HYDROGEOLOGIC REPORT

OF THE

EL RENO, FAIRVIEW, ISABELLA AND LOYAL MINOR GROUNDWATER BASINS

IN

CENTRAL OKLAHOMA

Technical Report 2000-1

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OKLAHOMA WATER RESOURCES BOARD
Planning and Management Division

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HYDROGEOLOGIC REPORT OF THE EL RENO, FARIVIEW, ISABELLA AND LOYAL MINOR GROUNDWATER BASINS IN CENTRAL OKLAHOMA

INTRODUCTION

The Oklahoma Water Resources Board (Board) is required by law to conduct hydrologic surveys and investigations of fresh groundwater basins to characterize the availability, extent and natural hydrologic conditions of the resource. The Board is further directed, upon completion of the hydrologic survey, to determine the maximum annual yield of fresh water to be produced from each minor groundwater basin and the equal proportionate share to be allocated to each acre of land overlying the basin, based on a minimum life of 20 years. The maximum annual yield of each minor groundwater basin shall be based upon present and reasonably foreseeable future use of groundwater from the basin, recharge and total discharge, the geographical region in which the basin is located, and other relevant factors.

The Board defines a minor bedrock groundwater basin as a distinct underground body of water overlain by contiguous land, having substantially the same geological and hydrological characteristics, and from which the average basinwide yield from wells is less than 50 gallons per minute. The Board defines a minor alluvium and terrace groundwater basin as a distinct underground body of water overlain by contiguous land, having substantially the same geological and hydrological characteristics, and from which the average basinwide yield from wells is less than 150 gallons per minute.

The purpose of this report is to provide the Board with the information needed to manage the quantity of water withdrawn from the El Reno, Fairview, Isabella and Loyal minor groundwater basins.

BASIN NAMES AND DESCRIPTIONS

Within the study area, one minor bedrock and three minor isolated terrace groundwater basins were identified. The minor bedrock basin is named the El Reno Basin and is shown in figures 1A, 1B, and 1C. The El Reno Basin consists of Permian aged formations that make up the El Reno Group. The El Reno Basin is bounded on the west by formations of the White Horse Group and on the east and south by formations of the Hennessey Group. The northern boundary is formed along the Oklahoma-Kansas State border in Harper and Woods Counties. The total area of the El Reno Basin is approximately 5,650 mi^2 or 3,600,000 acres. The alluvium associated with the small tributary streams in the study area will not be treated as separate groundwater basins because the deposits are thought to be too thin to store significant quantities of water. The alluvium associated with these small streams are considered to be in hydraulic communication with the El Reno Basin.

The three minor isolated terrace groundwater basins are named for the towns of Fairview (Fairview Basin), Isabella (Isabella Basin) and Loyal (Loyal Basin).

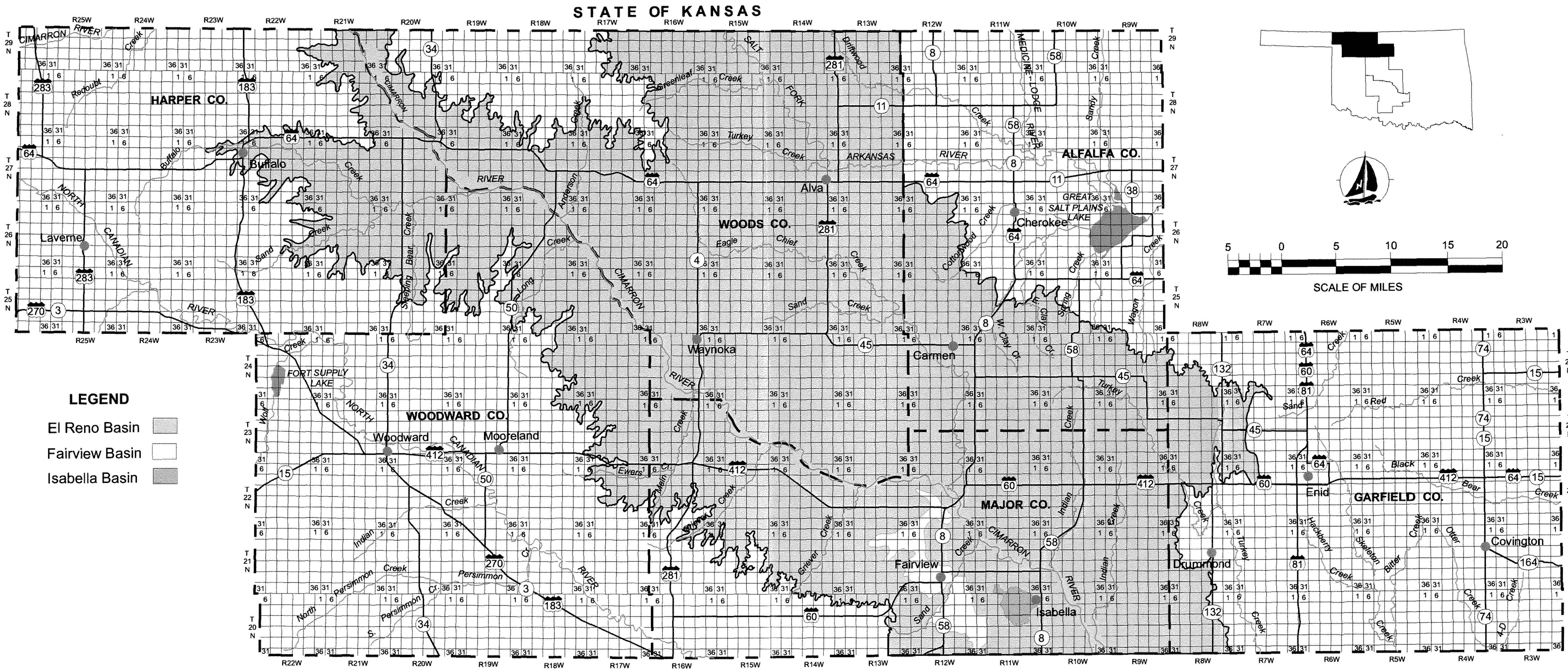

FIGURE 1A Boundaries of the Fairview and Isabella Basins and the Northern Portion of the El Reno Basin with Base Layers Which Include the Public Land Survey System, Rivers, Highways and Towns.

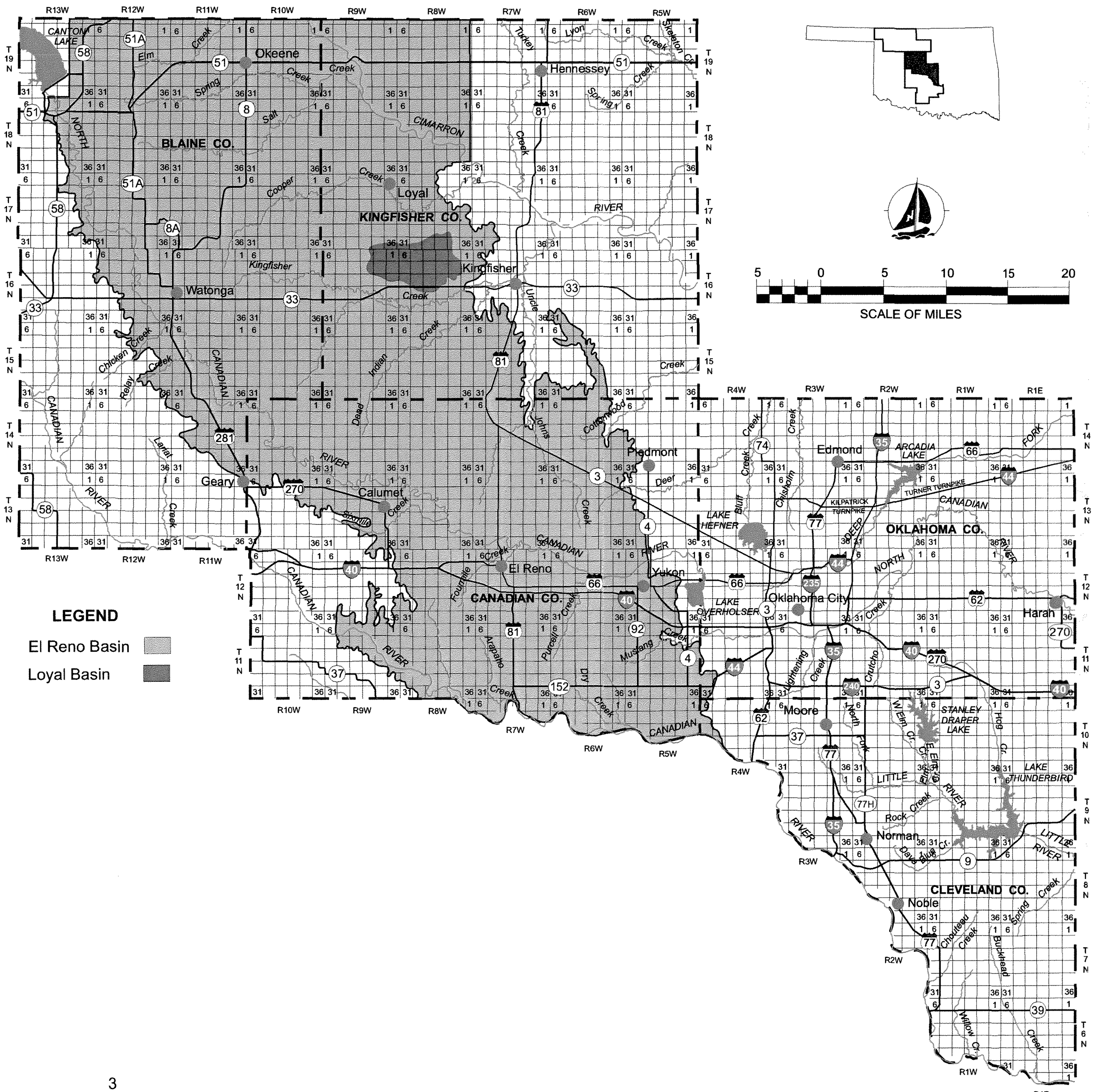

FIGURE 1B Boundaries of the Loyal Basin and Central Portion of the El Reno Basin with Base Layers Which Include the Public Land Survey System, Rivers, Highways and Towns.

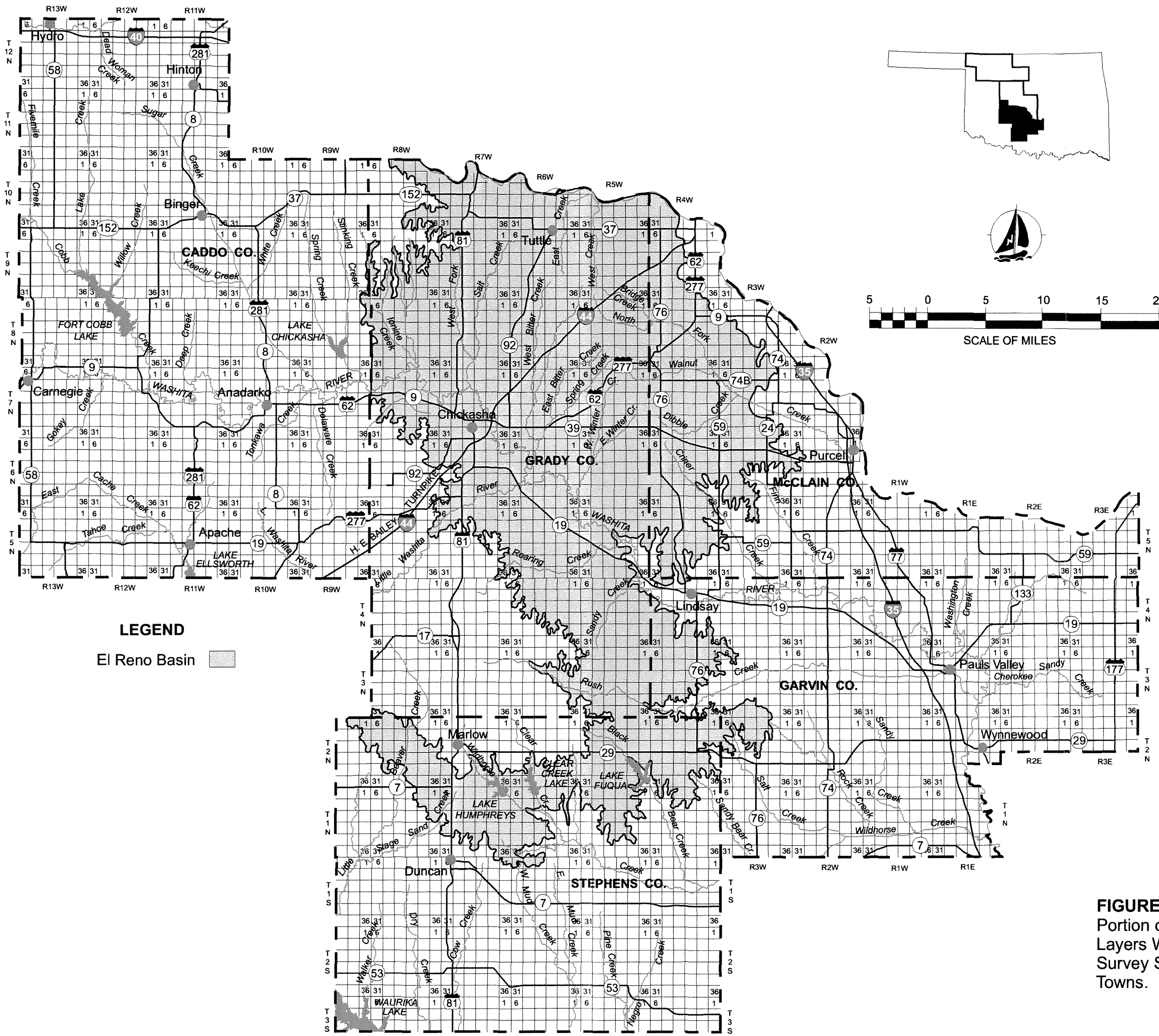

FIGURE 1C Boundaries of the Southern Portion of the El Reno Basin with Base Layers Which Include the Public Land Survey System, Rivers, Highways and Towns.

The Fairview and Isabella Basins were deposited upon the surface of the Flowerpot Shale, a Permian Formation of the El Reno Group. The two basins lie south of the present day stream channel of the Cimarron River in southeastern Major County. The Loyal Basin was deposited upon the Cedar Hills, Flower Pot and Chickasha formations of the El Reno Group. The deposits are believed to be remnants representing a former meander in the Cimarron River. Presently, small tributaries draining uplands south of the Cimarron River also cut through and drain these basins. The Fairview and Isabella Basins (Figure 1A) and Loyal Basin (Figure 1B) are isolated terraces of Quaternary age and are approximately 44, 9 and 24 mi^2 in area respectively.

PHYSICAL SETTING

Location

The study area for this report includes portions of Alfalfa, Blaine, Caddo, Canadian, Cleveland, Garvin, Grady, Harper, Kingfisher, Major, McClain, Oklahoma, Stephens, Woods and Woodward Counties. The principal groundwater basin in terms of surface area is the El Reno. From north to south, the El Reno Basin extends from the Kansas-Oklahoma state line in Harper and Woods Counties south-southeast to the northern portions of Garvin, Grady and Stephens Counties. The Fairview and Isabella Basins are located in Major County and underlie the towns for which they are named. The Loyal Basin is located in Kingfisher County, approximately 5 miles south of the Town of Loyal.

Physiography

The eastern three quarters of the study area is in the Redbed Plains physiographic region and the western quarter is in the Gypsum Hills physiographic region. The Redbed Plains is part of a gently eastward sloping homocline underlain by gently westward dipping Permian rocks. The gypsum hills region is an area characterized by a series of northwest trending ridges and hills which rise abruptly 100 to 300 feet above the plains. The ridges form prominent east-northeast facing escarpments capped by white, resistant beds of gypsum covering easily erodible shale formations with intervening plains underlain by gently sloping Permian rocks (Board, 1972, 1973).

The land surface elevation varies from 1,850 feet above mean sea level (msl) near the Town of Buffalo in Harper County to 970 feet msl near the Town of Lindsay in northwestern Garvin County along the Washita River. Surface drainage in the study area is accomplished by several major streams generally flowing east-southeast including the Salt Fork of the Arkansas River and Cimarron River in the northern portion, the North Canadian and Canadian Rivers in the central portion and the Washita River in the southern portion.

Climate

The climate throughout the study area is typically continental, temperate and subhumid. The state's long distance from the moderating effects of the oceans and an absence of mountains to the north often allows cold arctic winds to reach Oklahoma during the winter which is normally short and mild. In the spring, large thunderstorms develop when warm, moist air from the Gulf of Mexico converges with colder northern, humid eastern and dry western air masses, often producing large tornadoes and hail. Summers in Oklahoma are usually long and hot punctuated by droughts of varying degree and duration. Fall, though often wet, normally features mild days with cool nights. May ranks as the wettest month while January is the driest.

Climate is variable across the study area, but not to the extreme. The mean annual precipitation ranges from 24 inches in the northwest to 34 inches in the south and east. The mean annual snowfall ranges from 14 inches in the northwest to 6 inches in the south. Mean temperature ranges from 58 degrees in the northwest to 61 inches in the south. Mean runoff varies from less than 1 inch in the northwest to around 3.5 inches in the east. Mean annual lake evaporation varies from 64-56 inches from west to east (Oklahoma Climatological Survey: Period of Record: 1961-1990). Table 1 shows the estimated mean annual values for the study area.

PRECIPITATION	SNOWFALL	TEMPERATURE	RUNOFF	LAKE EVAPORATION
29 Inches	10 Inches	59.5 Degrees	2 Inches	60 Inches

TABLE 1 Study Area Mean Annual Values For Precipitaion, Snowfall, Temperature, Runoff And Lake Evaporation

REGIONAL GEOLOGY

General

The Permian-age formations of the El Reno Group are comprised of reddish-brown shales, siltstones, and sandstones interbedded with thin persistent beds of gypsum and dolomite and thick bedded evaporite (gypsum/anhydrite/dolomite) units interbedded with shale. Overlying parts of the Permian bedrock formations is a relatively thin mantle (usually less than 100 feet) of unconsolidated deposits of clay, silt, sand and gravel of Quaternary age deposited by large rivers and smaller streams.

The northern and eastern portions of the study area lie within the Northern Shelf Geologic Province and the southern and western portions of the study area lie within Anadarko Basin Geologic Province. All units within the El Reno Group become thinner and sandier northward toward the shelf area.

The strike of the formations is generally northwest with the dip of the beds being generally west-southwest (toward the Anadarko Basin) varying from 4-30 feet per mile (Morton, 1980). The maximum thickness of the El Reno Group ranges from about 950 feet in Blaine County to about 300 feet near the Oklahoma-Kansas border (Fay, 1962). The average thickness of the El Reno Group is estimated to be 600 feet.

Stratigraphy
The El Reno Group lies between the younger White Horse Group and older Hennessey Group. Table 2 shows their stratigraphic relationships.

<table>
<tr><th>System</th><th>Series</th><th>Group</th><th colspan="2">Formation</th></tr>
<tr><td rowspan="2">Upper Permian</td><td rowspan="2">Custerian</td><td rowspan="2">White Horse</td><td colspan="2">Rush Springs</td></tr>
<tr><td colspan="2">Marlow</td></tr>
<tr><td rowspan="8">Lower Permian</td><td rowspan="8">Cimarronian</td><td rowspan="4">El Reno</td><td>Dog Creek Shale</td><td rowspan="3">Chickasha Formation</td></tr>
<tr><td>Blaine Formation</td></tr>
<tr><td>Flowerpot Shale</td></tr>
<tr><td>Cedar Hills Sandstone</td><td>Duncan Formation</td></tr>
<tr><td rowspan="4">Hennessey</td><td colspan="2">Bison Formation</td></tr>
<tr><td colspan="2">Salt Plains Formation</td></tr>
<tr><td colspan="2">Kingman Siltstone</td></tr>
<tr><td colspan="2">Fairmont Shale</td></tr>
</table>

TABLE 2 Stratigraphic Column of the Permian Rocks Comprising the Hennessey Group, El Reno Group and White Horse Group

Following is a description of the formations that comprise the El Reno Group (in ascending order).

The Cedar Hills Sandstone is a sandstone in the northern part of the study area (Major County to the state line, typically north of the Cimarron River) grading to a shale with interbeded siltstone southward. The Cedar Hills Sandstone can be as much as 180 feet thick. The Cedar Hills Sandstone grades southward into the Duncan Sandstone in Canadian County.

The Duncan Formation is a sandstone with minor amounts of interbedded shales and siltstone conglomerates. The formation grades northward into the Cedar Hills Sandstone and northward and westward into the Chickasha Formation. The Duncan Formation ranges in thickness from 100-250 feet.

The Chickasha Formation is a heterogenous mixture of sandstones, shales, siltstones and siltstone conglomerates. Its upper part grades northward into the Dog Creek, Blaine and Flowerpot Formations and lower part grades into the

Duncan Sandstone. The Chickasha occurs as a deltaic tongue (about 30 feet thick) in the middle part of the Flowerpot Shale in Blaine County, pinching out northward. The Chickasha ranges in thickness from 100-600 feet.

The Flowerpot Shale, which occurs in the central and northern part of the of the study area is a formation described as red-brown shale with several salt and gypsum beds. Of particular note is the more than 50 feet of rock salt in the intermediate subsurface giving rise to the Ferguson Salt Plain in Blaine County and the Big and Little Salt Plains adjacent to the Cimarron River in Woods and Harper Counties. Gradational southward and eastward into the Chickasha Formation its thickness ranges from 180 to 450 feet.

The Blaine Formation consists of a cyclic series of interbedded gypsum, shale, and dolomite. Each cycle consists of a thin layer of dolomite, overlain by a layer of gypsum and topped with a layer of shale. The Blaine crops out in the northern two thirds of the study area. Within the study area, the gypsum units thicken northward while the shale units thicken southward. Southward, the gypsum beds grade into silty clay shales, and the dolomite beds grade into calcareous siltstones, eventually becoming indistinguishable from the Dog Creek Shale. Near the Canadian-Kingfisher County line the Blaine gives way to the Dog Creek Shale. The thickness of the Blaine ranges from 90-200 feet.

The Dog Creek Shale is a red-brown silty shale in the south with thin beds of siltstone and dolomite. Northward, the formation contains silty shale, gypsum, dolomite and some fine-grained sandstone. The Dog Creek grades northward and eastward into the Blaine and Chickasha Formations and has a thickness ranging from 30-200 feet.

GROUNDWATER RESOURCES OF THE EL RENO BASIN

Aquifer Parameters

From a review of water well completion reports (drillers' logs), it is estimated that approximately 25 percent of the rock units comprising the El Reno Basin consist of fine-grained sandstones and siltstones. Approximately 75 percent of the basin is comprised of rock units containing calcareous shale and evaporites (gypsum, dolomite, and halite). Groundwater is derived primarily from fine-grained sandstone units whereas the shale units typically yield very limited quantities of water. Locally, however, where fractures have formed or mineral dissolution has occurred, the storage and yield capacity of the shale units can be enhanced (Reed, 1952). Evidence of this is found in some higher yield areas in the outcrop area of the Cedar Hills Sandstone Formation north of the Cimarron River in Major County.

Groundwater stored in the formations and beds comprising the El Reno Basin exist under both unconfined and confined conditions. For unconfined aquifers, storage coefficient and specific yield are nearly equivalent. For this study, specific yield was estimated using a table of representative specific yield ranges for earth materials (Walton, 1970). Specific yield is estimated to be 0.05 for that portion of the basin comprised of fine-grained sandstone and siltstone and 0.01 for the shale and evaporite portion of the basin. The storage coefficient of interbedded sandstone and siltstone aquifers under confined conditions (at depths below ~ 250 feet) such as the El Reno approaches 1×10^{-5} Driscoll (1986). The amount of stored water within the confined portion of the El Reno Basin is negligible for the purpose of estimating initial storage.

Hydraulic conductivity (K) ranges from 50 to 1.0×10^{-4} feet per day (ft/day) for the type of rock units representative of the El Reno Basin (Freeze and Cherry, 1979). It is estimated that greater than 60 percent of the of the stored water occurs within 25 percent of the basin and is transmitted through the fine-grained sandstone parts of the basin. Consequently, K is weighted in favor of the more productive zones and is estimated to be 1 ft/day.

The average thickness of the formations comprising the El Reno Group is estimated to be 600 feet. The average thickness of the El Reno Basin is determined to be 250 feet, because at greater depths, the water becomes saline. A review of drillers' logs indicates the average depth to water in the basin is approximately 40 feet below land surface. The average saturated thickness is therefore estimated to be 210 feet. The transmissivity (T) (calculated as the product of K and the basins' saturated thickness) is estimated to 210 ft^2/day.

Groundwater movement in the study area is from uplands (where recharge occurs) toward streams. Recharge potential is higher where the surface soils and near surface bedrock have more sand content in contrast with those areas where clay soils and shale bedrock prevail. A higher percentage of recharge would be expected to occur within the outcrop areas of the Duncan, Chickasha and Cedar Hills Formations. Seepage to streams and evapotranspiration accounts for most of the groundwater discharge, and groundwater pumping accounts for a small fraction of the discharge.

Pettyjohn and others (1983) made estimates of effective annual recharge rates for Oklahoma using stream hydrographs which were separated into groundwater base flow and streamwater runoff. Groundwater base flow was then related to the size of the drainage basin above the stream gage and converted to inches. Estimated groundwater recharge rates in Oklahoma correspond closely to precipitation patterns. According to Pettyjohn, average annual recharge rates range from approximately 0.5 to 1 inch per year within the study area. For this study, the average rate of recharge is estimated to be 0.75 inches per year, or approximately 2 ½ percent of the total annual average precipitation (29 inches per year). Table 3 lists the estimated aquifer parameters for the El Reno Basin.

Area of Basin	Saturated Thickness	Specific Yield	K Ft/Day	T FT^2/Day	Recharge Rate (Inches/Year)
3,600,000 Acres	210 Feet	0.01-0.05	1	210	0.75

TABLE 3 Estimated Aquifer Parameters of the El Reno Basin

Aquifer Storage and Yield Capabilities

The initial storage of the El Reno Basin is determined by multiplying the area of the basin by its specific yield and its saturated thickness. The initial storage of the El Reno Basin was calculated to be 15,000,000 acre-feet. Table 4 shows the parameters used to calculate the initial storage.

AQUIFER TYPE	SPECIFIC YIELD	SATURATED THICKNESS	AREA OF BASIN (ACRES)	STORAGE (ACRE-FEET)
Fine-Grained Sandstone and Siltstone	0.05	52 Feet	3,600,000	9,350,000
Shale & Evaporites	0.01	158 Feet	3,600,000	5,650,000
Total		210 Feet		15,000,000

TABLE 4 Initial Storage Parameters of the El Reno Basin

A review of over 1,250 OWRB drillers' logs completed in the El Reno Basin indicated the average yield was approximately 25 gallons per minute (gpm). Reported yields range from a few gallons per minute to as much 800 gpm. The drillers' logs also indicated that the average water well completion depth to be approximately 150 feet.

High Yield Areas

Based on a review of literature and drillers' logs, the most productive formations of the El Reno Basin are the Duncan Formation, Chickasha Formation and Cedar Hills Sandstone. The higher production areas include McClain, Grady and Stephens Counties where the Duncan and Chickasha Formations outcrop; and extreme western Garfield and the eastern half of Major County (north of the Cimarron River) where the Cedar Hills Sandstone outcrops or closely underlies the Cimarron Terrace Aquifer. Numerous public water supply and irrigation wells tapping the Cedar Hills Sandstone reportedly yield in excess of 200 gpm near the communities of Drummond, Carrier, and Ames in Major County.

The water bearing units of the Cedar Hills Sandstone appear to be discontinuous and of a localized nature. Reed and others (1952) postulated that groundwater occurs and moves through the fractures and dissolution cavities which result from the removal of soluble materials (calcite) within discrete units. This phenomena has resulted in an extremely complex aquifer system which exhibits variable permeability and storage characteristics both laterally and vertically. This complexity is demonstrated when comparing depth and water production rates which produce from this strata. Numerous offset wells which yield very little water have been drilled in close proximity to wells with significant production.

Water Use and Water Rights

Groundwater from the El Reno Basin supplies several small (<4000 population) communities and rural water systems in the southern part of the basin, particularly Grady and McClain Counties. Stock and domestic wells are prevalent throughout the study area. Many housing additions in outlying areas of Oklahoma City are served by individual wells. The City of Enid has well fields that tap the El Reno Basin which supplies a small portion of its total water supply.

At the time of this study, the Board had issued around 100 temporary permits to groundwater users within the El Reno Basin totaling approximately 24,000 acre-feet. The Board has issued permits for irrigation, public water supply, industrial, mining, recreation-fish-wildlife, commercial and non-irrigated agricultural beneficial uses. Table 5 shows the relative percentages for temporary permits, prior rights and water right allocations for each of the beneficial use categories as well as the 1997 reported use. Prior Groundwater Rights established within the El Reno Basin prior to July 1, 1973 and recognized by the Board total 3,729 acre-feet.

Beneficial Use Categories	Temporary Permits	Prior Rights	Temporary Permit Allocations	Prior Right Allocations	Reported Water Use (Acre-feet)
Agriculture	58	68	73.5	55.4	131
Public Water Supply	30	29	23.9	40.3	851
Commercial	4	0	0.1	0	5
Industrial	5	3	0.3	4.3	.1
Fish/Wildlife	3	0	2.2	0	4

TABLE 5 Water Rights and Uses for the El Reno Basin

Future Use of the Basin

Future use of the basin will be self limiting because of the finite availability of water in storage, water quality and the availability of fresh groundwater resources from adjacent or overlying major alluvium and terrace groundwater basins. However, with the recent practice of connecting several low yield wells together, it is possible to obtain enough water for irrigation of row crops. Therefore, there might be an increase in water use for irrigation in the future. Also, because of the growth in the Mustang and Enid areas, domestic use can be expected to continue to increase.

GROUNDWATER RESOURCES OF THE ISOLATED TERRACE BASINS

Aquifer Parameters

A review of drillers' logs indicate that the deposits of the isolated terrace basins consist primarily of fine-medium sand and clay. Coarse sand and gravel commonly found in major alluvium and terrace deposits are absent.

On the basis of the reported grain size, specific yield is estimated at 0.10 for the Fairview, Isabella and Loyal Basins. The hydraulic conductivity of the sediments comprising the three basins is estimated to be 70 ft/day based on a range of values given for consolidated and unconsolidated aquifers (Freeze and Cherry, 1979) taking into consideration the relative proportions of sand and clay described on the drillers' logs. The recharge rate for the basins is assumed to be 0.75 inches per year, equivalent to that estimated for the El Reno Basin.

Fairview Isolated Terrace Groundwater Basin

The Fairview Basin contains approximately 28,000 surface acres. Based on information from eight drillers' logs the average basin thickness is (taken as the depth to the bedrock) determined to be 35 feet. The average depth to water is 13 feet, and the average saturated thickness is 22 feet. Using a hydraulic conductivity value of 70 ft/day, and a saturated thickness of 22 feet, the transmissivity of the basin is determined to be 1,540 ft^2/day.

Isabella Isolated Terrace Groundwater Basin

The Isabella basin contains approximately 5,800 surface acres. Thirteen drillers' logs were examined for this basin and the average thickness is determined to be 54 feet. The average depth to water is 17 feet, and the average saturated thickness is 37 feet. The transmissivity of the basin is determined to be 2,590 ft^2/day.

Loyal Isolated Terrace Groundwater Basin

The Loyal Basin contains 15,000 surface acres. Eighteen drillers' logs were examined for this basin and the average thickness is determined to be 46 feet. The average depth to water is determined to be 13 feet, and the average saturated thickness is 33 feet. The transmissivity of the basin is determined to be 2,310 ft^2/day. Table 6 summarizes the aquifer characteristics of the 3 isolated terrace basins.

Basin Name	Area (Acres)	Aquifer Thickness (Feet)	Specific Yield	Saturated Thickness (Feet)	K - Feet/day	T-$Feet^2$/day
Fairview	28,000	35	0.10	22	70	1,540
Isabella	5,800	54	0.10	37	70	2,590
Loyal	15,000	46	0.10	33	70	2,310

K - Hydraulic Conductivity; T - Transmissivity

TABLE 6 Aquifer Parameters of the Fairview, Isabella and Loyal Isolated Terrace Basins

Aquifer Storage and Yield Capabilities

Initial storage is 62,000 acre-feet for the Fairview Basin; 21,000 acre-feet for the Isabella Basin; and 50,000 acre-feet for the Loyal Basin. Drillers' logs indicated that well yields ranged from 7 to 700 gpm and average approximately 25 gpm from the three basins.

Water Use and Water Rights

Groundwater permits issued by the Board (post July 1, 1973) authorizing groundwater withdrawals from the basins and the 1997 reported water use by permit holders are summarized in Table 7. Prior Groundwater Rights established within the three basins prior to July 1, 1973 and recognized by the Board total 110 acre-feet for the Fairview Basin, zero acre-feet for the Isabella Basin and 310 acre-feet for the Loyal Basin.

Basin	Beneficial Use Category	# of Permits	Acre-feet Allocated	Reported Water Use (Acre-feet)
Fairview	Irrigation & Fish & Wildlife	1	320	21
Isabella	Irrigation	3	670	163
Loyal	Irrigation & Mining	3	800	0
Loyal	Public Water Supply	1	80	43
Total		8	1870	227

TABLE 7 Water Rights and Uses within the Fairview, Isabella and Loyal Basins

Future Use of the Isolated Terrace Basins

The Fairview, Isabella and Loyal Basins are limited in areal extent, thinly saturated, and have moderate storage capacity. These factors will likely limit overdevelopment of the basin. Small quantity users should have sufficient supplies of water into the foreseeable future.

GROUNDWATER QUALITY

El Reno Basin

Ground water quality data were obtained from the Hydrologic Atlases of Oklahoma (Hart, 1974; Bingham and Bergman, 1980; Carr and Bergman, 1976; Bingham and Moore, 1975 and Morton, 1980). The limited data suggest that there is considerable variability in the chemistry of the groundwater basin. The quality of the water in the south half of the study area and the far eastern part of the basin is generally better than in the north half. Those areas with lower concentrations of dissolved solids and sulfate tend to correspond to the rock units comprising the Chickasha and Duncan Formations in the south and Cedar Hills Sandstone in the east. This may be attributed to the depositional environments. The clastic rocks in the south generally have only minor inclusions or stringers of evaporite deposits within their framework while northward the amount of bedded gypsum and salt deposits become more prominent. Total dissolved solids (TDS), sulfate, and hardness components of the groundwater are much higher in the northwest and western portions of the basin than in the central, eastern and southern portions.

For the entire study area, median concentrations for TDS, sulfate and hardness are 980, 220 and 700 mg/l respectively. EPA's secondary maximum contaminate level (SMCL) for drinking water for TDS (500 mg/l) was exceeded in 35 of the sample analyses. In the Woodward quadrangle the SMCL's for TDS and sulfate (250 mg/l) were exceeded in all seventeen reported analyses. For the Clinton quadrangle, the SMCL for TDS was exceeded in all 12 sample analyses and the SMCL for sulfate was exceeded in 7 of the 12 analyses.

Table 8 shows the median as well as the maximum and minimum reported and calculated ionic concentrations for selected parameters of the basin.

The possibility of natural pollution of the basin as reflected by parameters such as chloride, TDS and sulfate can be minimized by proper well construction, treatment and water quality testing and analysis.

PARAMETER	MAXIMUM	MEDIAN	MINIMUM	# WELLS
TDS (mg/l)	4430	980	252	70
Chloride (mg/l)	1016	70	16	70
Sodium + Potassium (mg/l)	908	95	10	70
Calcium + Magnesium (mg/l)	2350	500	30	70
Bicarbonate (mg/l)	900	274	30	70
Nitrates (mg/l)	N/A	9	N/A	59
Hardness ($CaCO_3$) (mg/l)	N/A	700	N/A	59
Sulfate (mg/l)	2688	220	10	70

TABLE 8 Concentrations of Common Anions and Cations in Wells Sampled in the El Reno Basin

Isolated Terrace Groundwater Basins

Almost no water quality data were available for the groundwater resources of the isolated terrace basins. One analysis taken from a well completed in the alluvium of a tributary stream which cuts across the Loyal Basin (but just outside its basin boundary) had a reported TDS of less than 400 mg/l and chloride and sulfate concentrations well below drinking water standards. A second analysis for a well completed in the Loyal Basin shows concentrations of TDS, sulfate, and chloride all exceeding EPA drinking water SMCLs for these constituents. Without additional water quality sampling, it is concluded that the water quality of these basins is variable but not quantifiable. The possibility of natural pollution of the basin as reflected by parameters such as TDS, sulfates and chlorides, the source of which would most likely comes from the underlying Permian bedrock can be minimized by water quality testing, treatment and proper well construction. If an adequate supply of water can be obtained from the terrace deposits, water quality concerns related to the above parameters can be reduced if the wells are not completed in the underlying Permian deposits (Consideration should be given to not overdrilling the terrace deposits).

SUMMARY

EL RENO GROUNDWATER BASIN

The following data on the El Reno Group Groundwater Basin were derived in order to calculate and determine the Maximum Annual Yield and Equal Proportionate share of the basin:

1) The total land area overlying the basin is 3,600,000 acres;
2) The amount of water in storage in the basin on September 1, 1999 was determined to be 15,000,000 acre-feet;
3) The estimated rate of recharge is 2 1/2 percent of the average annual precipitation (29 inches) and totals approximately 4,500,000 acre-feet with a total discharge from the basin of 74,580 acre-feet over the life of the basin (20 years);
4) The transmissivity of the basin is estimated to be 210 ft^2/day;
5) The possibility of natural pollution of the basin as reflected by parameters such as chloride, TDS and sulfate can be minimized by proper well construction, treatment and water quality testing and analysis.

FAIRVIEW ISOLATED TERRACE GROUNDWATER BASIN

The following data on the Fairview Isolated Terrace Groundwater Basin were derived in order to calculate and determine the Maximum Annual Yield and Equal Proportionate share of the basin:

1) The total land area overlying the basin is 28,000 acres;
2) The amount of water in storage in the basin on September 1, 1999 was determined to be 62,000 acre-feet;
3) The estimated rate of recharge is 2 1/2 percent of the average annual precipitation (29 inches) and totals approximately 35,000 acre-feet with a total discharge from the basin of 2,200 acre-feet over the life of the basin (20 years);
4) The transmissivity of the basin is estimated to be 1,540 ft^2/day;
5) The possibility of natural pollution of the basin as reflected by parameters such as chloride, TDS and sulfate the source of which would most likely comes from the underlying Permian bedrock can be minimized by proper well construction (not overdrilling the terrace deposits), treatment, and water quality testing and analysis.

ISABELLA ISOLATED TERRACE GROUNDWATER BASIN

The following data on the Isabella Isolated Terrace Groundwater Basin were derived in order to calculate and determine the Maximum Annual Yield and Equal Proportionate share of the basin:

1) The total land area overlying the basin is 5,800 acres;
2) The amount of water in storage in the basin on September 1, 1999 was determined to be 21,000 acre-feet;
3) The estimated rate of recharge is 2 1/2 percent of the average annual precipitation (29 inches) and totals approximately 7,250 acre-feet with a total discharge from the basin of 0 acre-feet over the life of the basin (20 years);
4) The transmissivity of the basin is estimated to be 2,590 ft^2/day;
5) The possibility of natural pollution of the basin as reflected by parameters such as chloride, TDS and sulfate, the source of which would most likely comes from the underlying Permian bedrock can be minimized by proper well construction (not overdrilling the terrace deposits), treatment, and water quality testing and analysis.

LOYAL ISOLATED TERRACE GROUNDWATER BASIN

The following data on the Loyal Isolated Terrace Groundwater Basin were derived in order to calculate and determine the Maximum Annual Yield and Equal Proportionate share of the basin:

1) The total land area overlying the basin is 15,000 acres;
2) The amount of water in storage in the basin on September 1, 1999 was determined to be 50,000 acre-feet;
3) The estimated rate of recharge is 2 1/2 percent of the average annual precipitation (29 inches) and totals approximately 18,750 acre-feet with a total discharge from the basin of 6,200 acre-feet over the life of the basin (20 years);
4) The transmissivity of the basin is estimated to be 2,310 ft^2/day;
5) The possibility of natural pollution of the basin as reflected by parameters such as chloride, TDS and sulfate, the source of which would most likely comes from the underlying Permian bedrock can be minimized by proper well construction (not overdrilling the terrace deposits), treatment, and water quality testing and analysis.

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GLOSSARY

Alluvium

A general term for clay, silt, sand, and gravel, or similar unconsolidated material deposited during comparatively recent geologic time by stream or other body of running water as a sorted or partially sorted sediment in the bed of the stream or on its flood plain or delta, or as a cone or fan at the base of a mountain slope.

Aquifer

A formation, group of formations, or a part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Equal Proportionate Share

That portion of the maximum annual yield of water from a groundwater basin which shall be allocated to each acre of land overlying such basin. The percentage of the maximum annual yield is equal to the percentage of the land overlying the fresh groundwater basin which is owned or leased by an applicant for a regular permit.

Fresh Water

Water which has less than five thousand (5,000) parts per million total dissolved solids. All other water is salt water.

Groundwater

Fresh water under the surface of the earth regardless of the geologic structure in which it is standing or moving outside the cut beds or banks of any definite stream.

Groundwater Basin

A distinct underground body of water overlain by contiguous land having substantially the same geological and hydrological characteristics and yield capabilities. The areal boundaries of a basin can be determined by political boundaries, geological, hydrological, or other reasonable physical boundaries.

Hydraulic Conductivity

The volume of water that will move through a medium in a unit of time under a unit hydraulic gradient through a unit area measured perpendicular to the direction of flow.

Life of a Groundwater Basin

That period of time during which pumping of the maximum annual yield for a minimum twenty year life of such basin will result in a final basin storage which approaches zero. Fifteen feet of saturated thickness is maintained in bedrock aquifers to provide for domestic use.

Major Groundwater Basin
: A distinct underground body of water overlain by contiguous land and having substantially the same geological and hydrological characteristics and from which groundwater wells yield at least fifty gallons per minute on the average basinwide if from a bedrock aquifer and at least one hundred fifty gallons per minute on the average basinwide if from an alluvium and terrace aquifer, or as otherwise designated by the Oklahoma Water Resources Board (Board).

Maximum Annual Yield
: A determination by the Board of the total amount of fresh groundwater that can be produced from each basin allowing a minimum twenty year life of such basin.

Minor Groundwater Basin
: A distinct underground body of water overlain by contiguous land and having substantially the same geological and hydrological characteristics and from which groundwater wells yield less than fifty gallons per minute on the average basinwide if from a bedrock aquifer and less than one hundred fifty gallons per minute on the average basinwide if from an alluvium and terrace aquifer, or as otherwise designated by the Oklahoma Water Resources Board (Board).

Natural Recharge
: All flow of water into a groundwater basin by natural processes including percolation from irrigation.

Permeability
: The property of a porous medium to transmit fluids under a hydraulic gradient.

Porosity
: The ratio, usually expressed as a percentage, of the total volume of voids of a given porous medium to the total volume of the porous medium.

Prior Groundwater Right
: The right to use groundwater established by compliance with the laws in effect prior to July 1, 1973, the effective date of the Oklahoma Groundwater Act.

Specific Capacity
: The volume of water a well will yield per unit of drawdown, usually expressed in gallons per minute per foot (gpm/ft).

Specific Yield

The ratio of the volume of water which the porous medium after being saturated, will yield by gravity to the volume of the porous medium.

Storage Coefficient

The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head (virtually equal to the specific yield in an unconfined aquifer).

Terrace Deposits

Deposits of older alluvium which occupy positions topographically higher than recent alluvium and mark the former position of a stream.

Total Discharge from the Basin

Shall include but may not be limited to the amount of fresh groundwater withdrawn and placed to beneficial use prior to July 1, 1973, which amount shall be determined from the applicable final orders of the Board determining prior groundwater rights.

Transmissivity

The rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient.