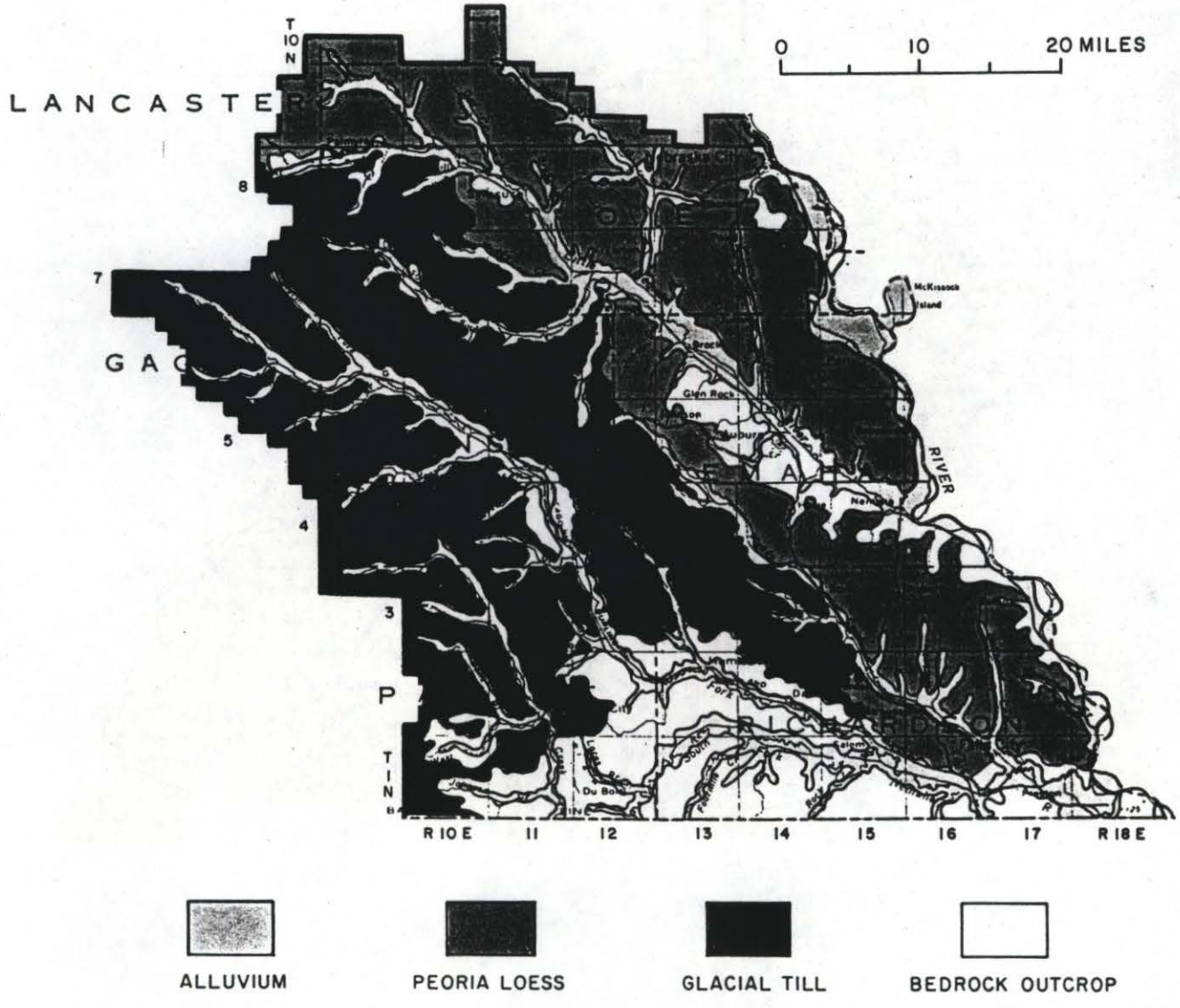
Figure 5



	TONS/SQ. MI./YR.	AC. FT./SQ. MI./YR.
	1000-3000	0.7-2.0
	3000-4000	2.0-2.6
	4000-5000	2.6-3.3
	5000-6000	3.3-3.9

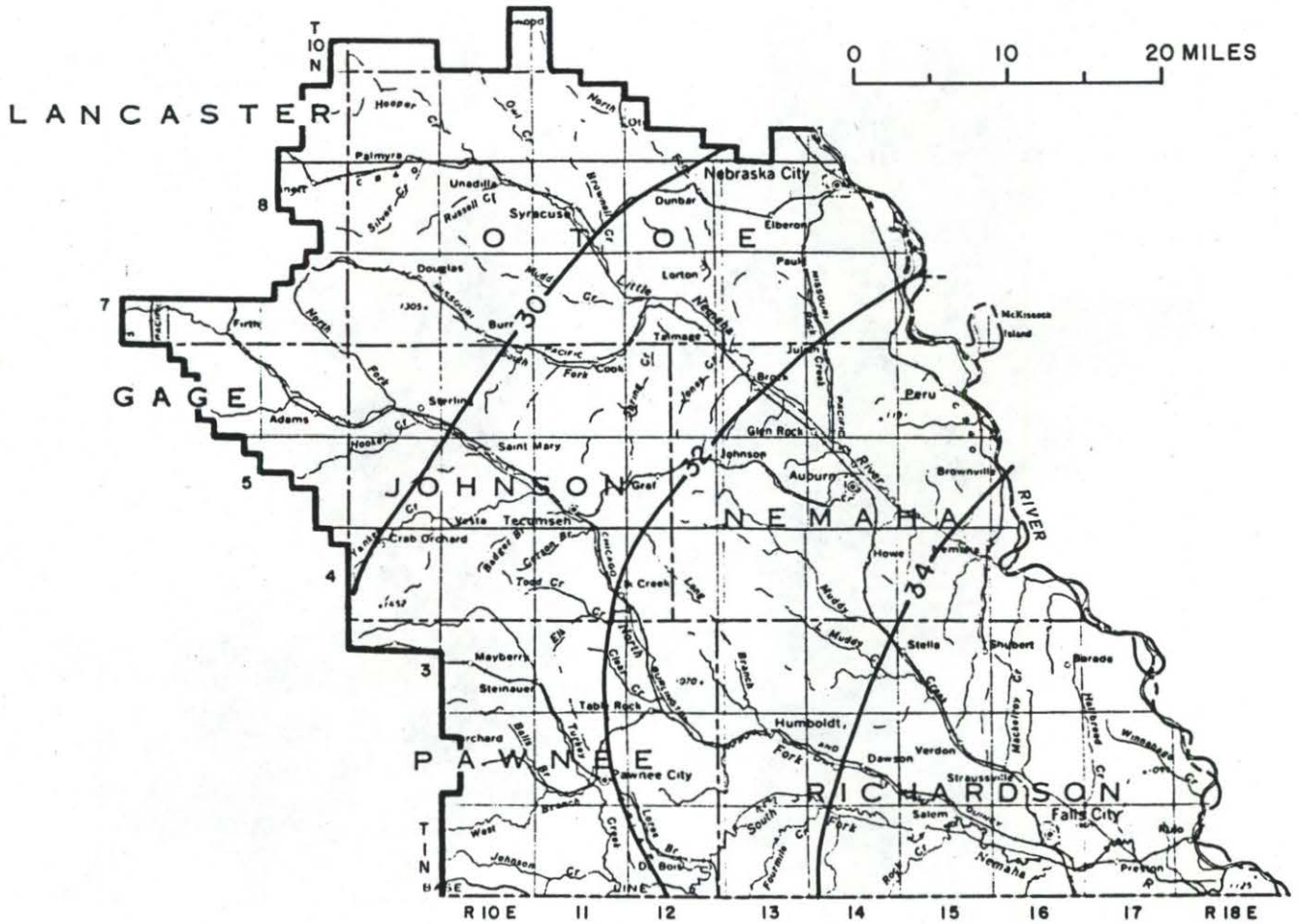
GENERALIZED SEDIMENT YIELD

Figure 6



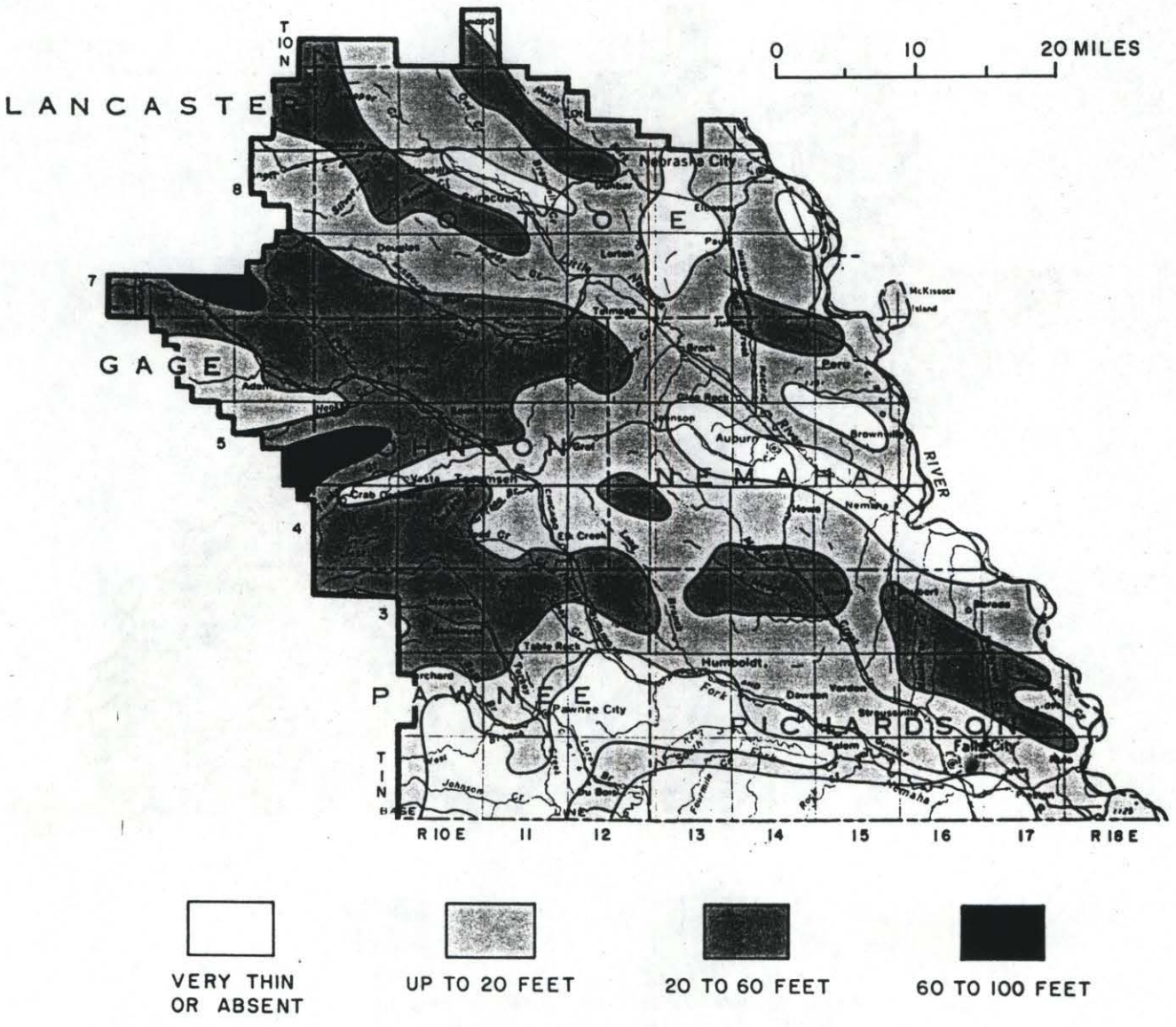
PLEISTOCENE DEPOSITS

Figure 7



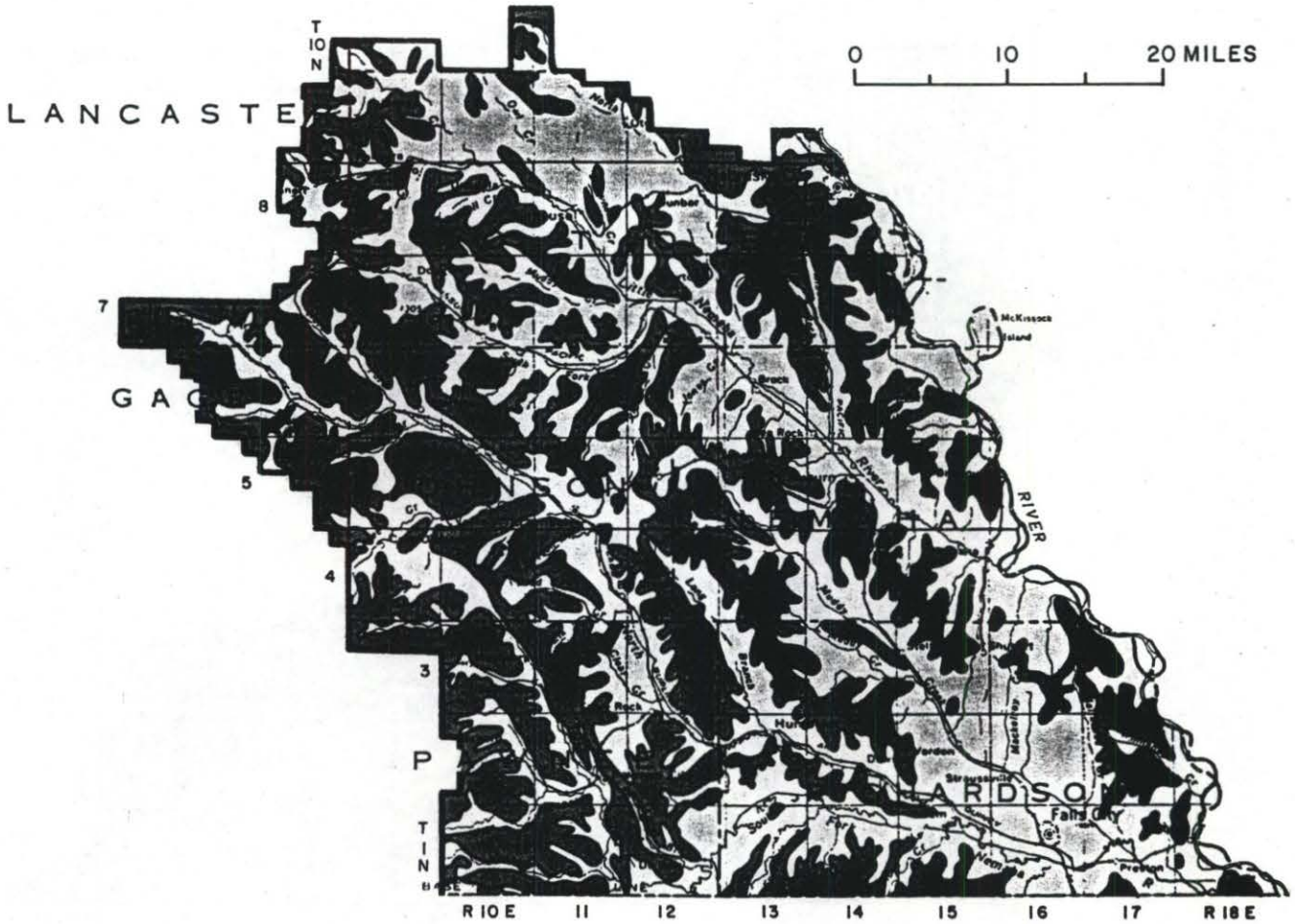
MEAN ANNUAL PRECIPITATION - ZONES

Figure 8



GROUNDWATER IN STORAGE IN THE PRINCIPAL AQUIFER

Figure 9

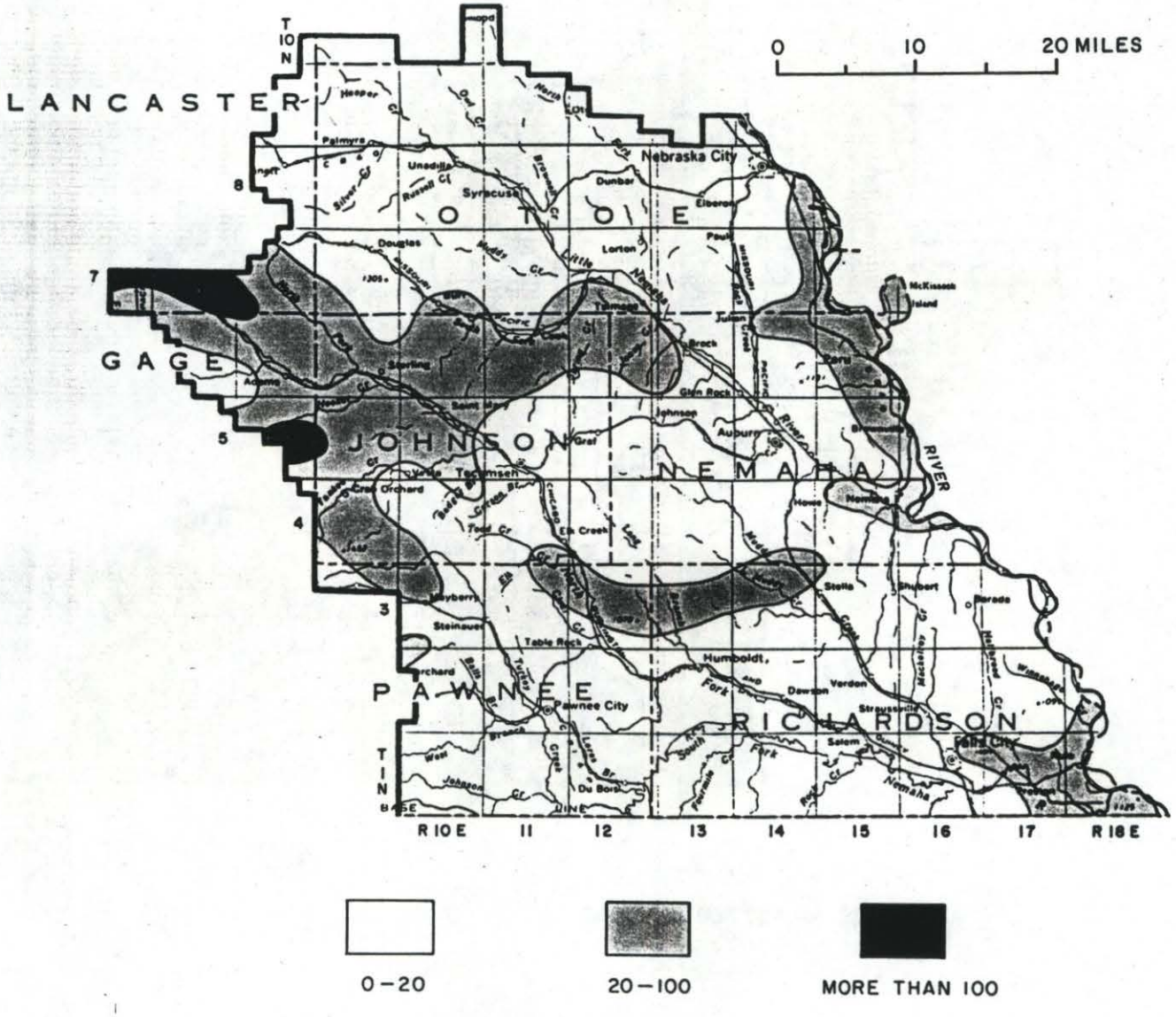


0-50 FEET
Recharge potential may be limited by shallow depth to saturated zone

OVER 50 FEET
Recharge potential includes storage in both fine and coarse textured material in unsaturated zone

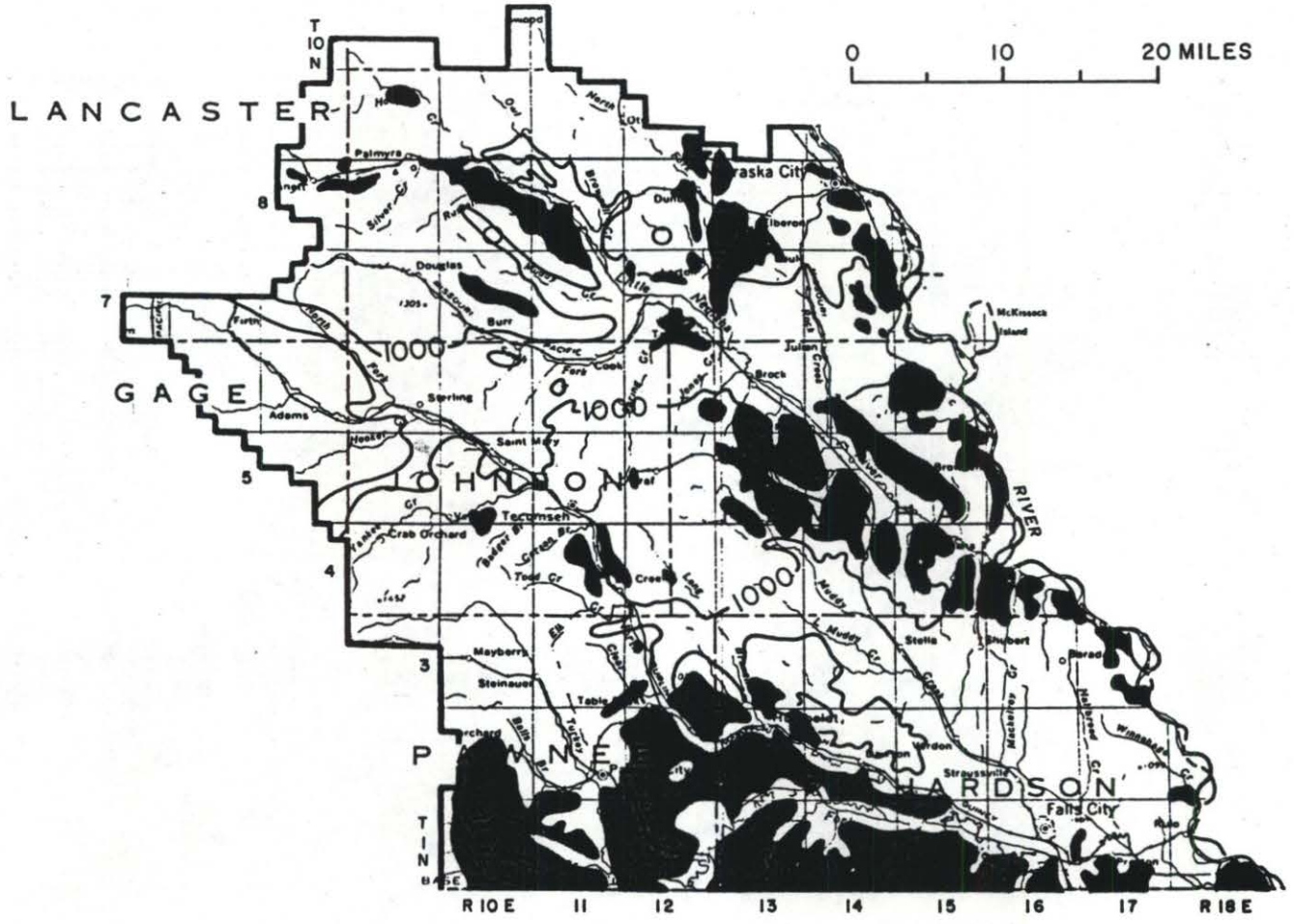
GENERALIZED DEPTH TO WATER

Figure 10



TRANSMISSIVITY OF PRINCIPAL AQUIFER

Figure 11



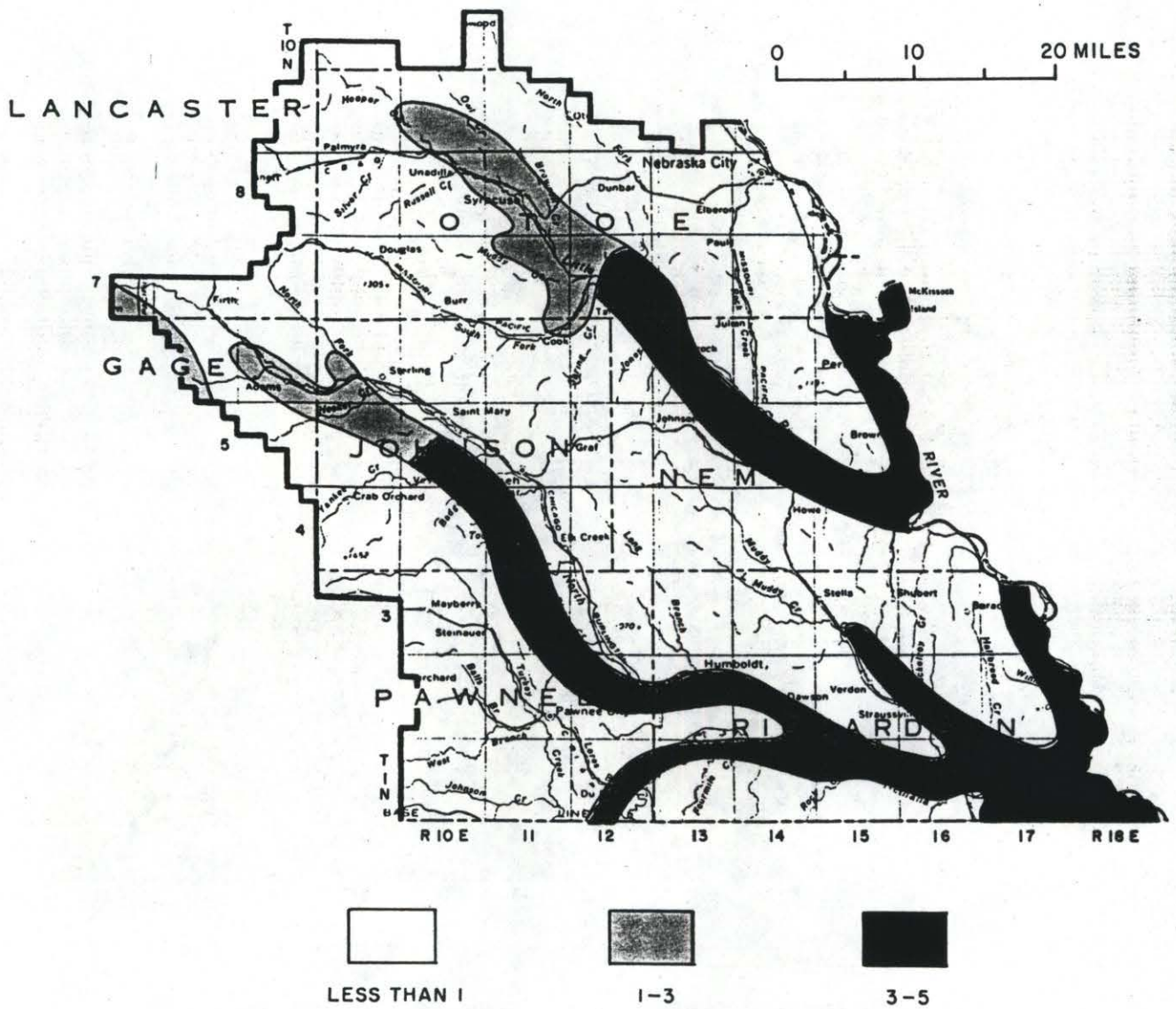
—— 1000 ——

BASE-OF-AQUIFER CONTOURS
(Contour interval 100 feet. Datum is mean sea level.)

PRINCIPAL AQUIFER ABSENT OR VERY THIN

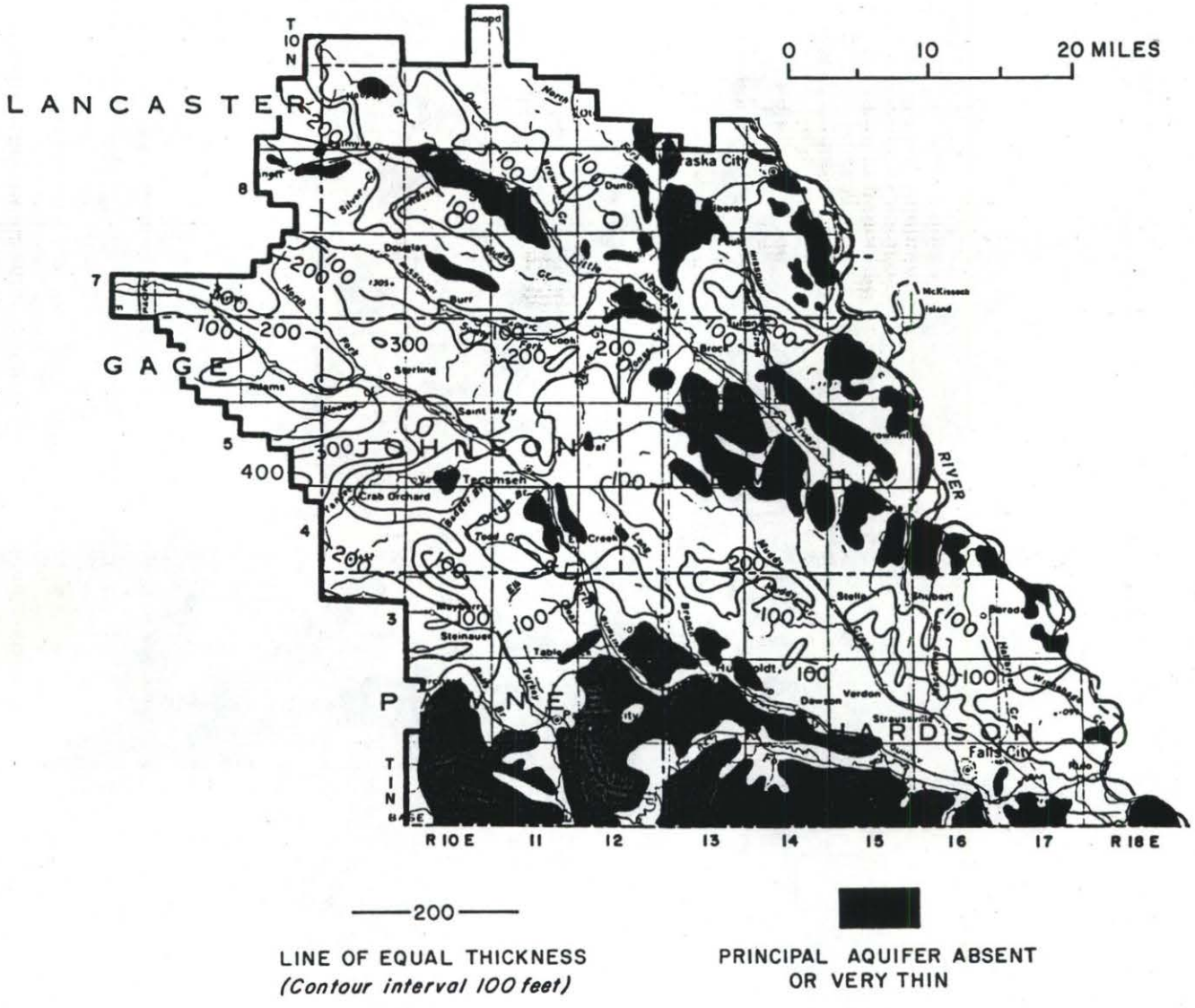
CONFIGURATION OF BASE OF PRINCIPAL AQUIFER

Figure 12



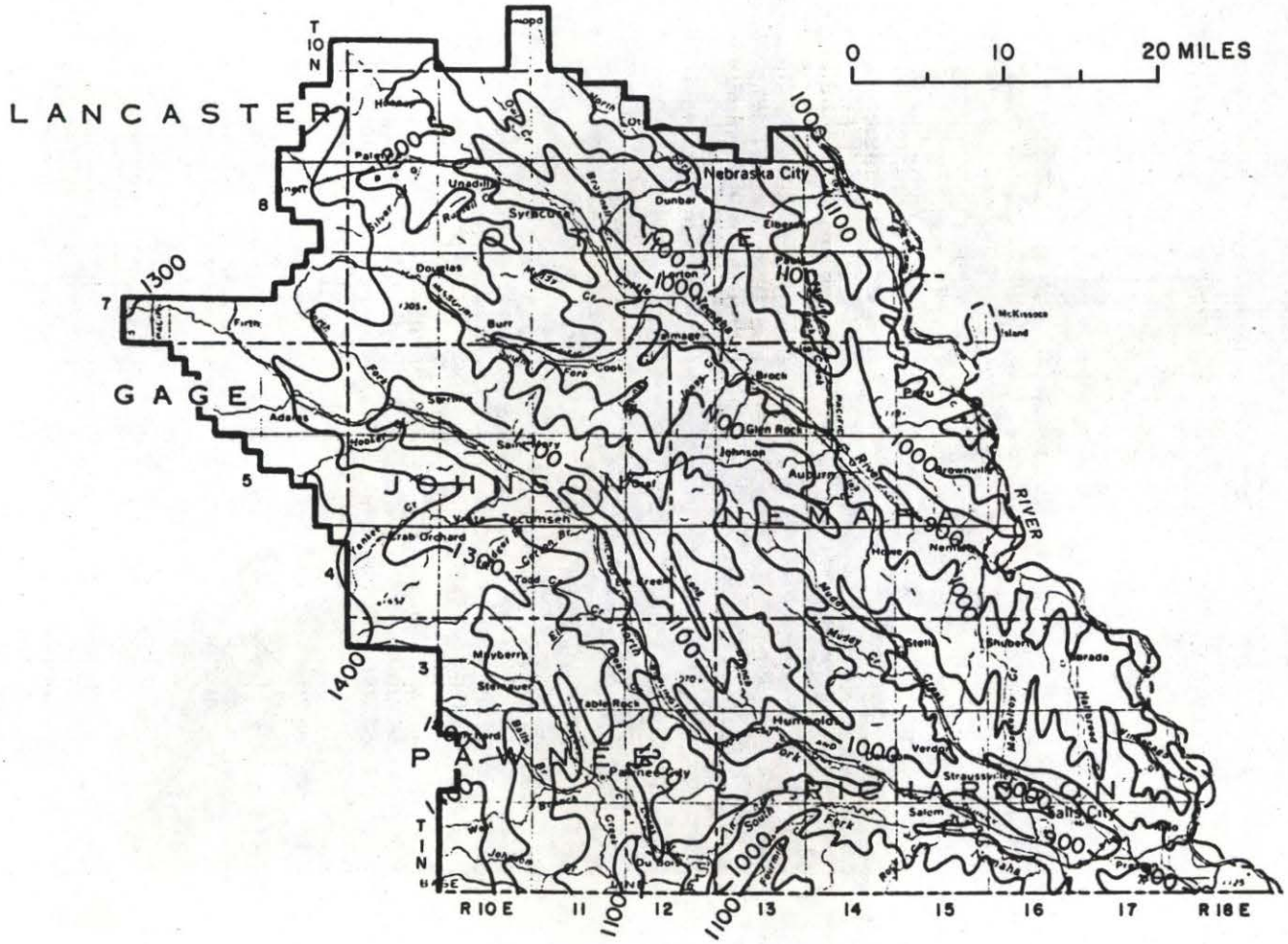
AVERAGE ANNUAL RECHARGE TO GROUNDWATER FROM PRECIPITATION SOURCES IN INCHES

Figure 13



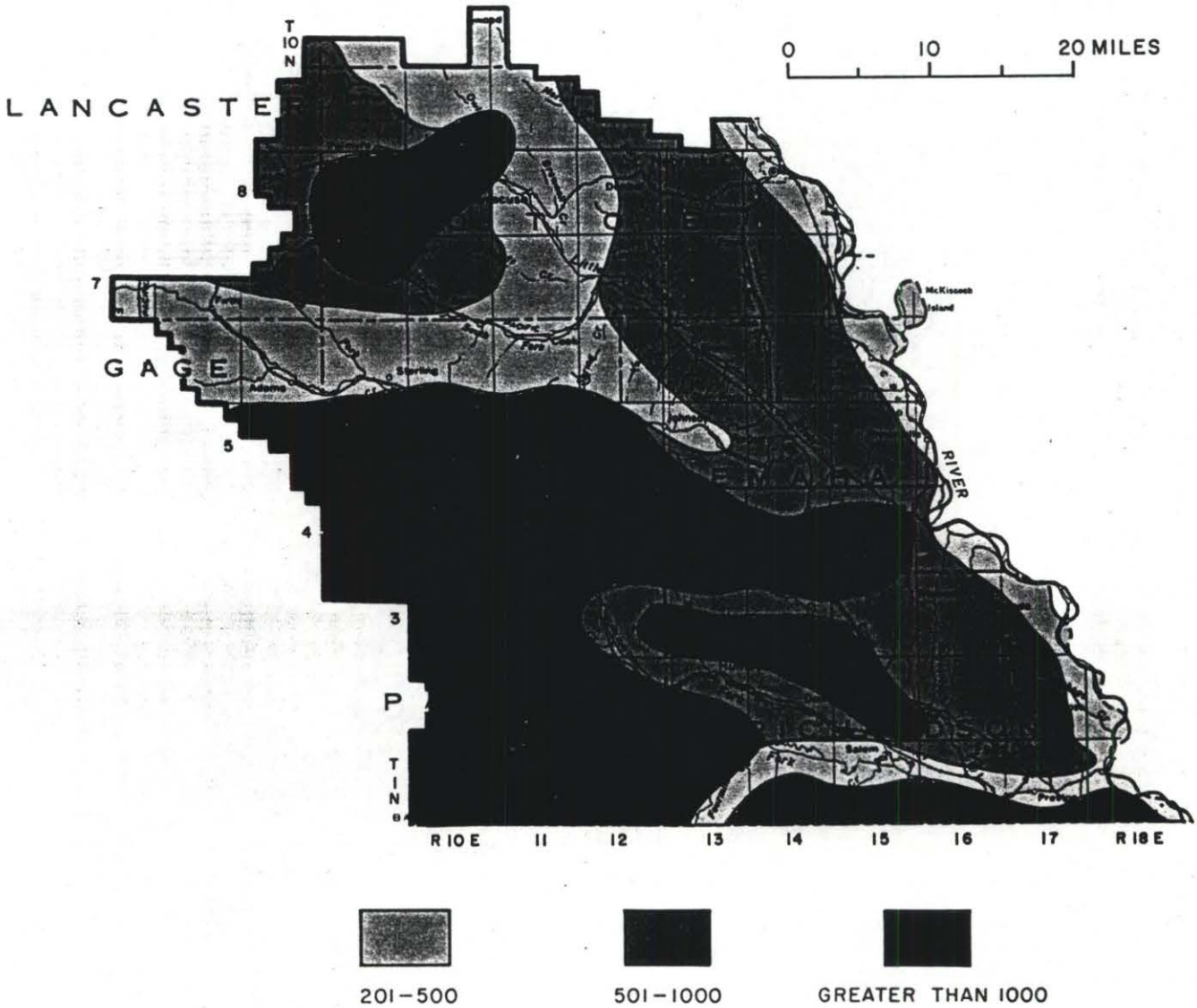
THICKNESS OF PRINCIPAL AQUIFER - 1979

Figure 14



CONFIGURATION OF WATER TABLES - SPRING, 1979

Figure 15



Zones of Concentration - milligrams per liter

CONCENTRATION OF DISSOLVED SOLIDS IN THE AQUIFERS OF THE NEMAHA NRD

Figure 16

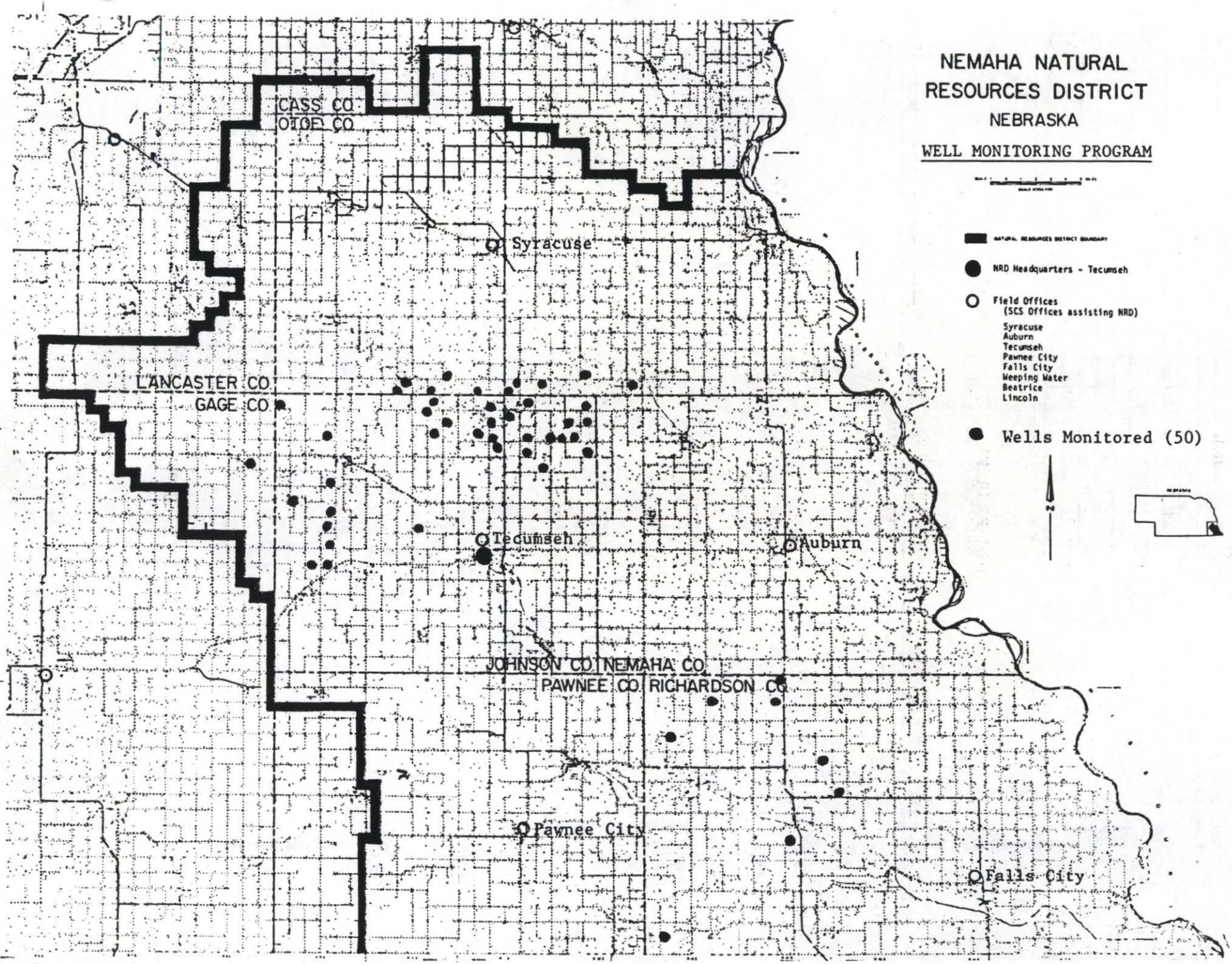

NEMAHA NATURAL
RESOURCES DISTRICT
NEBRASKA
WELL MONITORING PROGRAM
NATURAL RESOURCES DISTRICT BOUNDARY
NRD Headquarters - Tecumseh
Field Offices
(SCS Offices assisting NRD)
Syracuse
Auburn
Tecumseh
Pawnee City
Falls City
Weeping Water
Beatrice
Lincoln
Wells Monitored (50)
N
CASS CO
OTOE CO
LANCASTER CO
GAGE CO
JOHNSON CO
NEMAHA CO
PAWNEE CO
RICHARDSON CO
Syracuse
Tecumseh
Auburn
Pawnee City
Falls City

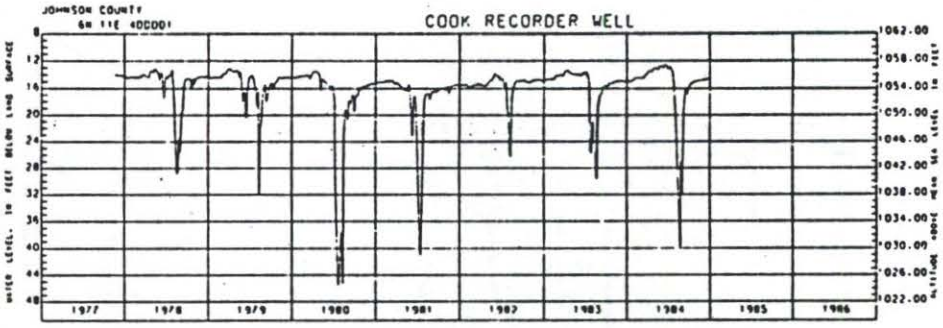
Figure 17

Johnson County: Cook

Estimated predevelopment water level: 13 ft

Net water-level change in 1984: +0.38 ft

Net water-level change since 1977: −0.30 ft



1984 COOK RECORDER WELL MEASUREMENTS

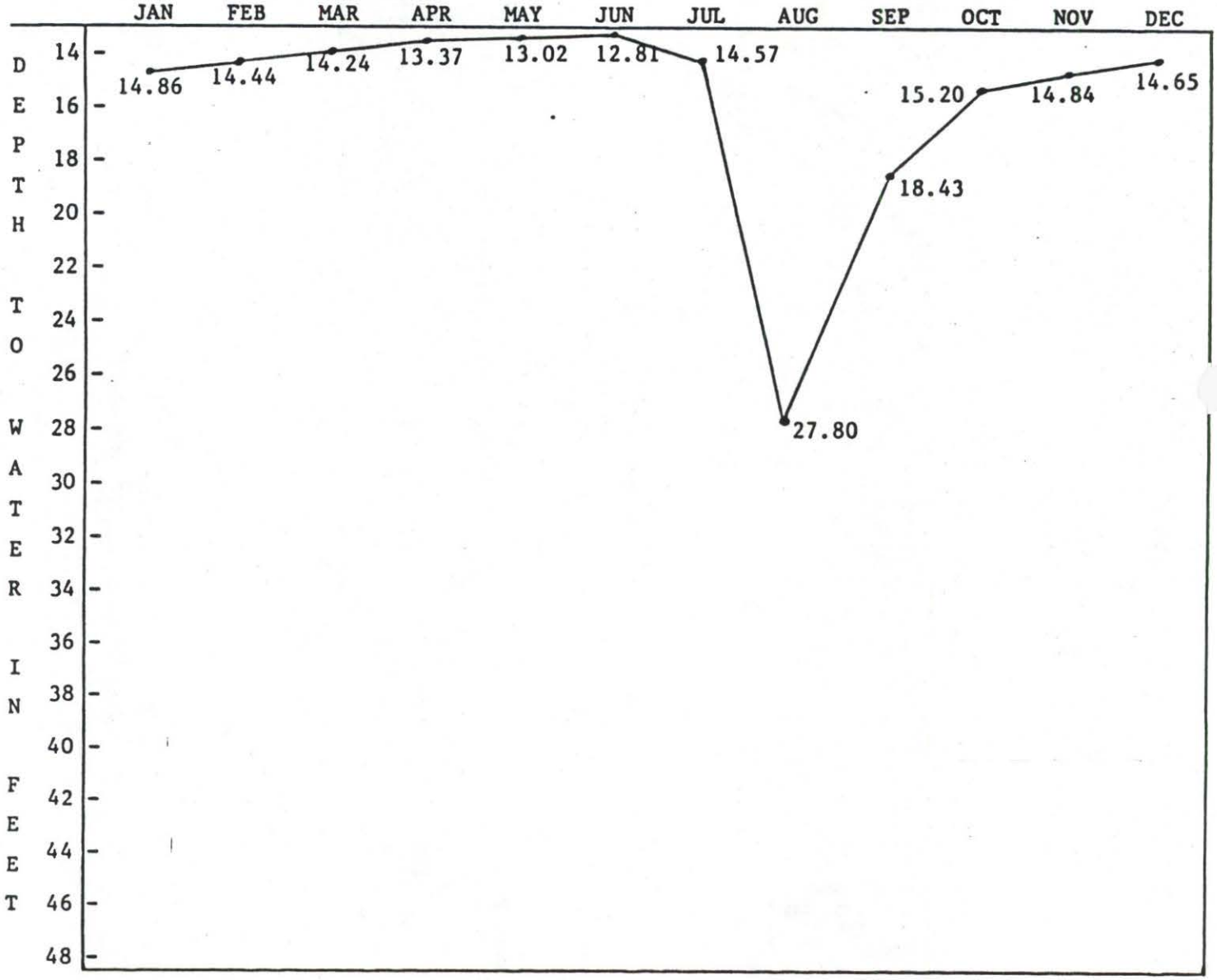
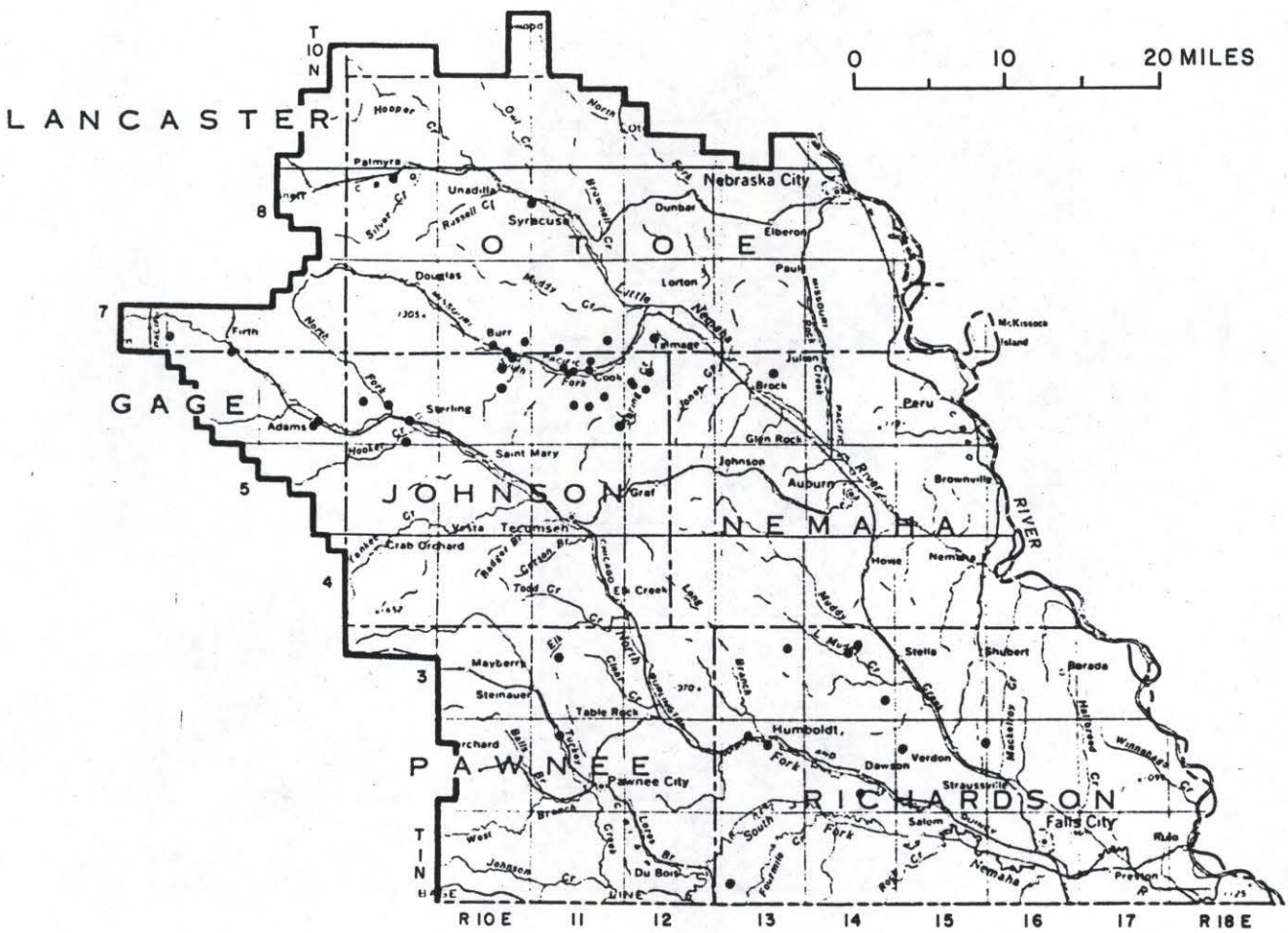
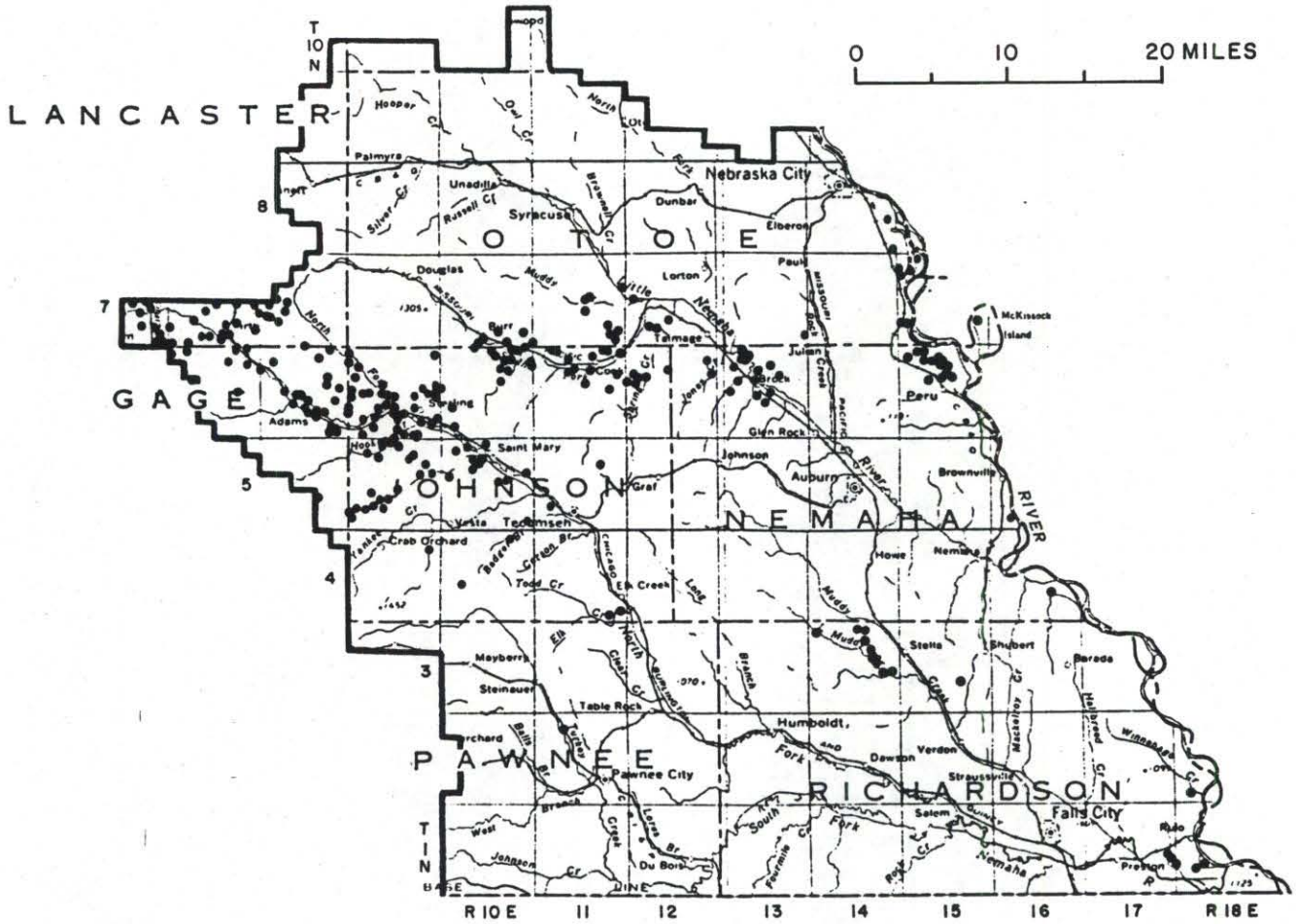


Figure 18



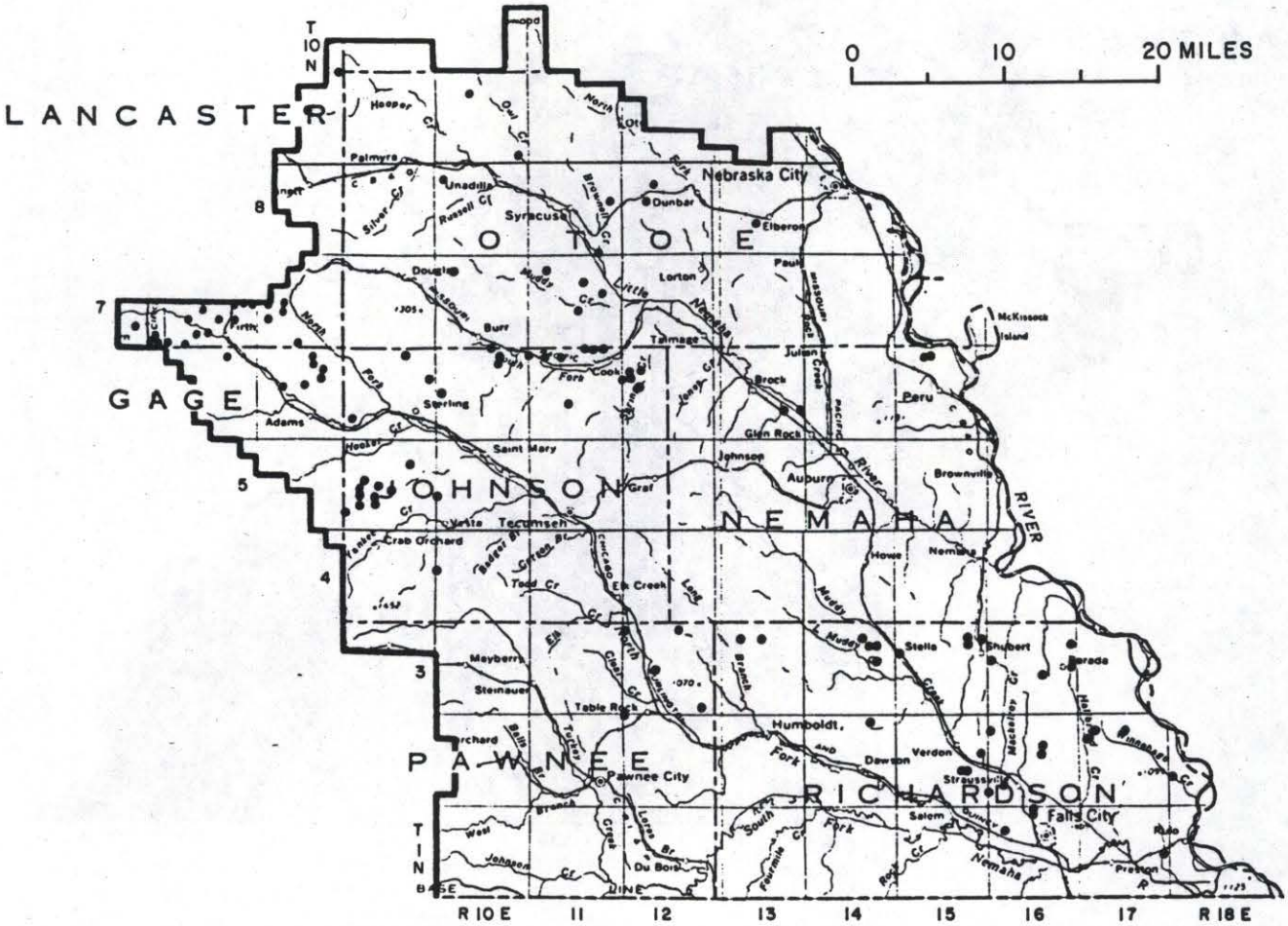
LOCATION OF OBSERVATION WELLS

Figure 19



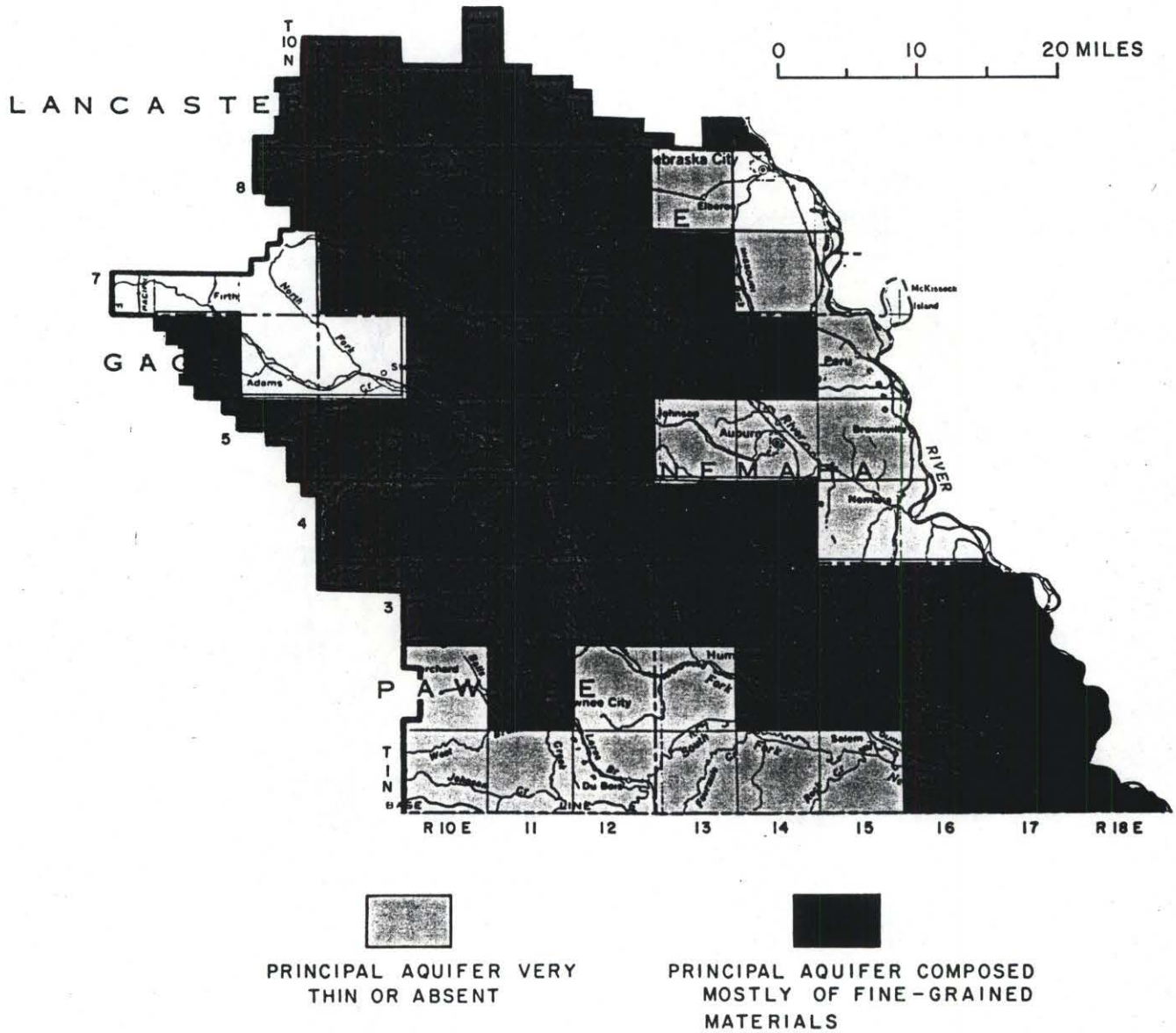
LOCATION OF REGISTERED IRRIGATION WELLS - 1983

Figure 20



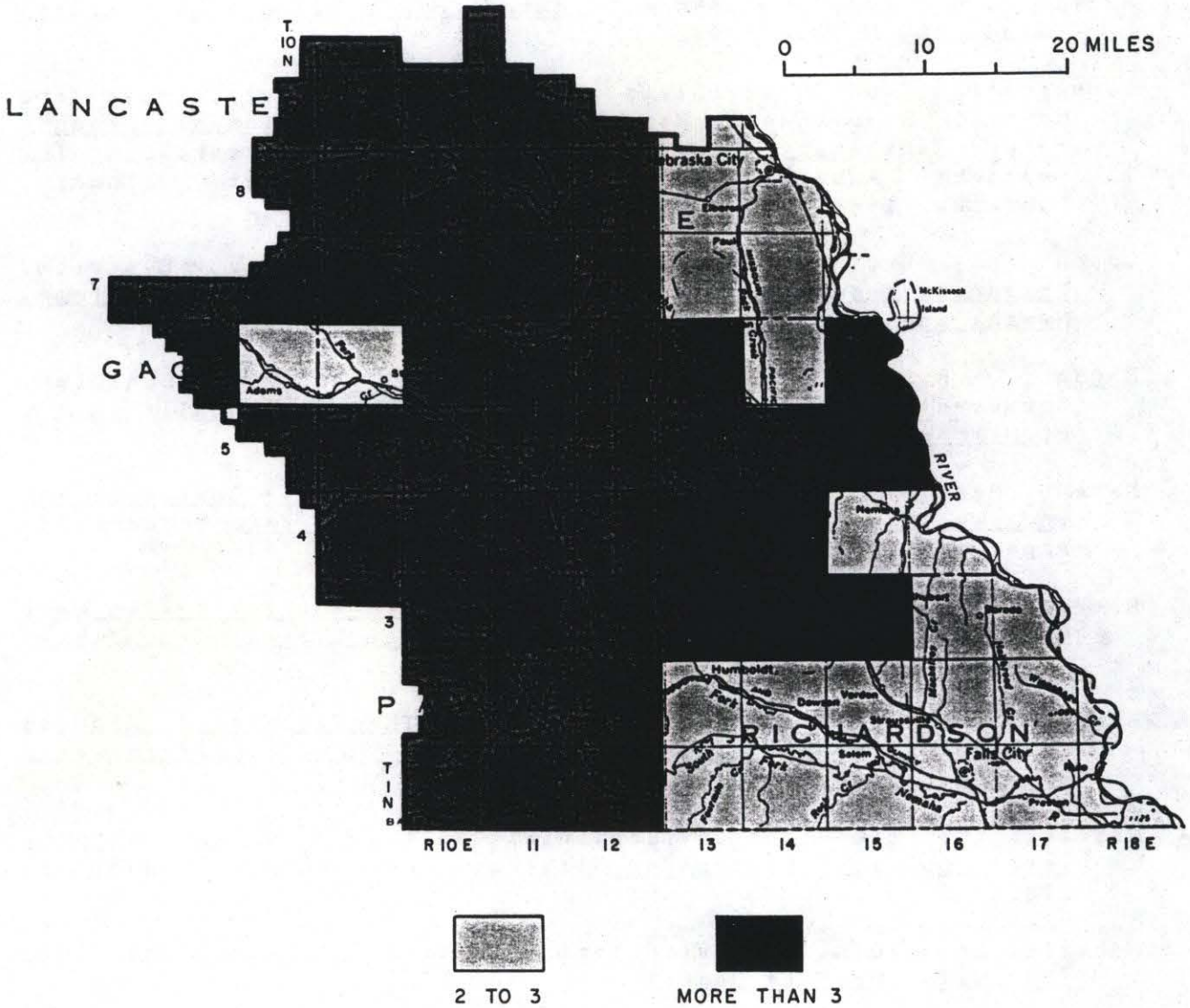
LOCATION OF CENTER PIVOT
IRRIGATION SYSTEMS - 1984

Figure 21



TOWNSHIPS CONTAINING AREAS OF LOW POTENTIAL FOR GROUNDWATER UTILIZATION FROM THE PRINCIPAL AQUIFER

Figure 22



MAXIMUM IRRIGATION DEVELOPMENT FROM GROUNDWATER BASED ON LAND SUITABILITY

Figure 23

REFERENCES

Ahuja, L.R., and O.R. Lehman. Journal of Environmental Quality, Volume 12, No. 1, 1983.

Conservation and Survey Division, Institute of Agriculture and Natural Resources. Handbook on the Preparation of Groundwater Management Plans. University of Nebraska-Lincoln, Nebraska Association of Resources District, Lincoln, Nebraska, 1984.

Corps of Engineers, U.S. Army, Kansas City District. Reconnaissance Report on Water and Related Resource Problems-Nemaha and Little Nemaha Rivers and Tributaries. 1978.

Engberg, R.A., U.S. Geological Survey, and R.F. Spalding, Conservation and Survey Division. Groundwater Quality Atlas of Nebraska. Resources Atlas No. 3, 1978.

Exner, Mary E., and Roy F. Spalding. Groundwater Contamination and Well Construction in Southeast Nebraska. Technical Paper, 1984.

Hiergesell, Robert A. Analysis of the Stream-Aquifer System Near Cook, Nebraska, Using a Finite-Difference Digital Groundwater Model. Technical Paper, 1985.

Logan, Terry J., and John R. Adams. The Effects of Reduced Tillage on Phosphate Transport from Ag. Land Lake Erie Waste Water Management Study. 1981.

Nebraska Department of Environmental Control. Nebraska Groundwater Quality Protection Strategy. A Technical Summary, 1985.

Nebraska Department of Environmental Control. Nemaha River Basin 1978 Water Quality Report.

Nebraska Soil & Water Conservation Commission. Report on the Framework Study. State Water Plan Publication Number 101, Pages 212-222, 1971.

Nebraska Natural Resources Commission. Groundwater Reservoir Management. State Water Planning and Review Process, 1982.

Nebraska Natural Resources Commission. Instream Flows. State Water Planning and Review Process, 1982.

Nebraska Natural Resources Commission. Municipal Water Needs. State Water Planning and Review Process, 1983.

Nebraska Natural Resources Commission. Preferences in the Use of Water. State Water Planning and Review Process, 1981.

Nebraska Natural Resources Commission. Supplemental Water Supplies. State Water Planning and Review Process, 1984.

Nebraska Natural Resources Commission. Water Quality. State Water Planning and Review Process, 1980.

Nebraska Natural Resources Commission. Water Use Efficiency. State Water Planning and Review Process, 1985.

Nemaha Natural Resources District. Master Plan. 1977.

Nemaha Natural Resources District. One & Six Year Plan & Progress Report. 1985.

Pederson, Darryll. Basic Concepts of Groundwater Hydrology. Technical Paper, 1985.

Robillard, Paul D., M.F. Walter, and L.M. Bruckner. A Planning Guide for the Evaluation of Agricultural Nonpoint Source Water Quality Control. Final project report R804925101. U.S. Environmental Protection Agency, Athens, Georgia. 1981.

Taylor, A.W., and A.W. Kunishi. Phosphate Equilibria on Stream Sediment and Soil in a Watershed Draining on Agirucltural Region. Jr. Ag. and Food Chem. 98:827-931. 1971.

U.S. Department of Agriculture. Nemaha River Basin Water and Related Land Resources. 1975.