Chapter 2. HYDROGEOLOGIC CHARACTERIZATION

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Hydrogeology can be defined as the study of ground water with particular emphasis given to its chemistry, mode of migration, and relation to the geologic environment. Ground water occurs in many types of geologic formations; aquifers are of most importance. An aquifer is defined as a formation that contains sufficient saturated permeable material to yield significant quantities of water. These ground water bearing formations store and transmit water. Generally, aquifers are areally extensive, and may be overlain or underlain by a confining bed. This confined bed may be defined as a relatively impermeable material stratigraphically adjacent to one or more aquifers. The TPNRD is generally underlain by the Ogallala Aquifer.

2.1 Aquifer Description

Beneath the land surface, water occurs in two distinct zones: the zone of aeration and the zone of saturation. The zone of aeration lies immediately beneath the land surface containing both air and water in the pore spaces. The zone of saturation lies beneath the zone of aeration and contains only water in the pore spaces. The boundary between these two zones is commonly referred to as the water table. For the purposes of this section, the term ground water will apply to water occurring in the zone of saturation.

2.1.1 Geographic/Areal Description

Nebraska is divided into thirteen ground water regions of which six are represented in the TPNRD. The ground water regions are shown in Figure 2.

Sand Hills

Region 1-Sand Hills: Large yields of good-quality water can be obtained from aquifers of Tertiary and Quaternary age. Deposits of the Ogallala Group of Tertiary age underlie the entire region but become thin toward the east. Runoff rarely occurs because precipitation readily infiltrates the sandy soils. Most groundwater either is lost by evapotranspiration from lakes between the dunes and from subirrigated meadows or is discharged by seepage into streams that are known for their uniform flow.

Platte River Valley

Region 2-Platte River Valley: High yields of good-quality water can be obtained from sand and gravel of Quaternary age in most parts of the region. The Ogallala Group underlies the alluvium in parts of the North Platte River and South Platte River valleys and the Platte River valley as far east as Grand Island. It is also a source of water supply. Concentrations of dissolved solids in groundwater range from 500 to more than 1,000 milligrams per liter in the alluvium throughout most of the western two-thirds of the re gion. The highest concentrations occur in the South Platte River valley. The water quality there is affected primarily by dissolved minerals carried from soils by infiltrating precipitation and irrigation water. In some of the Platte River valley, fertilizer applications are affecting ground water quality.

Southwestern Tablelands

Region 5-Southwestern Tablelands: Sandstone, sand and gravel deposits of the Ogallala Group have been developed extensively for irrigation. Pumping lifts of 200 feet or more are common. Ground water levels have declined progressively since development, began.

Panhandle Tablelands

Regions 6 and 7-Panhandle Tablelands: Although thick sequences of moderately permeable sediments of Tertiary age underlie the tablelands, wells are usually several hundred feet deep, and those of large capacity are restricted generally to areas underlain by the Ogallala or Arikaree Groups. Rocks beside major drainage courses usually are not saturated. In Region 7, wells also derive water from Brule Formation fractures in the valleys of Pumpkin and Lodgepole Creeks and in Sidney Draw.

East Central Dissected Plains

Region 8-East Central Dissected Plains: Ogallala Group deposits underlie the western two-thirds of the region, becoming thinner toward the east. In the central and eastern parts of the region, Pliocene and Pleistocene deposits of sand and gravel, mantled by loess, are thickest within buried paleovalleys. Water quality is generally good.

Republican River Valley and Dissected Plains

Region 9-Republican River Valley and Dissected Plains: Sand and gravel underlie the flood plains and terraces of the Republican River and its principal tributaries where they have cut into the uplands. Ogallala Group deposits are thickest in the northern and western parts of the region. Sand and gravel of Pliocene and Pleistocene age fill some buried paleovalleys. Cretaceous deposits of shale and chalk underlie the entire region and either are exposed or are thinly mantled by loess on the south side of the Republican River, where good-quality water is difficult to obtain.

2.1.2 Physical Characteristics

Transmissivity

Transmissivity is a measure of the volume of ground water that will flow through a given width of an aquifer under a specified slope of the water table. In practical terms, it provides a measure of the ability of an aquifer to supply water to wells. Transmissivity is dependent on a combination of the saturated thickness and the permeability of the aquifer. Thick aquifers of highly permeable materials have the highest transmissivity.

The conversion of transmissivity values to potential well yields requires the consideration of more factors than transmissivity alone, such as the type of well construction and development, the amount of drawdown and whether the ground water is confined or unconfined. Usually, where transmissivity values exceed 20,000 gallons per day per foot, wells can be developed with yields adequate for some types of irrigation. Where transmissivity values exceed 100,000 gallons per day per foot, high-capacity wells of more than one thousand gallons per minute can be developed for irrigation or other purposes.

Coarse-grained sediment is generally more permeable than fine-grained sediment. The areas showing the highest transmissivity have coarse-grained deposits of sand, sandstone and/or sandy gravel. Low transmissivity areas are characterized either by fine-grained deposits or by thin deposits of coarse-grained sediments. In such areas, the depth to bedrock generally is shallow or the overlying till is thick, as in the eastern part of the state.

The greatest thickness of saturated, coarse-grained deposits in the state underlies the Sand Hills region. Transmissivity values are high in this region, as they are in the North Platte River and South Platte River valleys, the Platte River valley and in much of the Big Blue River basin.

The transmissivity in the TPNRD is shown in Figure 6.

Base of the Principal Ground Water Reservoir

The shape of the bottom surface of the principal ground water reservoir in the TPNRD is shown by the contour lines on Figure 3. Although rocks below that surface may be saturated, they would yield water mostly at slow rates or would yield water of poor quality. Exceptions to this generalization are siltstone and sandstone of Oligocene age and sandstone, chalk, limestone and dolomite of the Cretaceous and Paleozoic ages.

The bottom surface of the principal ground water reservoir does not coincide with the bottom of a single stratigraphic layer in the rock sequence underlying Nebraska. Instead, it coincides with the bottom of different stratigraphic layers from one part of the state to another. For most of Nebraska's panhandle, the base of the principal ground water reservoir is considered to be the base of the Arikaree Group; for much of the central part of the state, it is the base of the Ogallala Group; and for most of the eastern part, it is either the base of the Quatemary deposits or the base of the lowest coarse-textured sediments within those deposits. Rocks directly underlying the principal ground water reservoir are of Pennsylvanian and Permian age in southeastern Nebraska, of Cretaceous age in most of the remainder of the state's eastern half and of the oldest Tertiary rocks (Chadron and Brule Formations of the White River Group) in its western half.

Water Table

The regional water table is generally defined as the upper surface of the water that fills spaces in unconsolidated sediments or in consolidated rocks throughout a given region. Such spaces are mainly between grains, in cavities caused by dissolution or in fractures. They allow water to be transmitted toward some point or area of discharge at the land surface.

As depicted on Figure 4 by the water-table contour lines (lines of equal elevation above mean sea level), the regional water table is a subdued reflection of the land surface. Thus, since the land surface of Nebraska slopes generally eastward, the water table slopes generally in the same direction. The land surface is irregular because streams have carved valleys into it, and the water table reflects those valleys that have been cut deep enough for groundwater to discharge. Even if streams were not shown on the map, their valleys could be located by the upgradient V's in the water-table contour lines.

The points of control used for delineating the water table configuration are water levels in wells not being pumped when those levels were measured in the spring of 1979 and of the topographic elevations anywhere ground water is known to be discharging at the land surface. Admittedly, the water level in many wells does not coincide precisely with the water table since the position of the screen through which water enters a well and local geologic conditions can affect the level at which water stands in the well.

In many places in eastern Nebraska and in some places elsewhere in the state, layers of very fine textured sediments that retard downward movement of water are contained within deposits that are coarser textured and capable of transmitting water more freely. These fine-textured layers so hamper percolation of water that they may create a zone of saturation above them. Such zones are known as perched ground water if they are separated from the regional zone of saturation by intervening unsaturated sediments. The existence of perched ground water cannot be determined readily unless water-level data for both perched and regional zones of saturation are available. The existence of perched ground water further complicates the accurate delineation of the regional water-table configuration.

Natural rates of lateral ground water movement range from a few inches per year to as much as a few feet per day. The movement is downgradient and perpendicular to the water-table contour lines. Pumping from a single well causes a temporary steepening of the water table around the immediate area of the well but has no appreciable effect on the representation of the water-table configuration. On the other hand, long term pumping of large-discharge wells that are concentrated in a single area can cause distortion of the shape of the water table.

Saturated Thickness of the Principal Ground Water Reservoir

The saturated thickness map was created by superimposing maps showing the regional water-table configuration in the spring of 1979 (see Figure 4) on same-scale maps showing the configuration of the base of the principal ground water reservoir (see Figure 3) and then computing the differences between those two surfaces. In the TPNRD, saturated thickness ranges from less than 100 feet to more than 500 feet.

The saturated thickness of the principal ground water reservoir in the TPNRD is shown in Figure 5.

Thicknesses on this map indicate water-saturated sediments ranging from fine to coarse texture. A thin saturated thickness of coarse-textured sediments may yield larger amounts of water than fine-textured sediments of a greater saturated thickness. Hence, saturated thickness is only one of several factors serving as guides to the development of water supplies.

In evaluating the volume of the principal ground water reservoir, it is also important to consider that this reservoir is part of a dynamic recharge and discharge system. Nearly all the recharge to a local aquifer results from precipitation falling on overlying land. Additional recharge may come from stream seepage and applied irrigation water. Ground water is discharged from wells that are pumped, wells that flow without being pumped, springs, perennial streams and some lakes and swamps that are hydraulically continuous with saturated earth materials.

Before development of the water supply, a dynamic equilibrium existed that was reflected by relatively stable ground water levels. Because recharge approximately equaled recharge in that condition, ground water in storage remained about the same. Since the rate of intensive development of the state's ground water began to accelerate during the 1940s and 1950s, pumping for irrigation and other uses has increased the amount of discharge. A decline of water levels reflects the removal of ground water from storage. In some areas of the state, storage, transmission and application of surface water for irrigation have in creased the amount of recharge and have raised ground water levels.

The large volume of water stored in ground water reservoirs in Nebraska is of interest because few other regions of a similar size have comparable amounts of readily available, good-quality water occurring at relatively shallow depths. However, the amount of water available for withdrawal is an issue subject to many diverse considerations, including economics, surface water-ground water relationships, adverse environmental impacts and the use of a variety of management techniques, such as artificial recharge or the regulation of ground water withdrawals.

Depth to Ground Water

Depth to water is another important consideration in developing ground water supplies. However, factors of more importance are the thickness of the saturated zone and the capacity of that zone to transmit water to wells. Depth-to-water data do indicate the thickness of deposits that must be penetrated to reach an unconfined zone of saturation, but they are only one factor indicating how much pumping lift is required to bring water to the land surface. Other important considerations regarding lift are the transmissivity of the aquifer being developed and the kind of well construction and development. Where ground water is confined under much pressure, as in an artesian aquifer, water would rise in a well beyond the top of the confined saturated zone, and the pumping lift could be less than the depth to that confined zone. In addition, in the area where perched ground water is common, water may occur in a well at a depth less than is indicated by the depth-to-water patterns.

In a large part of the TPNRD Sand Hills region, the dune topography makes practically impossible any indication of depth-to-water patterns on a map of the size than can be included in this plan. Depth to water beneath the higher dunes may be greater than 300 feet and beneath intervening valleys may be less than 50 feet. In places, such a wide range would require four depth-to-water patterns within distances too small for them to be clearly represented on a map.

2.2 Ground Water Recharge Sources

2.2.1 Precipitation

The primary source of natural recharge to the ground water reservoir is the precipitation that falls directly on the land. The annual precipitation in the TPNRD varies from slightly less than 18 to slightly more than 20. The mean annual precipitation from 1900 to 1979 is shown in Figure 7.

2.2.2 Surface Water

Within the TPNRD are storage facilities and canals for the Nebraska Public Power District (NPPD) which supplies surface water for irrigation in Dawson and Buffalo Counties and storage facilities and canals for the Central Nebraska Public Power and Irrigation District (CNPPID) which supplies surface water for irrigation in Kearney, Phelps and Gosper Counties. CNPPID has an incidental ground water recharge right along the CNPPID supply canal in east central Lincoln County.

Within the TPNRD are seven Irrigation Districts which irrigate lands within the North Platte valley and/or the South Platte valley.

The Keith-Lincoln Irrigation District diverts water from the North Platte River and irrigates lands in the North Platte River valley south of the North Platte River in an area between Sutherland, NE and Paxton, NE and in the South Platte River valley west of Sutherland, NE. The Keith-Lincoln Irrigation District has an incidental ground water recharge right. The application for the incidental ground water recharge right was prepared by the TPNRD. The application is on file in the TPNRD offices.

The Platte Valley Irrigation District diverts water from the North Platte River and irrigates lands in the North Platte River valley and the South Platte River valley south of the North Platte River in an area near Hershey, NE. The Platte Valley Irrigation District has an incidental ground water recharge right. The application for the incidental ground water recharge right was prepared by the TPNRD. The application is on file in the TPNRD offices.

The Paxton-Hershey Irrigation District diverts water from the North Platte River and irrigates lands in the North Platte River valley south of the North Platte River in an area north of Hershey, NE. The Paxton-Hershey Irrigation District has an incidental ground water recharge right. The application for the incidental ground water recharge right was prepared by the TPNRD. The application is on file in the TPNRD offices.

The Surburban Irrigation District diverts water from the North Platte River and irrigates lands in the North Platte River valley and the South Platte River valley south of the North Platte River in an area between Hershey, NE and North Platte, NE. The Surburban Irrigation District has an incidental ground water recharge right. The application for the incidental ground water recharge right was prepared by the TPNRD. The application is on file in the TPNRD offices.

The Cody-Dillon Irrigation District diverts water from the North Platte River and irrigates lands in the North Platte River valley south of the North Platte River in an area west of North Platte, NE.

The Birdwood Irrigation District diverts water from the North Platte River and irrigates lands in the North Platte River valley north of the North Platte River in an area north of Hershey, NE.

The Western Irrigation District diverts water from the South Platte River and irrigates lands in the South Platte River valley south of the South Platte River in an area south of Brule, NE. The Western Irrigation District has an incidental ground water recharge right. The application for the incidental ground water recharge right was prepared by the TPNRD. The application is on file in the TPNRD offices.

There are numerous other individual surface water rights within the TPNRD. The records of the NE Department of Water Resources may be consulted for information for these water rights.

A complete description of the interrelationship of the surface water resources and the ground water resources in the TPNRD is necessary so that management decisions can be systematically and logically made. Studies have not been made by the TPNRD in regard to the interrelationship of the surface water resources and the ground water resources in the TPNRD. This Plan therefore does not provide for the interrelationship of the surface water resources and the ground water resources in the TPNRD.

2.2.3 Supplemental Sources

Supplemental water sources are used to augment an existing system or supply to meet current demand or to provide for new uses. Supplemental water sources are additional water supplies that are made available within a specific location by either moving it from one area to another or storing it for later usage. The area's supplemental water sources are physically limited to essentially two alternatives: 1) construction and use of surface water reservoirs; and 2) importing ground and/or surface water from other locations.

Currently, surface water reservoirs in the TPNRD are those of NPPD and CNPPID.

The TPNRD has considered surface water reservoirs for storage of South Platte River water as provided for in the South Platte River Compact with Colorado. The Compact provides for a South Divide canal which could provide for off stream storage at reservoir sites identified by the TPNRD in Keith County. The TPNRD is currently not pursuing this project.

Potential future development of significant surface water reservoirs within the TPNRD is rather limited. Economic justification for such projects and legal/political issues could be insurmountable.

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