CHAPTER 3

AFFECTED ENVIRONMENT

3.1 INTRODUCTION

The purpose of Chapter 3 is to describe the natural resources, such as geology, water, vegetation, and wildlife; and the human resources, such as socioeconomics and cultural resources, of the areas which could be affected by the proposed project. These discussions will address the natural resources of the affected areas for each of the alternatives carried forward from Chapter 2. The affected environment for the ILWSP 150 MGD Option and the 100 MGD Option is within four counties: Sedgwick, Harvey, Reno, and Kingman. Within Sedgwick and Harvey counties, the affected environment is the Equus Beds Well Field, Bentley Reserve Well Field, and Local Well Field. Within most of Reno County, and small portions of Kingman and Sedgwick Counties is Cheney Reservoir. In the case of human resources, the relevant affected environment study area is the Wichita metropolitan area. Discussions of the affected environments will be restricted to only what is relevant.

3.2 GENERAL SETTING

The project area includes and surrounds the City of Wichita in south-central Kansas. The majority of the project area is in Sedgwick, Harvey, and Reno counties, with a small portion lying in Kingman County.

Geographically, the City of Wichita is centered on the confluence of the Little Arkansas and Arkansas rivers, which enter the City from the north and northwest, respectively. The North Fork of the Ninnescah River and Cheney Reservoir are approximately 20 miles west of the City. The mainstem of the Ninnescah River is located approximately 15 miles southwest of the City, and empties into the Arkansas River about 30 miles south of the City of Wichita.

The project area is in the mixed grass prairie vegetation region. Today, agriculture and urban development have replaced most of the natural vegetation. Land in the project area is primarily used for agricultural activities. These activities include growing crops, raising livestock, and producing hay and pasture. Reservoirs and rivers in the project area are used for recreational activities such as fishing, boating, and swimming.

Topography. The topography varies from extremely flat areas along the major rivers to gently rolling uplands adjacent to the river lowlands. Drainage for this area is by way of the Arkansas River and its tributaries. Surface elevations range from approximately 1,200 feet above mean sea level (msl) in the valleys to 1,600 feet msl on the high plains.

Climate. The climate in the area is characterized by daily and seasonal variations. The winters are cold and typically last from December to February. Hot humid summers last for approximately six months while spring and fall are short transitional seasons between winter and summer. Thunderstorms, tornadoes, and drought characterize the general precipitation regime in the area. The average annual precipitation for Wichita is 29.33 inches (Slater and Hall 1996). The average temperature in the area is 68.1 degrees Fahrenheit (^{o}F) with extreme lows of -10°F and highs of 108°F.

3.2.1 GEOLOGY

The physiographic regions in the project area include the Flint Hills, High Plains, Arkansas River Lowlands, and Wellington McPherson Lowlands.

Permian-age limestone and shale underlie the Flint Hills region. The limestone in the Flint Hills contains numerous bands of chert and flint deposited 245 to 286 million years ago, during the Permian Period, when shallow seas covered a large portion of the state (Kansas Geological Survey 1999).

The High Plains region formed from eroded material carried into the area primarily by streams from the Rocky Mountains to the west approximately 1.6 to 66 million years ago. This mass of eroded gravel, sand, and other rock debris that lies below the surface in the High Plains is known as the Ogallala Formation (Kansas Geological Survey 1999). In the study area, this formation is comprised predominantly of unconsolidated material.

The Arkansas River Lowland and Wellington-McPherson Lowland regions have very similar geographic characteristics. The regions are relatively flat, alluvial plains comprised of sand, silt, and gravel that was deposited by streams and rivers. The Arkansas River Lowland was formed during the last 10 million years while the Wellington-McPherson Lowland was formed between 1 and 2 million years ago. The Wellington-McPherson region is comprised of alluvial material which overlays the Hutchinson salt bed, one of the largest salt beds in the world (Kansas Geological Survey 1999). The salt bed is thought to extend as deep as 400 feet and is found under much of central Kansas. The unconsolidated alluvial material contains the Equus Beds aquifer which, is an important source of water for Wichita and the surrounding communities. The aquifer is comprised of saturated sand, silt, and gravel deposited during the Pliocene and Pleistocene Age.

3.2.2 SOILS

Soil is defined as a collection of natural bodies composed of mineral, organic, and living materials that have the capability to support plant life (Soil Conservation Service 1971, 1974). Soil properties are the result of the integrated effects of climate and living matter acting upon parent material over periods of time. When similar soil properties occur in the same area, a soil association is formed.

A soil association is a group of soils geographically associated in a characteristic repeating pattern, defined and described as a single map unit. An association normally consists of one or more major soils and at least one minor soil. The name of the association is derived from the composition of the major soils. Each association has distinctive soil type, relief, and drainage.

The soil associations identified in the project area are described below by county.

Sedgwick County. The project area in Sedgwick County consists primarily of the Equus Beds aquifer and a small portion of Cheney Reservoir dam. Approximately 82 percent of Sedgwick County is covered by soils classified as prime farmland. Sedgwick County has four soil associations within the project area (SCS 1979). The bottomlands adjacent to the Little Arkansas River and North Fork of the Ninnescah consist of the Elandco-Canadian-Elandco soil association. These alluvial soils are deep, nearly level, and well-drained with loamy subsoil. They occupy about 8 percent of the county and are mainly used for growing cultivated crops.

The soil associated with the Arkansas River is of the Lesho-Lincoln-Canadian association. These alluvial soils are shallow to deep, nearly level, moderately poorly to excessively well-drained, and have a sandy subsurface. This association also makes up 8 percent of the county and growing cultivated crops is the main use.

Another soil association in the Arkansas River valley is the Naron-Farnum-Carwile association. These old alluvial soils consists of deep, nearly level, poorly- to well-drained soils, which have a loamy subsurface. This association covers about 9 percent of the county and is mainly used for growing cultivated crops.

A small amount of the Goessel-Tabler-Farnum association exists in the project area south of the town of Sedgwick. These alluvial soils are deep, nearly level, gently sloping, and moderately drained to well-drained, with a clay- to loam-like subsoil. It covers 9 percent of the county and is used mainly to grow cultivated crops.

Harvey County. The project area in Harvey County consists of the Equus Beds. Within Harvey County, there are five soil associations that are in the project area (SCS, 1974). The Farnum-Slickspots-Naron association is found in southwest Harvey County. It consists of deep, nearly level to gently sloping, poorly to well-drained loams and fine sandy loams. This association occupies about 10 percent of the county and is commonly used to grow wheat and sorghum.

The floodplain of the Little Arkansas River consists of the Detroit-Hobbs association. These soils are deep, nearly level, well-drained silt and silty clay loams. This association occupies about 6 percent of the county. Almost all of this association is cropland mainly used for growing wheat and sorghum.

The Crete-Ladysmith association is found west of the Little Arkansas River. The soils are deep, nearly level to gently sloping, moderately well-drained to well-drained silt, and silty clay loams on uplands. This association is in the western part of the county on broad ridges and side slopes. It occupies about 13 percent of the county. About 90 percent of this association is used for growing crops, primarily wheat and sorghum with some alfalfa. Small areas of native grass are scattered throughout the association.

The Carwile-Pratt association is scattered throughout the western portion of the project area in this county. It consists of deep, nearly level, poorly-drained fine sandy loams, and deep well-drained loamy fine sands on the uplands. This association is in four areas in the central and western parts of the county. It occupies about 7 percent of the county,

most used for wheat and sorghum, with a small part in native grass.

The Farnum-Hobbs-Geary association contains deep, nearly level to gently sloping, well-drained loams and silt loams on both uplands and floodplains. This association is along streams in the central and eastern parts of the county. It occupies about 10 percent of the county and is mostly used for growing crops, such as wheat and sorghum. Approximately 72 percent of the surface area of Harvey County are covered by soils classified as prime farmland.

Reno County. The majority of Cheney Reservoir is in Reno County. There are two major soil associations around the reservoir (SCS, 1966). These include the Farnum-Shellabarger association and the Renfrow-Vernon association. The Farnum-Shellabarger association is deep brown loamy soils, which often overlay sandy/gravelly material on sloping, dissected plains. This association occupies a large area along the southern boundary of the county and is mainly used for cultivation of crops. The Renfrow-Vernon soils consist of deep and shallow reddish soils over clayey white shale. This association occupies a large area in the southeastern part of the county and consists of 85 percent Renfrow and Vernon and 15 percent minor soils. The main use is cultivation of crops. Approximately 67 percent of the surface area of Reno County is covered by soils classified as prime farmland.

Kingman County. A small portion of Cheney Reservoir is located in the northeast corner of Kingman County. The soil in this area is of the Shellabarger-Milan-Renfrow association. These gently sloping soils are on the uplands and occupy the more sloping part of the landscape. They are primarily used for growing crops, but some small areas are still in native range.

3.2.3 LAND USE

Sedgwick, Harvey, and Reno counties have land areas totaling 1.8 million acres. The City of Wichita occupies approximately one-tenth of the area in Sedgwick County and is an important transportation and distribution center. The metropolitan area includes important industries such as production and refinery of petroleum products, military and private aircraft, chemical manufacturing, and milling and storage of grain.

Approximately 1.28 million acres of land in the above counties are used for growing crops. Wheat and sorghum are better suited for the climate of this area and have historically been the main crops harvested. Approximately 375,000 acres are used as pasture in the three counties. Raising livestock is an important source of income for the rural areas of the project area. Animals typically raised on farms in the area include cattle, swine, sheep and lamb, and poultry. The remainder of the land in these counties is in other uses such as woodland, urban, residential, and commercial development (Figure 3–1).

Arkansas River

John Martin Reservoir, which is located in Bent County, Colorado, and is also affected by extensive diversions for irrigation. The river has a predominantly sandy bottom.

The Little Arkansas River is found in five counties in south-central Kansas including Lyons, McPherson, Reno, Harvey, and Sedgwick counties. This river travels generally southeast from its headwaters near Geneseo to its confluence with the Arkansas River in Wichita. Major tributaries of the Little Arkansas River include Turkey, Kisiwa, Emma and Sand creeks. The river has a predominantly clayey bottom in the northern portion of the study area, becoming progressively sandier to the south. There are no large reservoirs in the Little Arkansas basin but discharge in the river is heavily influenced by diversions for irrigation and by groundwater withdrawals. There are also diversion structures located near Valley Center and Wichita that divert a portion of higher discharges into the Little Arkansas and Chisholm Creek Floodways. These floodways help alleviate flooding in the City of Wichita by diverting floodwaters to the Arkansas River.

Little Arkansas River

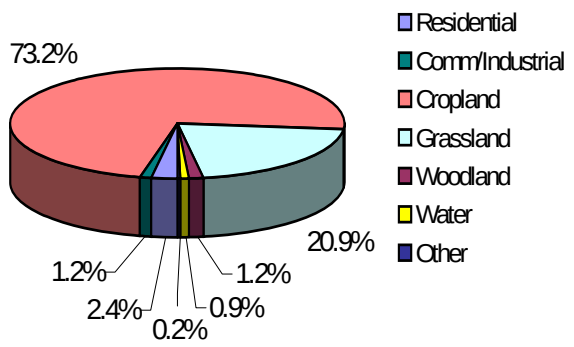
The North Fork travels through five counties in south-central Kansas including Stafford, Pratt, Reno, Kingman and Sedgwick. From its headwaters in Pratt and Stafford counties, the North Fork flows generally east and southeast to its confluence with the Ninnescah River in Sedgwick County. The streambed of the North Fork is predominantly sandy.

North Fork of the Ninnescah River

Cheney Reservoir is formed by a dam located on the North Fork about 15 miles upstream of its confluence with the Ninnescah River. The reservoir occupies land in Reno, Kingman and Sedgwick counties. The U.S. Bureau of Reclamation (Reclamation) began construction of Cheney Reservoir in 1962 and the first water was stored in the reservoir in November 1964. The reservoir is used as a water supply for the

sheep and lamb, and poultry. The remainder of the land in these counties is in other uses such as woodland, urban, residential, and commercial development (Figure 3–1).

Figure 3-1 Land Cover Use for Affected Counties



Cheney State Park and Cheney Wildlife Management Area are both located at Cheney Reservoir approximately 25 miles west of Wichita. Cheney State Park land currently encompasses 1,913 acres while another 5,439 acres of land and 4,109 acres of water make up the Cheney Wildlife Management Area. Cheney Reservoir covers approximately 9,600 surface acres and has about 67 miles of shoreline. The State of Kansas Department of Wildlife and Parks (KDWP) lease all the land and surface water areas except for the reserved tracts.

A portion of the project area includes the Equus Beds well field in portions of Sedgwick and Harvey counties. The land use in this area is predominantly made up of croplands, warm season pasture, and riparian[1] woodlands. Small amounts of cool season pasture, native grassland, wood lots, fence rows, shelter belts, and residential areas can be found in the area. Approximately 10 acres are occupied by municipal well facilities.

3.3 WATER RESOURCES

The major water resources of the ILWSP project area include both surface and groundwater sources. The major components of these resources are discussed in the following sections.

3.3.1 SURFACE WATER

The principal streams of the ILWSP project area are the Arkansas River, the Little Arkansas River, and the North Fork of the Ninnescah River (North Fork). Both the Little Arkansas River and North Fork are tributaries of the Arkansas River.

3.3.1.1 General

The Arkansas River originates in the Rocky Mountains of central Colorado. From its headwaters in Colorado, it travels generally east to the ILWSP project area, and then turns southeast across the northeastern corner of Oklahoma before flowing through central Arkansas and joining the Mississippi River. Its drainage basin covers portions of Colorado, Kansas, Oklahoma, New Mexico, Texas, and Arkansas.

The major tributaries of the Arkansas River in Kansas are the Pawnee River, Walnut Creek, Rattlesnake Creek, Cow Creek, Little Arkansas River, Ninnescah River, and Walnut River. Flow in the Arkansas River is somewhat regulated by

[1] *Riparian* – pertaining to the banks of a river, stream, waterway, or other, typically, flowing body of water as well as to plant and animal communities along such bodies of water.

Cheney Reservoir

City of Wichita, and for fish and wildlife conservation, flood control, and recreation.

Reclamation originally computed and published Cheney Reservoir's firm yield as 52,600 acre-feet per year. This firm yield number was based on streamflow data through May 1956, when Reclamation was required to finalize the various planning reports for the Wichita Project for submission to the U.S. Congress for project authorization. In the 1957 report that went to Congress, Reclamation stated that "as of May 1956, the critical period has not yet ended and the storage-yield relationship at Cheney Reservoir should be reviewed prior to construction in light of the hydrologic data available at that time."

The critical period subsequently ended in 1959. In 1960, Reclamation did review the complete critical period data and, using that data, recomputed a revised firm yield of 42,900 acre-feet per year for Cheney Reservoir.

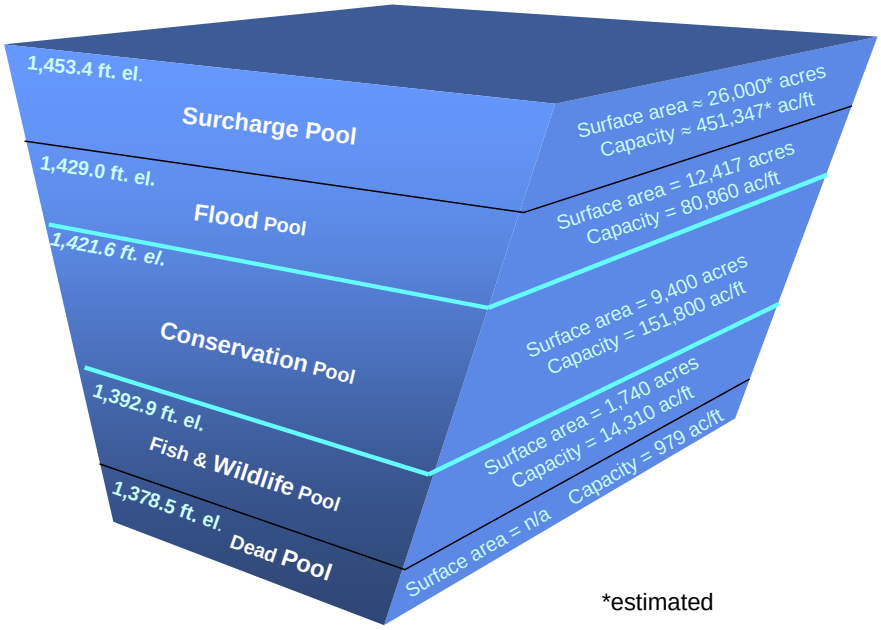
With the ILWSP in place, the City could operate Cheney Reservoir by withdrawing a daily maximum from the conservation pool of 47 MGD (the average daily equivalent of 52,600 acre-feet per year) rather than the 38.2 MGD (the average daily equivalent of 42,900 acre-feet per year). In theory, if all the firm yield assumptions are valid and the City were to pump 47 MGD from Cheney Reservoir during a "critical period", Cheney Reservoir would run out of water before the critical period ended.

The reservoir has a total storage of 566,300 acre-feet, which is allocated in a series of defined "pools" or areas as shown in Figure 3–2. Each pool serves a different purpose and is defined by top and bottom elevations developed during Reclamation's planning and design process for the Wichita Project. For example, the surcharge pool is designed to temporarily store flows from the probable maximum flood, a result from a worst-case storm; release of water from the surcharge pool would be directed by Reclamation. The flood control pool is positioned immediately beneath the surcharge pool and is designed to temporarily store flood waters that occur more commonly. The size of the flood control pool is determined by the amount of downstream flood protection benefits provided; releases from the flood control pool is directed by the U.S. Army Corps of Engineers (Corps). The conservation pool lies directly under the flood control pool and is designed to store municipal and industrial water for the City. The fish and wildlife pool or minimum pool lies under the conservation pool; and the last or dead pool is the lower most pool in the reservoir. No releases can be made from the dead pool, for it is located below the lowest release structure elevation (USGS 1999; Reclamation 2002).

3.3.1.2 Quantity

The quantity of water discharged to the Arkansas, Little Arkansas and North Fork rivers was estimated using streamflow data collected by the U.S. Geological

Figure 3-2 Cheney Reservoir Storage Pools



Survey (USGS). The USGS has operated stream gaging stations at several locations in the ILWSP project area. Those of interest in this analysis are listed in Table 3–1, along with other pertinent data on these gages. The locations of these gages are shown on Figure 3–3. The recorded streamflow data available at these gages were used to develop a set of historic flow data with a common period of record for use in an operations model for the ILWSP project. This common period of record was water years 1923–1996 (October 1, 1922–September 30, 1996).

The flow discharge in project area streams is primarily a function of direct runoff, which results due to precipitation that falls within the stream's watershed. As a result, the rate of discharge in these streams is highly variable and can change dramatically from day-to-day as well as seasonally and annually. Figure 3–4 contains graphs of the historic annual discharge in the Little Arkansas, Arkansas and North Fork rivers which illustrates this variability on an annual basis. Review of these graphs will show the drought periods of the 1930's and mid-1950's contrasted with the floods of 1951, 1973 and 1993.

Some flow discharge statistics for project area streams are listed in Table 3–2. The minimum and maximum recorded discharges for these three streams are surprisingly similar given the difference in the size of their drainage areas. The other statistics listed in Table 3–2 are more as expected. On an average, or mean basis, the flow in the Arkansas River is roughly three times that of the Little Arkansas River, which in turn is about twice that of the North Fork.

From the peak flow records available for the locations listed in Table 3–2, frequency analyses indicate that the 100-year flood on the North Fork is actually higher than that of either the Arkansas or Little Arkansas rivers. This results

Table 3-1 USGS Stream Gages

Station Number & Name	Location (Latitude/ Longitude)	Drainage Area (miles^2)	Period of Record
07143330 Arkansas R near Hutchinson, KS	37° 56' 47" 97° 45' 29"	38,910	10/01/59–present
07143375 Arkansas R near Maize, KS	37° 46' 53" 97° 23' 33"	39,110	03/01/87–present
07143400 Arkansas R near Wichita, KS	37° 42' 30" 97° 21' 50"	39,072	10/01/21–03/31/35
07143665 Little Arkansas R at Alta Mills, KS	38° 06' 44" 97° 35' 30"	736	06/06/73–present
07144100 Little Arkansas R near Sedgwick, KS	37° 52' 59" 97° 25' 27"	1,239	10/01/93–present
07144200 Little Arkansas R at Valley Center, KS	37° 49' 56" 97° 23' 16"	1,327	06/10/22–present
07144300 Arkansas R at Wichita, KS	37° 38' 41" 97° 20' 06"	40,490	10/01/34–present
07144550 Arkansas R at Derby, KS	37° 32' 34" 97° 16' 31"	40,830	10/01/68–present
07144780 NF Ninnescah R above Cheney Res, KS	37° 43' 17" 97° 47' 39"	787	07/01/65–present
07144800 NF Ninnescah R near Cheney, KS	37° 40' 00" 97° 46' 00"	930	10/01/50–09/30/64
07145500 Ninnescah R near Peck, KS	37° 27' 26" 97° 25' 20"	2,129	04/01/38–present
07146500 Arkansas R at Arkansas City, KS	37° 03' 23" 97° 03' 32"	43,713	10/01/21–present

Source: USGS website (http://water.usgs.gov).

primarily from a single peak flow of 87,000 cfs that was recorded on theNorth Fork above Cheney Reservoir on October 30, 1979. On this same date, the average flow was only 47,900 cfs—the overall maximum listed in Table 3–2. The high ratio between peak and mean discharge on this date indicates this extreme flood resulted from a very intense but short duration thunderstorm.

When there is little or no direct runoff to a stream, any discharge is primarily a result of groundwater discharge — also known as base flow. The low flow statistics listed in Table 3–2 give a good indication of the base flow in these streams. The interaction between area streams and aquifers is discussed further below.

An indication of the seasonal variability of discharge in project area streams is provided by the monthly median flow data presented in Table 3–3. Median flows are those which fall in the statistical middle of historic values. Actual daily flow discharges will be higher than the median half the time and less than the median the other half of the time.

The Kansas Water Office (KWO), in collaboration with the Kansas Division of Water Resources, KDWP, and the

Figure 3-3 USGS Stream Gage Locations

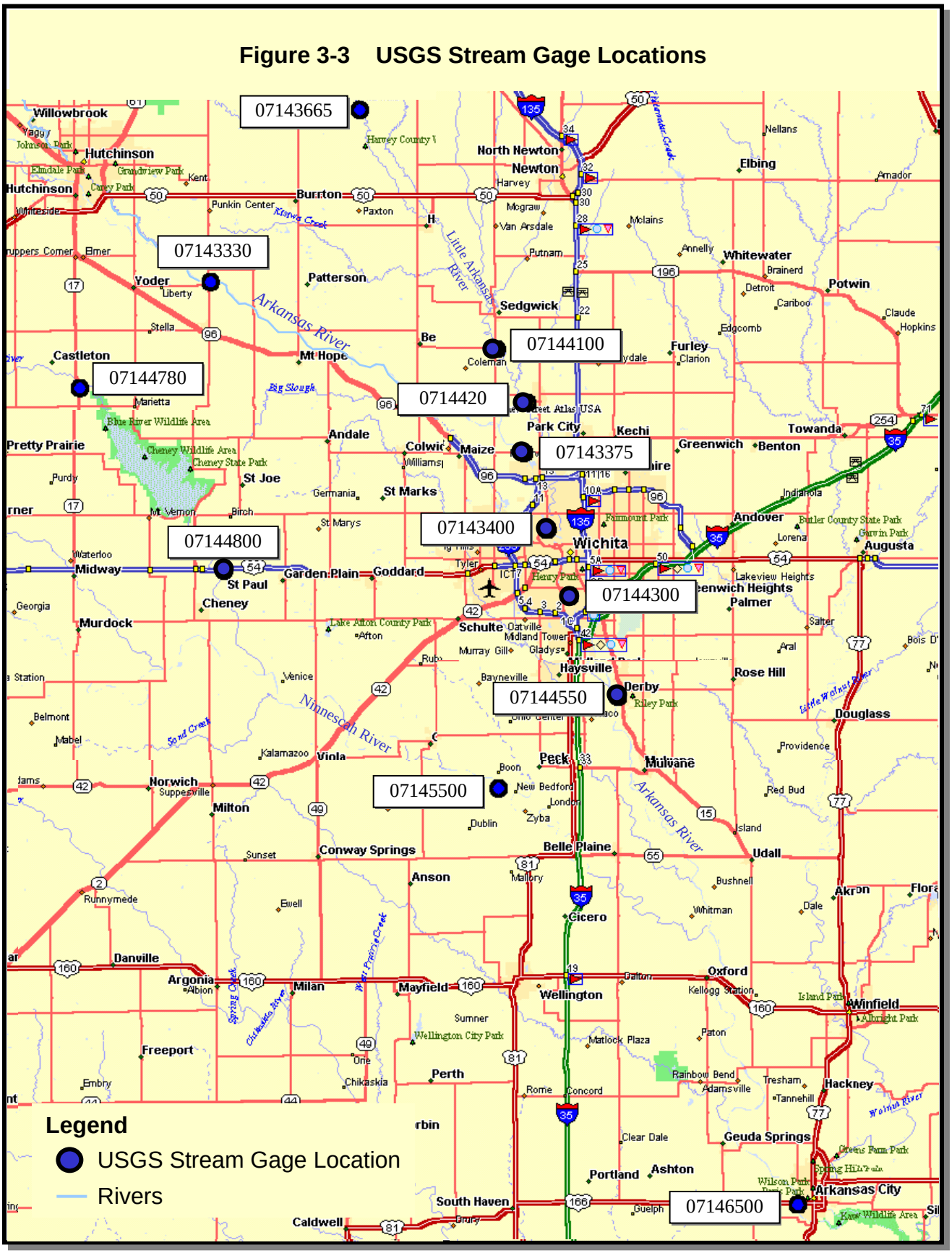


Figure 3–4 Historic Annual Discharge for Project Area Streams

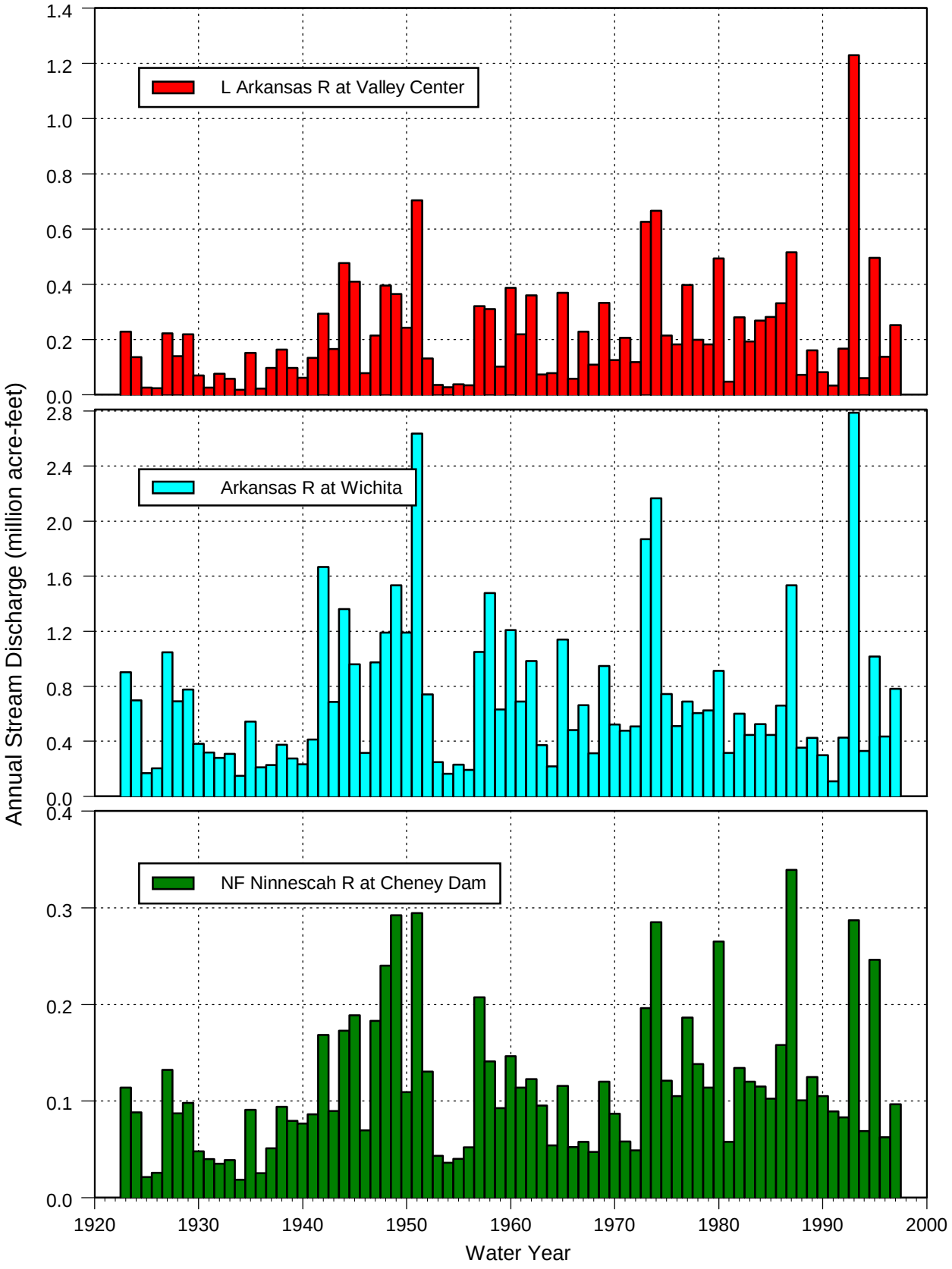


Table 3–2 Discharge Statistics for Project Area Streams

Statistic		Mean Daily Discharge (cfs)		
		Arkansas River at Wichita	Little Arkansas River at Valley Center	North Fork Ninnescah River at Cheney Dam
Overall Minimum		5	1	0
Overall Maximum		41,100	28,600	47,900
Mean (Average)		986	305	159
Percent of Time Discharge Equaled or Exceeded	90%	101	20	19
	50%	402	58	79
	10%	2,030	456	257
Floods	2-year	10,600	6,830	3,920
	10-year	27,500	19,900	20,700
	100-year	48,600	37,200	84,900
7-Day Average Low Flows	2-year	92.2	18.9	10.3
	10-year	29.4	8.6	5.4
	100-year	10.3	2.5	0.7

Source: Statistics based on estimated mean daily discharges, which were derived from USGS streamflow records, for water years 1923–1996. Flood discharges estimated from analysis of recorded annual instantaneous peak discharges.

Table 3–3 Median Flow by Month for Project Area Streams (cfs)

Month	Arkansas River			Little Arkansas River		North Fork Above Cheney
	Hutchinson	Wichita	Arkansas City	Alta Mills	Valley Center	
Jan	124.9	249.9	571.1	23.3	53.8	60.2
Feb	169.4	327.1	645.5	26.0	61.1	60.1
Mar	207.2	387.7	801.0	31.0	70.4	62.4
Apr	216.8	459.7	947.1	35.0	76.4	60.5
May	273.5	573.4	1,198.2	45.5	107.6	63.2
Jun	405.1	825.1	1,515.8	57.0	129.4	82.8
Jul	248.4	504.5	959.6	31.5	75.6	102.3
Aug	166.5	321.6	659.7	22.7	54.7	96.9
Sep	150.0	293.2	555.5	21.6	53.5	72.8
Oct	117.6	226.9	520.6	18.7	49.6	81.1
Nov	149.6	306.0	634.2	26.0	58.8	60.1
Dec	142.3	287.8	595.8	24.5	58.4	58.4

Kansas Department of Health and Environment, has established minimum desirable streamflow (MDS) rates at various locations in the Little Arkansas and Ninnescah River basins. The MDS values for the points of interest in this analysis are listed in Table 3–4. As listed in this table, the MDS at Valley Center is 20 cfs year-round. However, the KDWP's regional recommendations were substantially higher at 60 cfs during April,

Table 3–4 Minimum Desirable Streamflow Values

Month	Little Arkansas River		North Fork Ninnescah River above Cheney Res.	Ninnescah River near Peck
	at Alta Mills	at Valley Center		
Jan	8	20 (34)	40	100
Feb	8	20 (34)	50	100
Mar	8	20 (34)	50	100
Apr	8	20 (60)	50	100
May	8	20 (60)	40	100
Jun	8	20 (60)	30	70
Jul	8	20 (34)	10	30
Aug	8	20 (34)	5	30
Sep	8	20 (34)	5	30
Oct	8	20 (34)	10	50
Nov	8	20 (34)	40	100
Dec	8	20 (34)	40	100

Source: Kansas Water Office, 1983 and 1985. Values in parentheses are values recommended by Kansas Department of Wildlife and Parks.

May and June, and 34 cfs the remainder of the year (KWO 1983, 1985).

Figure 3–5 contains graphs that compare the historic median flows in the Little Arkansas and Ninnescah rivers with the specified MDS values. As expected, historic median discharges for each of these streams exceeds the established MDS in each month, although to differing degrees.

3.3.1.3 Water Surface Elevations and Depths

The elevation of the water surface in a stream is dependent on the discharge at the point in question, the physical characteristics of the stream, and potentially, the water surface elevations of points downstream as well. Using the most recently available rating tables and mean daily discharges at the corresponding USGS stream gages, water surface elevations were estimated for water years 1923–1996. These water surface elevation estimates were then used to calculate the median monthly water surface elevations listed in Table 3–5. The corresponding water depths listed in Table 3–5 are the estimated maximum depths measured at the lowest point in the stream cross section.

3.3.1.4 Quality

The quality of surface waters in the ILWSP project area can vary significantly with time and location. Table 3–6 contains a summary of surface water quality data for the vicinity that have been collected by the USGS. Although the number of samples and their respective collection periods vary, the data shown in Table 3–6 are considered representative of surface water quality in the project area.

Though moderately hard, the water from these streams is generally acceptable for delivery to the City's water treatment plant for subsequent treatment and distribution to customers. The one exception is found in the elevated salinity levels in the Arkansas River. Several natural and man-made sources of salinity that contribute to these elevated salinity levels exist in the Arkansas River basin

Figure 3–5 Comparison of Historic Median Flow and MDS Values

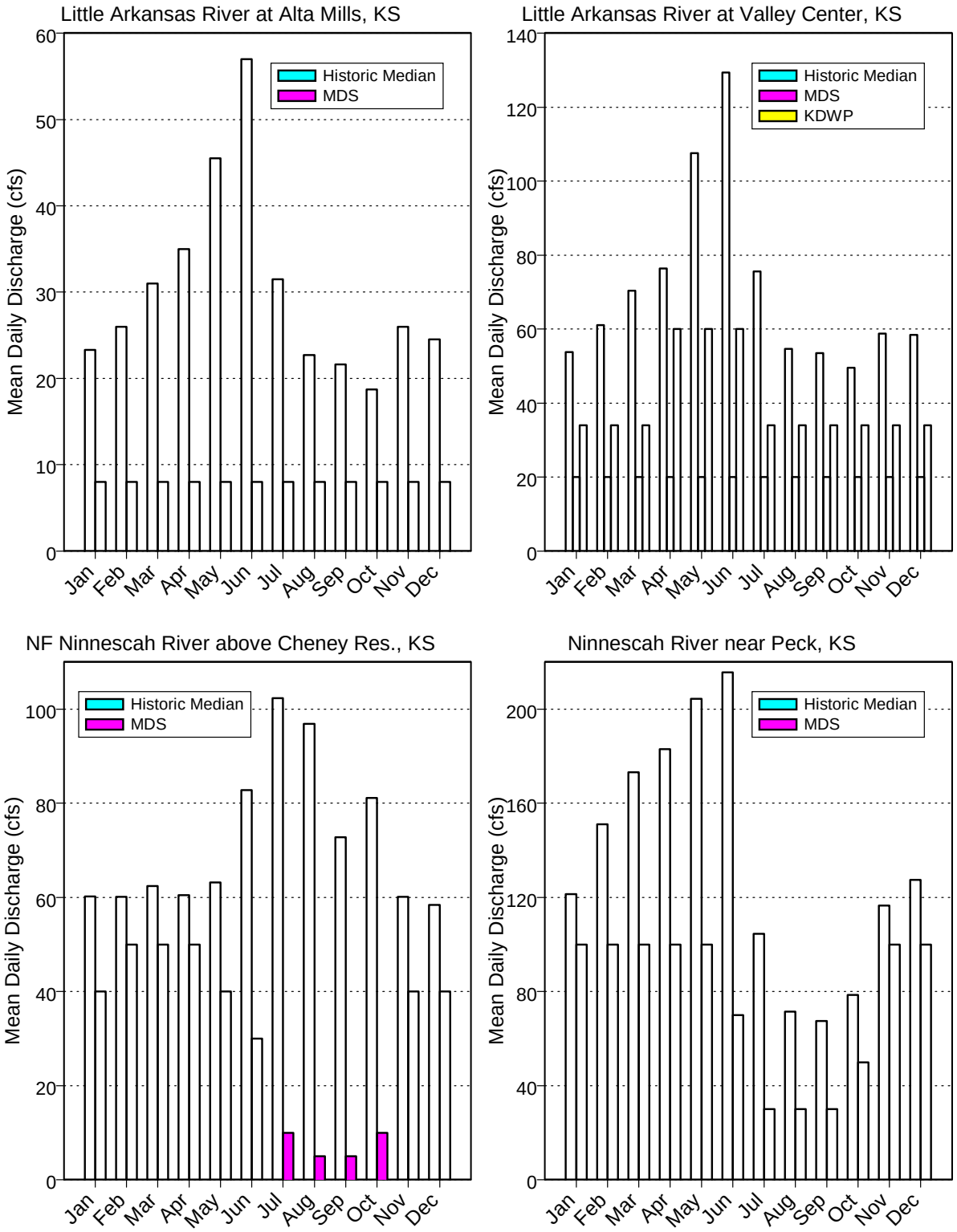


Table 3–5 Median Monthly Water Surface Elevations (and Flow Depths) for Project Area Streams (feet)

Month	Arkansas River			Little Arkansas River		North Fork Above Cheney
	Hutchinson	Wichita	Arkansas City	Alta Mills	Valley Center	
Jan	1,457.10 (0.27)	1,266.47 (1.25)	1,059.48 (1.10)	1,392.84 (1.08)	1,326.95 (0.71)	1,463.25 (0.56)
Feb	1,457.19 (0.36)	1,266.68 (1.46)	1,059.57 (1.19)	1,392.92 (1.15)	1,327.00 (0.77)	1,463.25 (0.56)
Mar	1,457.26 (0.43)	1,267.85 (1.63)	1,059.72 (1.34)	1,393.02 (1.26)	1,327.08 (0.84)	1,463.26 (0.57)
Apr	1,457.28 (0.45)	1,267.00 (1.79)	1,059.86 (1.48)	1,393.10 (1.34)	1,327.12 (0.89)	1,463.25 (0.56)
May	1,457.39 (0.56)	1,267.21 (2.00)	1,060.09 (1.71)	1,393.32 (1.56)	1,327.33 (1.10)	1,463.27 (0.58)
Jun	1,457.64 (0.81)	1,267.60 (2.38)	1,059.88 (1.94)	1,393.52 (1.76)	1,327.47 (1.24)	1,463.40 (0.71)
Jul	1,457.34 (0.51)	1,267.09 (1.87)	1,059.88 (1.50)	1,393.03 (1.27)	1,327.12 (0.88)	1,463.54 (0.85)
Aug	1,457.18 (0.35)	1,266.67 (1.45)	1,059.58 (1.20)	1,392.83 (1.06)	1,326.95 (0.72)	1,463.50 (0.81)
Sep	1,457.15 (0.32)	1,266.59 (1.37)	1,059.45 (1.07)	1,392.79 (1.03)	1,326.94 (0.71)	1,463.33 (0.64)
Oct	1,457.09 (0.26)	1,266.40 (1.18)	1,059.40 (1.02)	1,392.70 (0.94)	1,326.91 (0.68)	1,463.39 (0.70)
Nov	1,457.15 (0.32)	1,266.62 (1.41)	1,059.56 (1.18)	1,392.92 (1.15)	1,326.99 (0.75)	1,463.25 (0.56)
Dec	1,457.14 (0.31)	1,266.57 (1.36)	1,059.51 (1.13)	1,392.88 (1.12)	1,326.98 (0.75)	1,463.24 (0.55)

upstream of Wichita. Conventional water treatment processes cannot economically remove salinity; as a result, it is important to find a water source that contains acceptable levels of salinity.

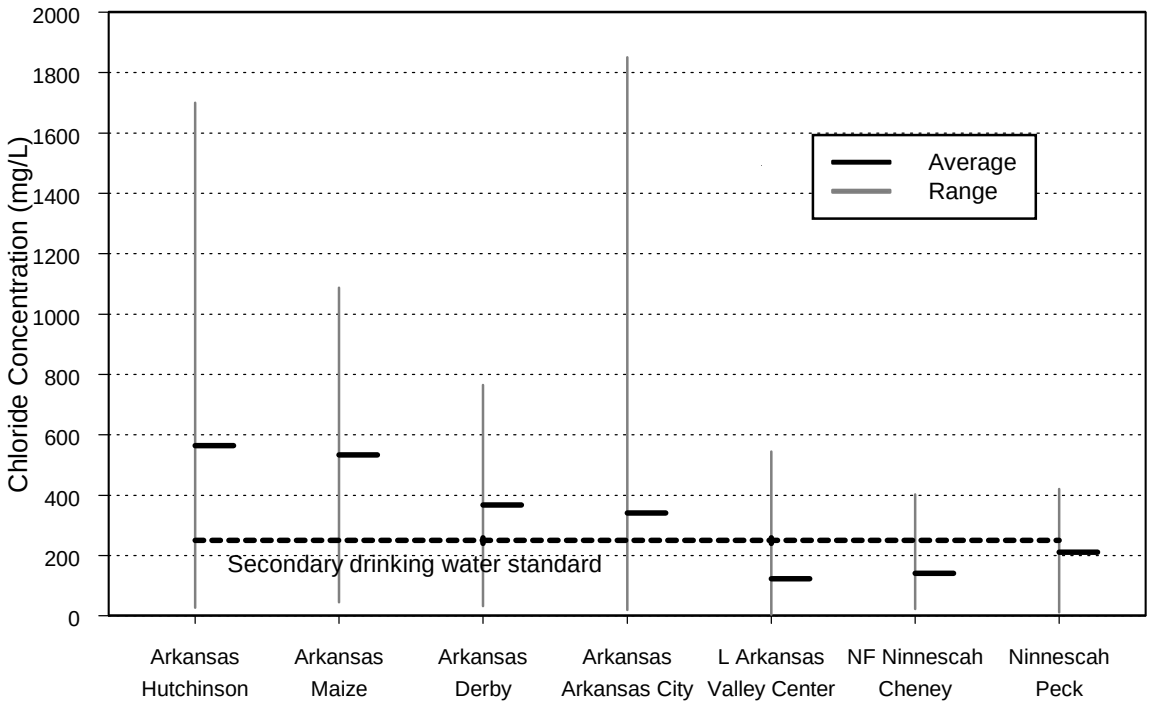
The concentration of chloride ions in the Arkansas River, which is a measure of salinity, can range up to 1,700 mg/L upstream of Wichita (see Table 3–6). The U.S. Environmental Protection Agency (EPA) has established secondary drinking water standards that recommend limiting chloride concentrations to 250 mg/L (40 CFR 143). The contaminants that are included in the secondary drinking water standards, like chloride, are those that primarily affect the aesthetic qualities of drinking water, such as taste, odor and color.

Figure 3–6 is a graph showing the range and average of chloride concentrations for those stations listed in Table 3–6 that have at least 50 data points. This graph shows that water in the Little Arkansas, North Fork and Ninnescah rivers has significantly lower chloride concentrations than that of the Arkansas River. Comparison of average chloride concentrations in the Arkansas River near Maize, which is just above Wichita, with that at Derby, which is just below Wichita, shows a distinct water quality improvement as the river flows through Wichita. This is primarily a result of

Table 3-6 Surface Water Quality Data

Station	Conductivity	Dissolved Oxygen	pH	Dissolved Concentrations									Suspended Solids
				Hardness	Calcium	Magnesium	Sodium	Potassium	Chloride	Sulfate	Fluoride	Dissolved Solids	
	µseimens	mg/l		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Arkansas River													
07143330 near Hutchinson, KS	300 - 5900	1.3 - 13.6	6.9 - 9.1	0 - 805	22 - 214	3.5 - 72	23 - 1110	6.2 - 23	27 - 1700	18 - 918	0.2 - 1.2	208 - 3470	5 - 6120
07143375 near Maize, KS	235 - 4150		7.1 - 9.4		19 - 160	3.9 - 70	26 - 500	6.5 - 13	45 - 1088	11 - 800		162 - 1750	
07144200 at Wichita, KS	200 - 2620		6.8 - 9.2										76 - 2500
07144550 at Derby, KS	185 - 3560	5.8 - 13.4	6.8 - 8.9	80 - 717	25 - 187	3.4 - 64	22 - 536	4 - 16	33 - 765	20 - 738	0.3 - 1	193 - 2150	1340 - 1560
07146500 at Arkansas City, KS	213 - 6540	1 - 17.1	6.6 - 10	24 - 760	17 - 216	3.5 - 56	18 - 1180	0.6 - 28	20 - 1850	15 - 630	0 - 1.1	132 - 4090	0.8 - 74
Little Arkansas River													
07143665 at Alta Mills, KS	105 - 3200		7 - 8.7	330 - 452	105 - 142	17 - 24	152 - 258	5.3 - 6	274 - 532	54 - 125	0.4	820 - 1380	9 - 2130
07144100 near Sedgwick, KS	85 - 1467	4.2 - 18.8	3.99 - 8.6		11.6 - 113	2.2 - 20.3	4.82 - 123	5.24 - 10.55	8 - 218	7 - 211	0.12 - 0.82	92 - 759	12 - 3680
07144200 at Valley Center, KS	79 - 7300	5.7 - 14.6	6.6 - 8.7	1 - 474	9.6 - 142	0.2 - 32	3 - 260	3.3 - 10	5 - 545	5 - 110	0.1 - 0.8	64 - 1250	9 - 9990
North Fork of the Ninnescah River													
07144780 above Cheney Reservoir, KS	152 - 1560	7.5 - 10.4	7.2 - 9.1	188 - 266	54 - 83	9.1 - 16	137 - 190	3.6 - 8.2	196 - 282	49 - 88	0.4 - 0.5	628 - 776	1 - 2460
07144800 near Cheney, KS	260 - 1770		7.2 - 8.3	84 - 307	26 - 87	4.6 - 30	16 - 265	1.6 - 8	23 - 402	11 - 85	0.2 - 0.5	158 - 967	27 - 1740
Ninnescah River													
07145500 near Peck, KS	15 - 4020		6.8 - 8.8	48 - 320	14 - 99	3.2 - 23	7.5 - 273	1.4 - 8.2	12 - 421	6 - 82	0 - 0.7	95 - 936	11 - 4000

Figure 3–6 Surface Water Chloride Concentrations



dilution by the better-quality water from the Little Arkansas River.

The herbicide, atrazine, is typically applied to agricultural lands where crops are grown primarily in spring and fall. Coincidentally, this application occurs when precipitation is most intense and runoff can be greatest. Atrazine concentrations and loading in runoff in the Little Arkansas River is greatest during the spring and early summer months (May through July). During this 15- to 40-day period, runoff used for recharge of the Equus Beds aquifer may have to be treated to remove atrazine and other herbicides.

3.3.2 GROUNDWATER

Groundwater is a very important resource within the ILWSP project area. It is used to supply water for municipal, industrial, irrigation, domestic and livestock uses. Groundwater aquifers, levels and quality in the project area are discussed below.

3.3.2.1 Geologic Formations and Aquifers

An aquifer is a geologic formation, group of formations, or portion of a formation that is water-bearing. The project area is underlain by a number of geologic formations that can yield water to wells. The major formations and aquifers, and their water-bearing properties, are discussed below.

3.3.2.1.1 Wellington Formation

The Wellington Formation forms the bedrock surface over much of the project area. It crops out, or is exposed at the surface, to the east of Wichita and the Arkansas River Valley but is covered by more recent rocks and sediments to the west. The thickness of this formation ranges from about 80 feet in the eastern portion of the project area to about 550

feet farther west (Lane and Miller 1965). This formation consists chiefly of gray and blue-gray shale with small thin beds of maroon shale, limestone, gypsum and anhydrite. There is also a thick salt bed within this formation that can attain a thickness of 350 feet. This salt bed has been removed by solution within the Arkansas Valley and to the east but still exists under the more westerly portions of the project area (Lane and Miller 1965).

East of the Arkansas Valley and Wichita, where it is not covered by more recent sediments, the Wellington Formation is the only source of groundwater. The quantity and quality of groundwater available varies widely in this area. In most cases, this water is very hard or has other undesirable properties such as a high sulfate content. Farther west, where the salt bed still exists, this formation can contain saturated brine, making this water unusable for most purposes (Lane and Miller 1965).

3.3.2.1.2 Ninnescah Shale

The Ninnescah Shale overlies the Wellington Formation and is composed of alternating beds of reddish-brown silty shale and siltstone. In its lower part, it can also contain thin beds of gray-green silty shale. The Ninnescah Shale forms the bedrock in areas generally west of the Arkansas Valley. It ranges in thickness from a featheredge to about 175 feet (Lane and Miller 1965).

The Ninnescah Shale yields water to wells in its outcrop area where it is not overlain by more recent sediments. Yields are generally small and most of its water is believed to originate from its weathered surface zone. Water from this zone is generally of good quality although it typically has high concentrations of nitrates. Water from deeper parts of the formation usually contains large concentrations of dissolved solids, with sulfate being the most objectionable constituent (Lane and Miller 1965).

3.3.2.1.3 Ogallala Formation

There is a broad depression in the bedrock surface in the project area that generally follows the current course of the Arkansas River. This depression ranges up to about 10 miles wide and its floor is up to about 150 feet lower than the surrounding bedrock surface. The lower portions of this depression are occupied by rocks believed to be equivalent in age to those of the Ogallala Formation. This formation is composed of calcareous, gray to pink-tan silt and clay, fine to coarse sand, and fine to coarse gravel. Where present, this formation ranges in thickness from a featheredge to a maximum of about 150 feet. It does not crop out in the project area but is covered by younger sediments (Lane and Miller 1965).

The Ogallala Formation consists of finer grained sediments, and is less permeable than the overlying sediments. Where present, this formation is hydraulically connected to the more permeable beds that overlie it so that a portion of the water yielded to wells in this area is derived from the Ogallala Formation. Most of the wells with large yields in the project area penetrate the complete section of unconsolidated rocks, including the Ogallala and overlying sediments. The water from this formation is only moderately hard and generally suitable for most uses. The exception to this is localized areas near the base of this formation that may be contaminated with salt (Lane and Miller 1965).

3.3.2.1.4 Lower Pleistocene Deposits

The Pleistocene Series in Kansas is divided into four glacial stages and three interglacial stages. Sediments derived from the two earliest glacial stages — the Lower Pleistocene, or Nebraskan, and Kansan ages — are found primarily within the Arkansas Valley. At one time, these deposits probably covered the entire project area but were later removed by erosion. Where present, these undifferentiated deposits are composed of silt, clay, sand, and gravel, and range in thickness from a featheredge to about 150 feet.

The water derived from these Lower Pleistocene deposits is moderately hard but suitable for most uses. Although most large wells in the vicinity penetrate several formations, the well yields from these deposits are estimated to range from 50 to 1,000 gallons per minute (gpm) (Lane and Miller 1965).

3.3.2.1.5 Illinoisan Terrace Deposits

Illinoisan terrace deposits, a member of the Upper Pleistocene Series, underlie large portions of the project area west of the Arkansas Valley and north of the Ninnescah valley. These deposits consist of fine to coarse sand and fine to coarse gravel, grading into sandy silt in their upper extremities. Within the Arkansas valley, these terrace deposits range in thickness from 0 at the valley wall to a maximum of about 75 feet (Lane and Miller 1965).

The Illinoisan terrace deposits supply water to many stock and domestic wells in the project area and some municipal, industrial and irrigation wells. In the Arkansas valley, well yields of 500 gpm are readily obtainable in these deposits, with yields possibly as high as 1,000 gpm in more favorable areas. Within the Ninnescah valley, these deposits are thinner, and have lesser saturated thicknesses, so yields are correspondingly lower (Lane and Miller 1965).

3.3.2.1.6 Wisconsinan Terrace Deposits and Recent Alluvium

The youngest sediments in the project area are the Wisconsinan terrace deposit and recent alluvium. These deposits underlie a broad, flat surface — ranging from four to nine miles wide — adjacent to the Arkansas and Little Arkansas rivers, with an average thickness of about 45 feet. These deposits consist of fine to coarse sand and fine to coarse gravel with only small amounts of silt and clay (Lane and Miller 1965).

The Wisconsinan terrace deposits and recent alluvium are the most widely used source of groundwater within the project area, although most large capacity wells penetrate these deposits and lower unconsolidated deposits as well. Well yields up to 2,000 gpm are possible from these formations. The quality of water from these deposits varies, generally improving with greater distances from the Arkansas River (Lane and Miller 1965).

3.3.2.1.7 Equus Beds Aquifer

The Equus Beds aquifer is the eastern-most part of the aquifer system known as the High Plains aquifer in Kansas. The Equus Beds are named for the equine fossils of Pleistocene age found in the unconsolidated sediments of the area. The Equus Beds aquifer underlies an area of about 900,000 acres within portions of Sedgwick, Harvey, McPherson, and Reno counties. The extent of the Equus Beds aquifer generally corresponds to the boundaries of Groundwater Management District No. 2 (GMD2) as shown on Figure 3–7.

The Equus Beds aquifer generally includes all of the unconsolidated sediments deposited within the bedrock depression noted above. As such, it is comprised of portions of: the Ogallala Formation; Lower Pleistocene deposits; Illinoisan and Wisconsinan terrace deposits; and recent alluvium.

3.3.2.2 Groundwater Levels

Prior to 1940, there was little utilization of groundwater within the ILWSP project area except for domestic use and stock watering. The local water table was near the ground surface in many areas so shallow wells, many hand-dug, were typical. In the early 1940's, the City of Wichita began development of the Equus Beds Well Field as a water supply source for the City. Subsequent to this, large areas within the well field area were converted from dry land to irrigated cropland. The annual withdrawal of groundwater by the City, other municipalities, industries and irrigators has exceeded the natural recharge to the underlying aquifers in most years. Most natural recharge is a direct function of precipitation so it can vary widely from year to year, as can groundwater withdrawals. In wet years, there tends to be more recharge and less withdrawals, and the converse is true in dry years.

Since groundwater withdrawals often exceed natural recharge, large declines in groundwater levels, as much as 40 feet, have occurred in some areas. Figure 3–8 is a map showing the saturated thickness of the Equus Beds aquifer under pre-development conditions and the declines that have occurred since then.

As mentioned in Section 3.3.1.2, the base flow in area streams is a result of the interaction with local aquifers. Due to the sandy nature of soils along the Arkansas and Little Arkansas rivers, there is a strong hydraulic connection between these two streams and the Equus Beds aquifer. Figure 3–9 shows the relationship between water levels and infiltration (gains) to and discharge (losses) from the Equus Beds aquifer. In Figure 3–9, water levels are expressed in terms of storage deficits as compared to pre-development conditions. As the Equus Beds aquifer is depleted (that is, as storage deficits increase and water levels decline), infiltration to the aquifer from the Arkansas River increases and discharge to the Little Arkansas River decreases.

As shown in Figure 3–9, under pre-development conditions — zero storage deficit — the Equus Beds aquifer and the Arkansas River were nearly in equilibrium, with an infiltration rate estimated to be less than 8 cubic feet per second (cfs). Under these same conditions, the aquifer discharged about 38 cfs to the Little Arkansas River. Under recent conditions, with a storage deficit estimated to be near 200,000 acre-feet, there is about 26 cfs of infiltration from the Arkansas River and discharge to the Little Arkansas River has declined to about 14 cfs, a decrease of about 24 cfs.

3.3.2.3 Quality

The quality of groundwater in the project area varies greatly depending on the geologic formation it is derived from and its depth. In general, groundwater tends to become more mineralized with increasing depth. Table 3–7 lists the chemical constituents of groundwater samples from various wells located in the project area (see Figure 3–10).

Review of Table 3–7 shows that the total dissolved solids content of these waters

Figure 3–7 Groundwater Management District No. 2 Boundaries

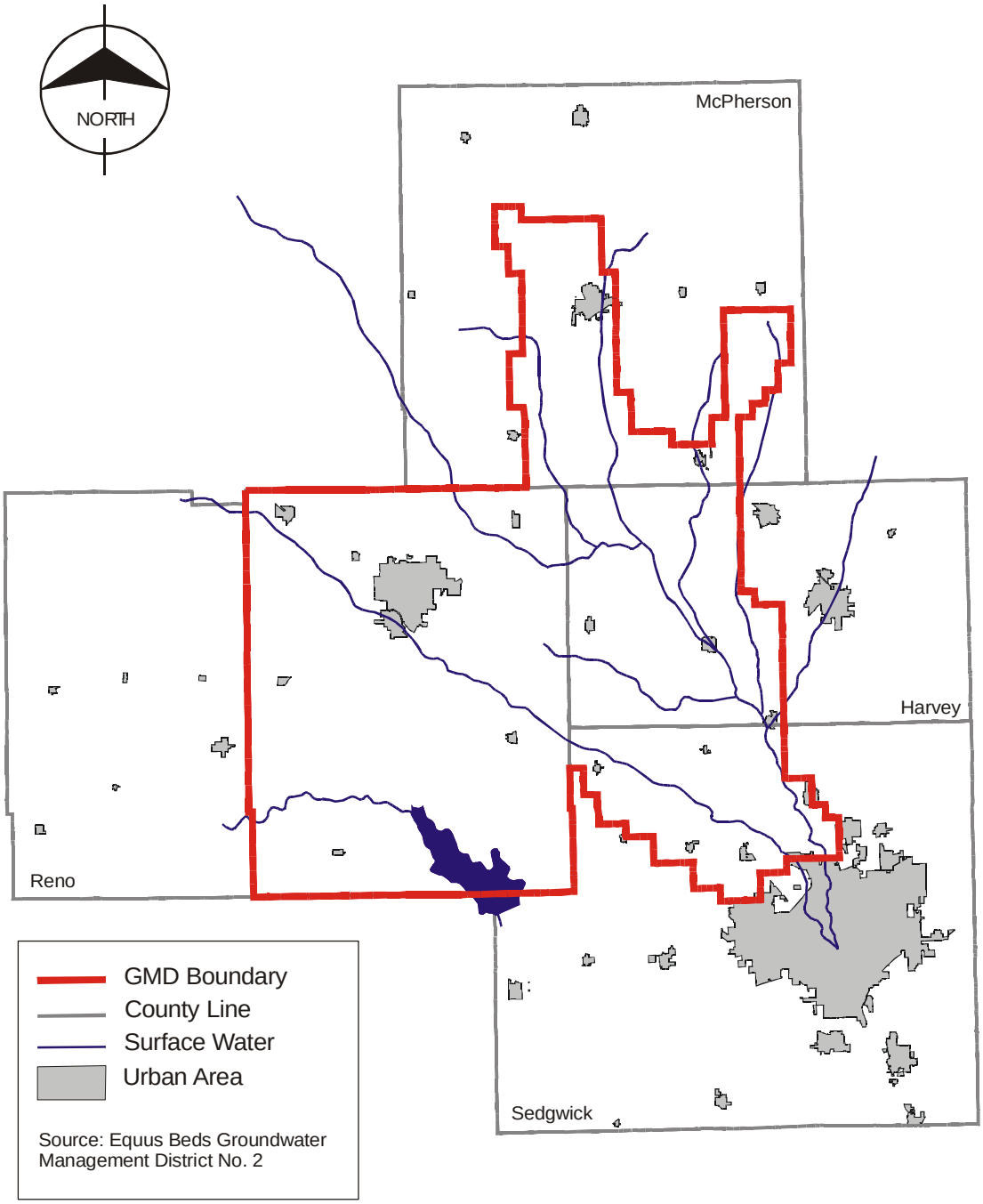
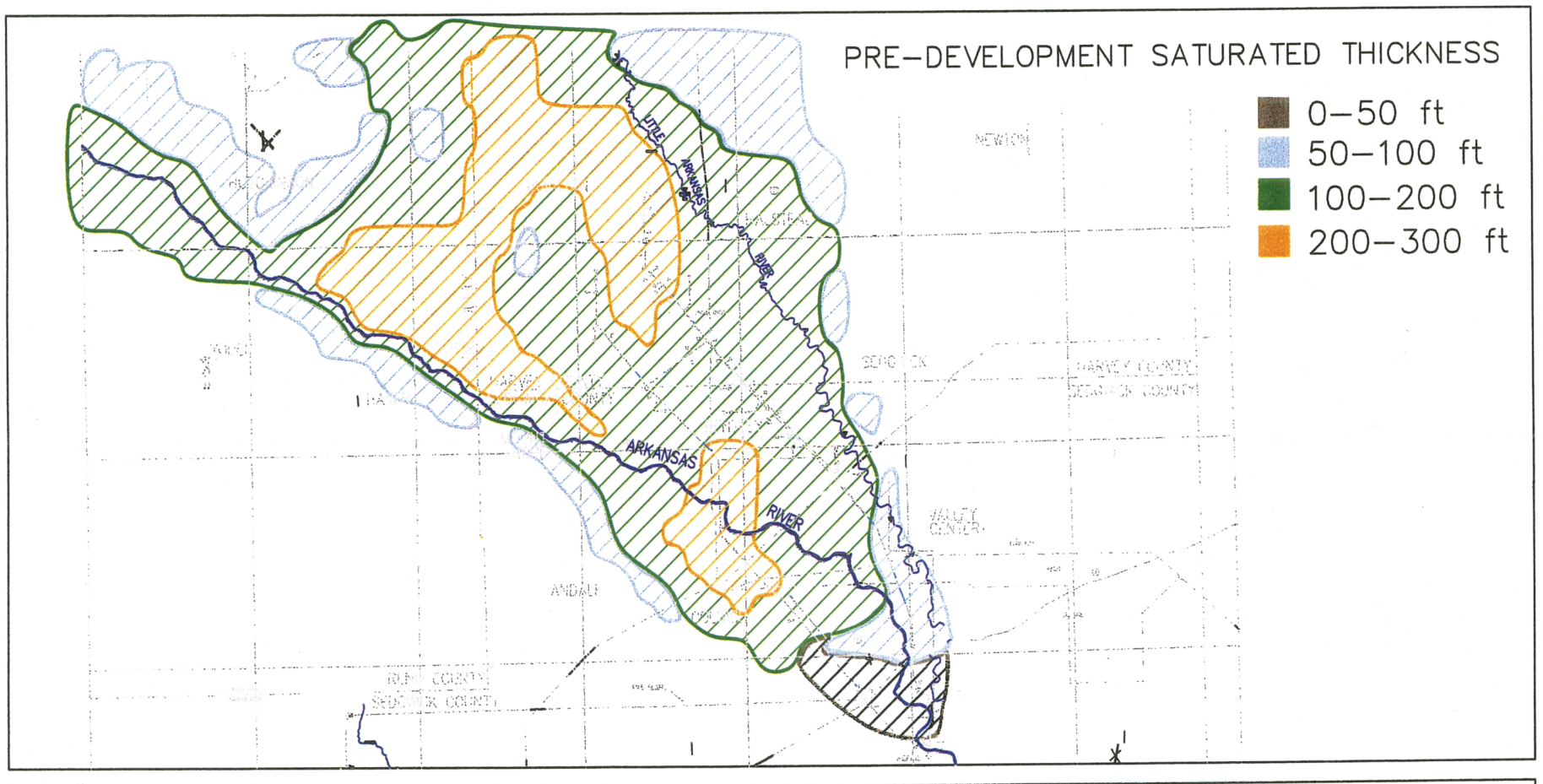
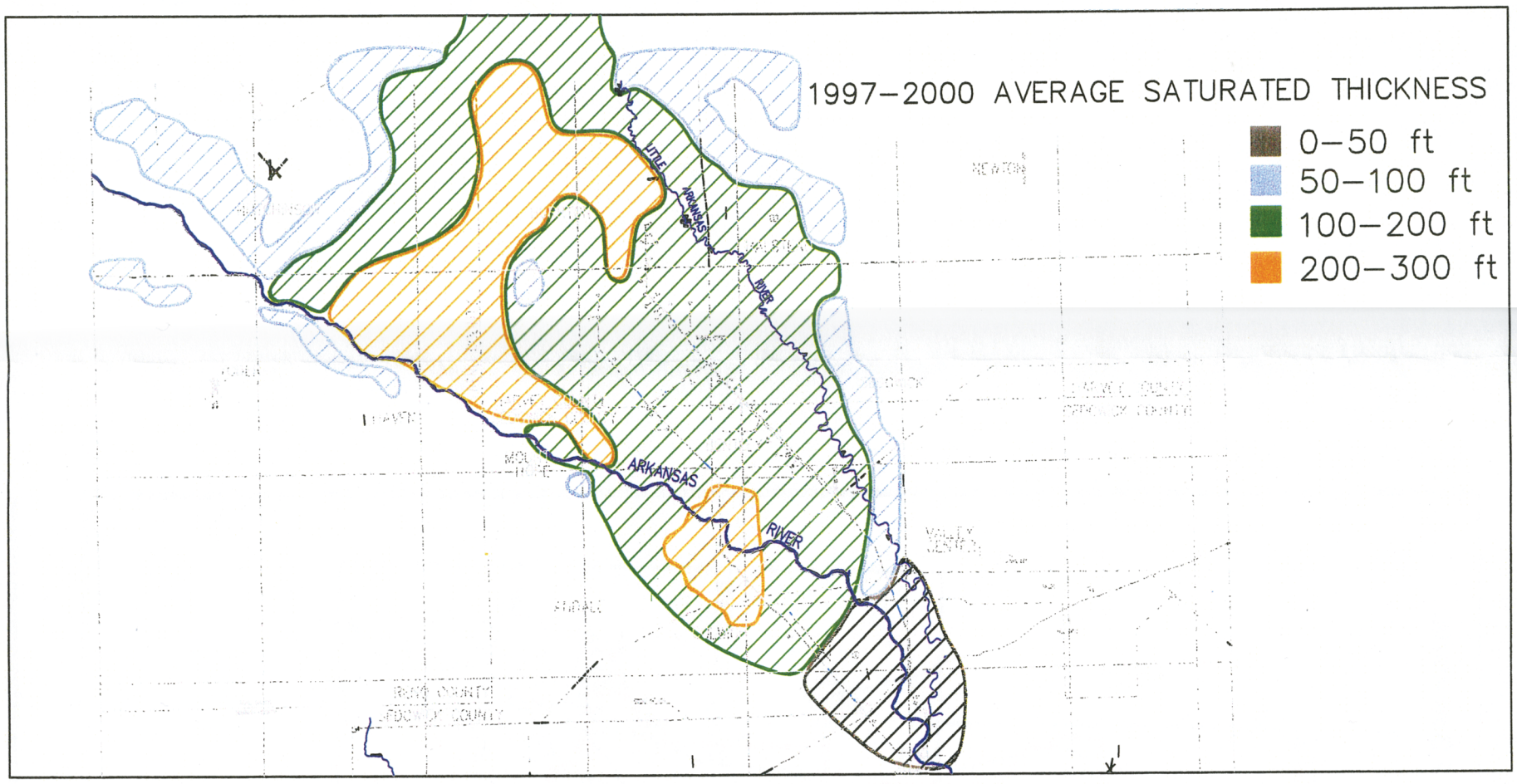
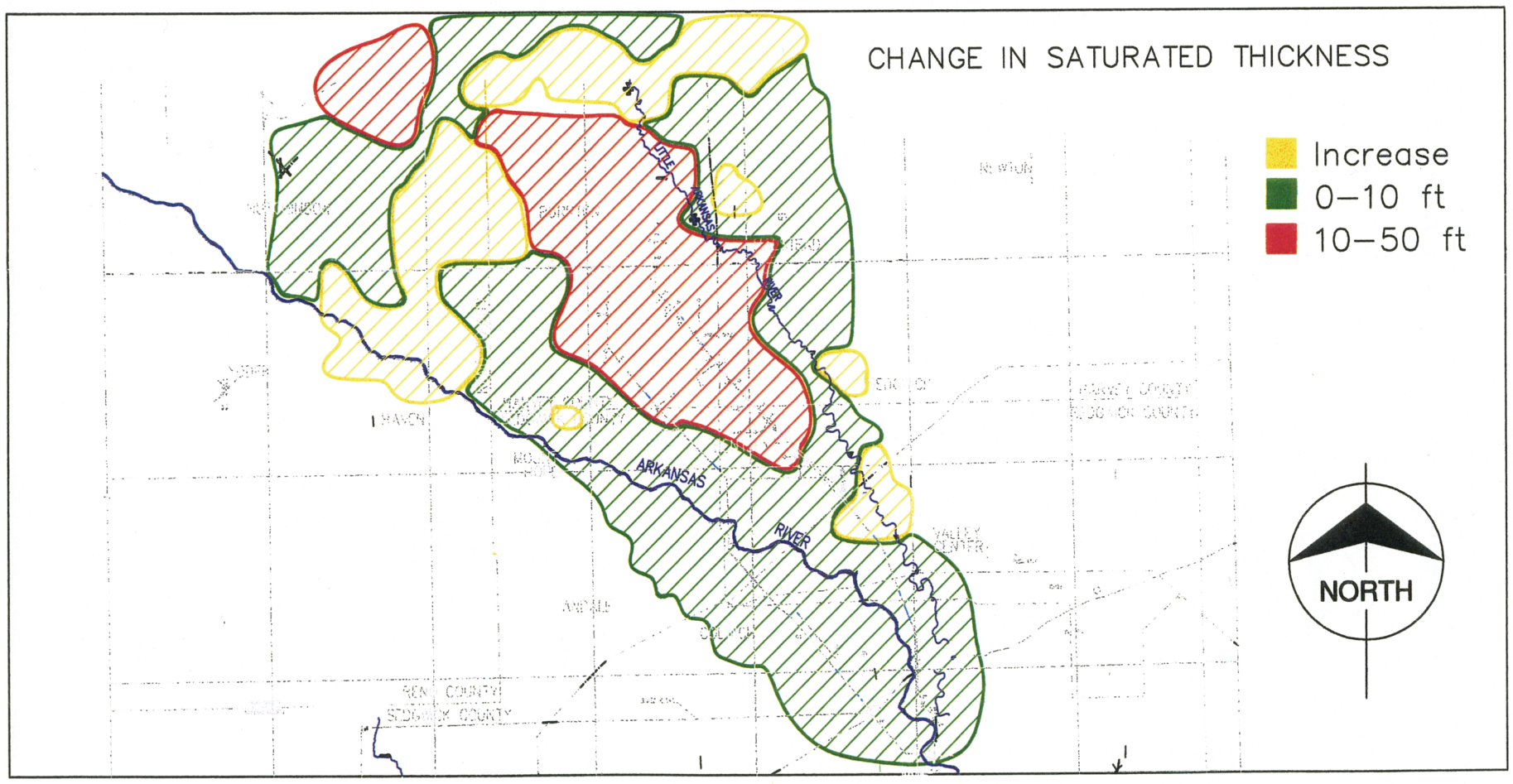


Figure 3–8 Equus Beds Aquifer Saturated Thickness



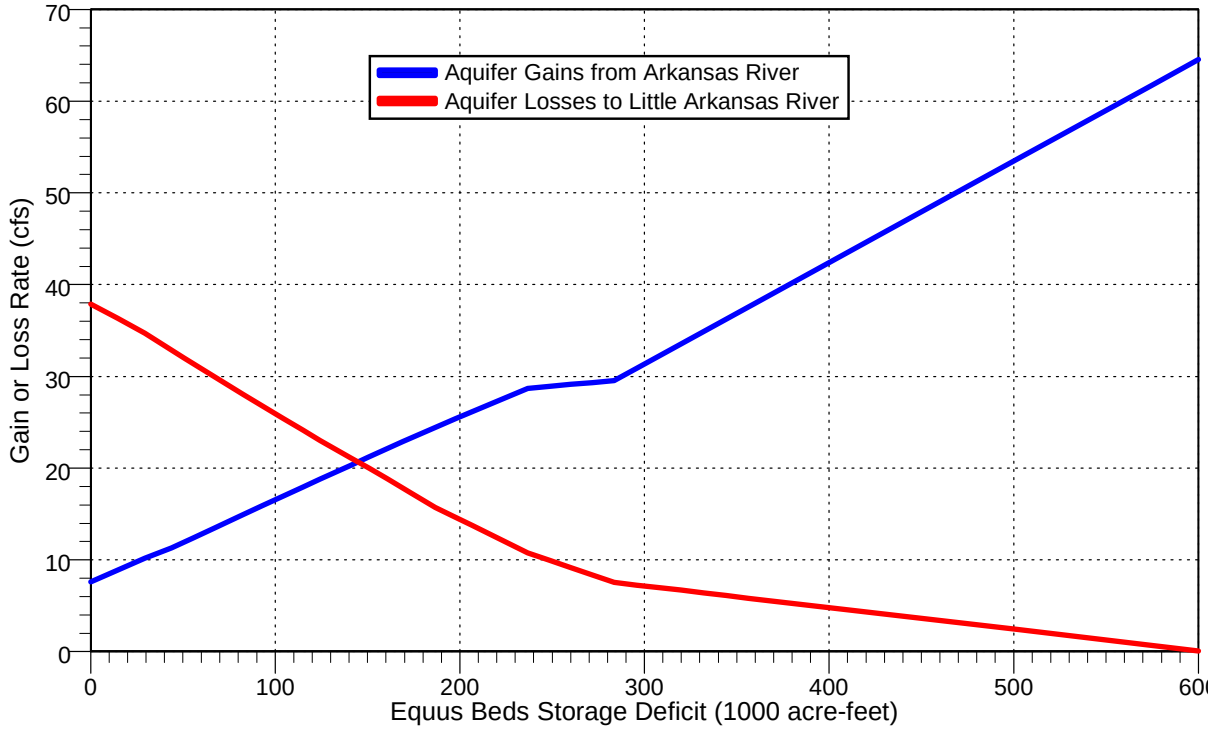




0 7 14
SCALE IN MILES

NOTE: SATURATED THICKNESS APPROXIMATED FROM USGS KANSAS DISTRICT MAPS

Figure 3–9 Gains To and Losses From the Equus Beds Aquifer



is a minimum of about 300 milligrams per liter (mg/L) and ranges as high as about 2,700 mg/L. Water with a total dissolved solids content below 500 mg/L is generally suitable for domestic use. With a total dissolved solid content above 1,000 mg/L, water will generally contain enough constituents that it has an objectionable taste or odor.

As discussed above for surface water, one of the primary quality issues for groundwater is high salinity. The quality of groundwater in the project area is generally good, except where salinity, as indicated by the presence of chlorides, from natural and manmade sources has entered the groundwater. Naturally occurring sources of salinity include Arkansas River water and water from deeper geologic formations. Brine from oil field and salt-refining operations are sources of manmade salinity (Reclamation 1993).

Figure 3–11 shows chloride concentrations in groundwater for the area northwest of Wichita. As shown in this figure, the highest chloride concentrations, ranging over 2,000 mg/L, occur near Burrton and result primarily from past oil field operations. This plume of saline groundwater has been migrating to the southeast in the direction of the prevailing groundwater gradient. Chloride concentrations are also generally higher near the Arkansas River and result from migration of higher chloride water from the river into the Equus Beds aquifer.

3.3.3 WATER RIGHTS

Chapter 5, Article 3 of the Kansas Administrative Regulations (K.A.R.) regulates the appropriation of the State's water resources for beneficial use, which is administrated by the Department of Agriculture, Division of Water Resources. Several articles of these regulations are particularly relevant to this water supply

Table 3- 7 Groundwater Quality Data

Station	Conductivity (µseimens)	pH (Std. Unit)	Dissolved Concentrations (mg/L)							
			Calcium	Magnesium	Sodium	Potassium	Chloride	Sulfate	Fluoride	Total Solids
Harvey County										
375613097363101	1098 - 1510	6.8 - 7.4	133 - 162	23.1 - 29.0	122 - 142	3.4 - 5.4	77 - 112	226 - 310	0.42 - 0.61	
355628097270201	622 - 997	6.5 - 7.5	62 - 73	9.8 - 12.5	55 - 72	2.4 - 5.7	30 - 44	44 - 64	0.28 - 0.38	332 - 449
380028097310901	942 - 1224	6.3 - 6.9	111 - 140	13.6 - 18.6	92 - 112	2.8 - 3.6	161 - 190	3 - 5	0.17 - 0.21	602 706
380028097311001	686 - 1390	6.3 - 7.0	66 - 141	8.6 - 19.8	59 - 125	2.2 - 6.2	85 - 264	5 - 35	0.31 - 0.52	408 - 942
380028097311002	476 - 580	6.5 - 7.3	49 - 62	6.9 - 8.8	50 - 57	1.8 - 2.1	14 - 36	27 - 40	0.30 - 0.32	286 - 351
380028097311101	1094 - 1237	6.4 - 6.8	124 - 151	16.3 - 19.2	85 - 99	2.6 - 3.2	128 - 178	8 - 24	0.15 - 0.20	637 - 714
380031097311001	1 - 782	4.3 - 7.4	57 - 87	8.2 - 12.1	51 - 65	1.8 - 2.4	22 - 66	31 - 45	0.24 - 0.30	292 - 438
380107097400902	567 - 1004	6.4 - 7.0	62 - 81	14.9 - 18.8	59 - 85	6.0 - 8.1	82 - 119	61 - 105	0.20 - 0.33	472
Reno County										
375340098111701	462 - 608	7.0 - 7.6	32 - 44	3.5 - 5.2	40 - 64	1.8 - 2.0	43 - 80	16 - 69	0.20 - 0.30	293
375647097462801			203 - 272	45 - 67	606 - 1067	7.2	1138 - 1860	155 - 241		
375647097462802			107 - 134	20.7 - 25.6	193 - 220	4.0	367 - 487	50 - 61		
375647097462803			286 - 657	58.2 - 128	431 - 654	15.0	1016 - 2320	127 - 233		
375741098245101	460 - 614	6.8 - 7.4	30 - 65	5.0 - 6.6	30 - 33	2.7 - 3.0	42 - 55	11 - 18	0.20 - 0.30	
380324097561301	1590 - 1829	7.2 - 7.5	122 - 143	19.0 - 22.5	184 - 217	5.3 - 6.0	228 - 280	143 - 179	0.47 - 0.60	1000
Sedgwick County										
373233097205801	525 - 735	7.0 - 7.9	40 - 84	11.0 - 18.0	44 - 53	1.5 - 2.1	14 - 25	23 - 48	0.10 - 0.40	314 - 362
373325097203401	1060 - 1300	7.1 - 7.4	100 - 144	19.0 - 21.9	85 - 100	3.2 - 4.2	93 - 150	150 - 170	0.50 - 0.65	780
374738097332201			83 - 86	16.7 - 19.1	48 - 61	3.6	29 - 32	29 - 44	0.23 - 0.33	
Sedgwick County (cont.)										

Table 3- 7 Groundwater Quality Data

Station	Conductivity (µseimens)	pH (Std. Unit)	Dissolved Concentrations (mg/L)							
			Calcium	Magnesium	Sodium	Potassium	Chloride	Sulfate	Fluoride	Total Solids
374743097201601	948 - 1140	7.1 - 7.4	100 - 136	30.0 - 35.3	45 - 51	2.3 - 2.7	32 - 42	150 - 196	0.28 - 0.43	
374832097330401			33 - 38	7.9 - 8.8	340 - 380	1.6	314 - 381	101 - 122		
374832097330402			33 - 36	5.8 - 6.6	159 - 182	2.5	135 - 148	57 - 72		
374832097330403			44 - 73	7.2 - 11.6	118 - 150	3.9	99 - 125	26 - 96	0.46 - 0.59	
375006097224601	706 - 932	7.0 - 7.4	91 - 121	21 - 28	25 - 41	1.7 - 3.1	13 - 21	77 - 153	0.30 - 0.50	409 - 546
375111097281101	638 - 805	6.0 - 7.4	71 - 96	10.9 - 14.0	48 - 58	2.7 - 9.7	41 - 58	49 - 60	0.40 - 0.50	
375115097304803			122 - 147	27.7 - 32.4	402 - 466	4.6	515 - 613	280 - 352	0.51 - 0.60	
375115097403303			31 - 58	6.4 - 11.4	13 - 23	2.4	8 - 26	11 - 22	0.17 - 0.27	
375218097372701	1725 - 2380	6.9 - 7.5	120 - 168	26 - 32	190 - 270	3.0 - 5.6	310 - 510	123 - 190	0.43 - 0.50	1220
375259097252901	605 - 677	6.3 - 7.0	67 - 77	10.8 - 12.2	41 - 45	2.8 - 3.3	22 - 25	76 - 88	0.39 - 0.41	369 - 391
Sumner County										
370432097315201	547 - 683	7.0 - 7.8	55 - 76	15.9 - 22.0	34 - 39	2.0 - 3.3	28 - 45	47 - 64	0.2 - 0.3	352 - 372
371300097151201	930 - 3480	6.8 - 7.7	2 - 450	0.5 - 115.2	61 - 318	0.6 - 7.1	41 - 530	111 - 1240	0.1 - 0.6	732 - 2720
372304097395401	235 - 304	7.2	26.5	5.2	13 - 16	0.5 - 1.0	7 - 9	26	0.3	169
372810097151101	794 - 1350	6.8 - 7.5	74 - 101	13 - 19	43 - 140	2.0 - 5.4	24 - 200	108 - 140	0.40 - 0.52	506

Figure 3-10 Location of Groundwater Stations

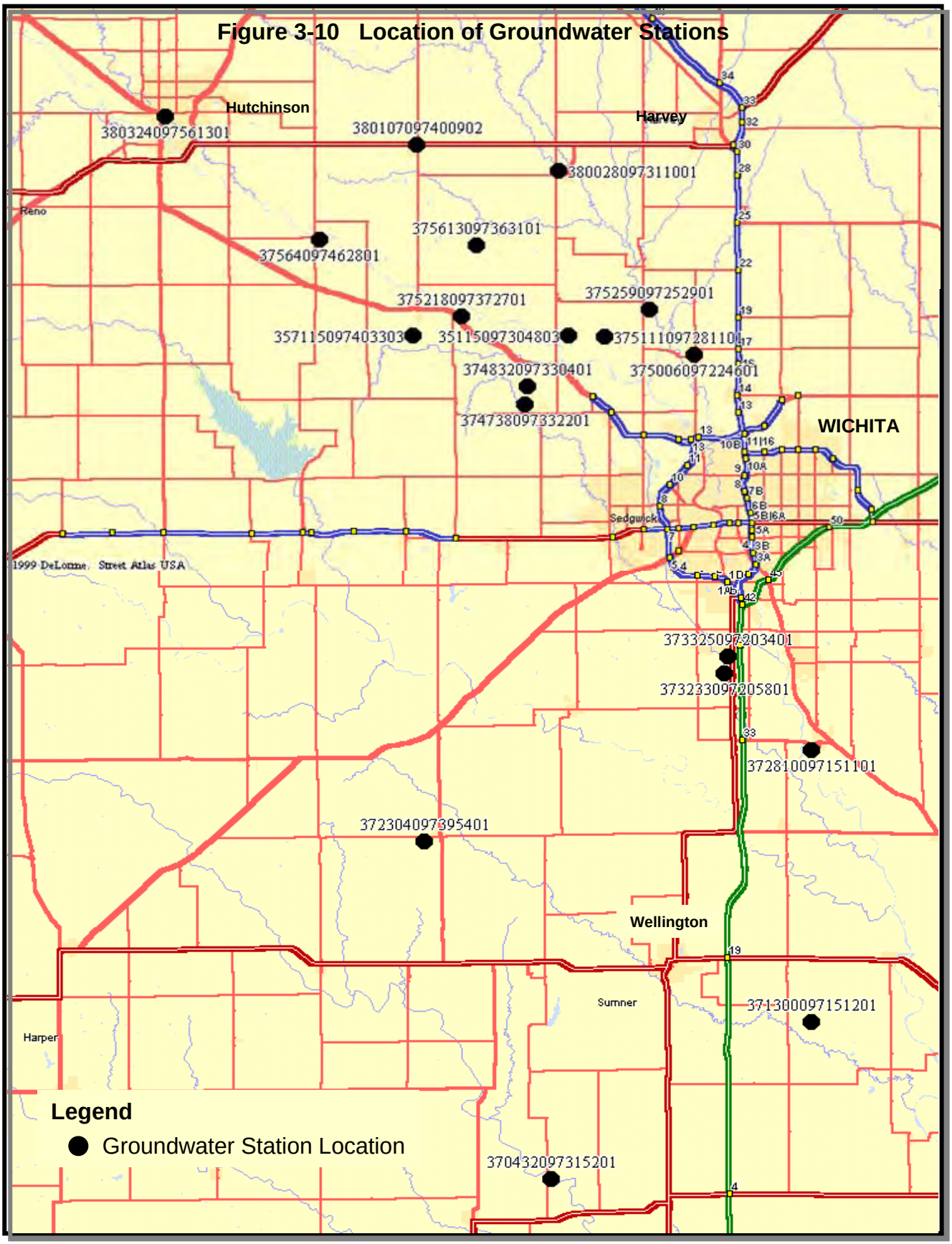
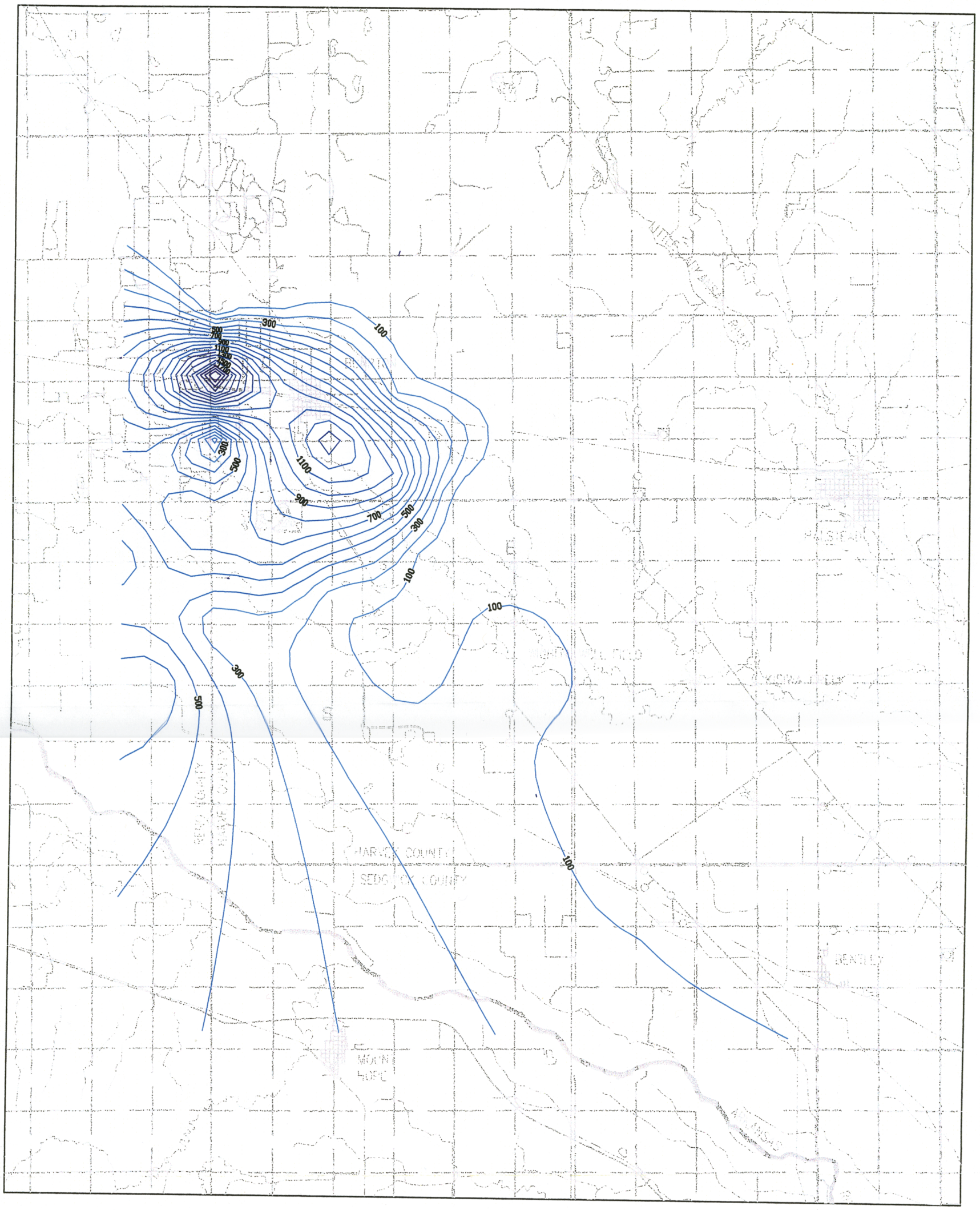
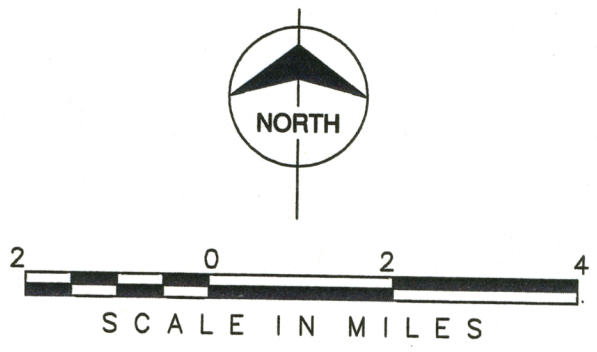


Figure 3–11 Year 2000 Equus Beds Chloride Levels



LEGEND

- EXISTING CITY OF WICHITA SUPPLY WELL AND CHLORIDE CONCENTRATION
- EXISTING CITY OF WICHITA RECHARGE LOCATION AND CHLORIDE CONCENTRATION
- 1000 CHLORIDE CONCENTRATION CONTOUR IN MILLIGRAMS PER LITER



project. K.A.R. defines "Beneficial uses of water" as domestic, stock watering, municipal, irrigation, industrial, recreational, water power, artificial recharge, hydraulic dredging, and contamination remediation (K.A.R. 5-1-1(f)). "Recreational use" is further defined as a use of water in accordance with a water right which provides entertainment, enjoyment, relaxation, and fish and wildlife benefits (K.A.R. 5-1-1(w)).

A large number of water appropriation applications have been filed to use groundwater in the Equus Beds Well Field area. Some surface water applications have been approved to divert from the Little Arkansas River adjacent to the well field area. Early use of groundwater, developed in the late 1930's and early 40's, was mainly for municipal supplies. A total of 16,417.3 acre-feet of water are vested water rights, water use that was in place at the time that the Kansas Water Appropriation Act was implemented in 1945. Throughout the 1960's and 70's, large increases in the number of water appropriation applications resulted mainly from irrigation development.

At the present time, approximately 120,000 acre-feet per year (acre-ft/yr.) of water rights have been filed in the Equus Beds Well Field study area. This study area contains approximately 175 square miles. Of the total, 51,000 acre-ft/yr. are for municipal use and 52,000 acre-ft/yr. are for irrigation purposes. The remaining water rights are for industrial and recreational use.

The area groundwater rights are significantly over-allocated in relation to ground water recharge values. The estimated safe yield of water is 50,240 acre-ft/yr. based on early recharge estimates of 6 inches per year (in/yr.). Revised recharge values are 3.2 in/yr according to a recent USGS study. (Hansen, 1991). Based upon this figure, the actual safe yield is about 29,900 acre-ft/yr.

The City's water rights for the Equus Beds Well Field currently allow for 40,000 acre-feet of water to be used each year, with a maximum daily withdrawal rate of 78 MGD.

The City of Wichita has water rights of approximately 99,300 acre-ft/yr, from all current sources, including the Equus Beds Well Field, Cheney Reservoir and the Local Well Field. This volume is estimated to be sufficient to supply the City's water demands until the year 2016 when additional water rights will be required.

Because of falling water table levels, the Equus Beds Groundwater Management District No.2 was formed in 1974 to manage the aquifer's resources. Accordingly, a safe yield policy was adopted which resulted in closing most areas within the City's well field to development of additional water rights.

Current groundwater rights for the Local Well Field are 6,604.7 acre-ft/yr. Surface water rights for Cheney Reservoir total 52,641 acre-ft/yr. Table 3–8 provides a breakdown of the current water rights.

3.4 AIR QUALITY

The project area contains both rural and urban areas. The area north of Wichita is predominantly farmland and smaller towns. Air pollution sources in the rural areas are for the most part, dust from unpaved roads and farming activities. Smoke from occasional grass fires or

crop stubble being burned is also a factor. These sources of air pollution are generally temporary in nature.

Table 3-8 Current Wichita Water Rights

Water Right No.	Annual Quantity (acre-feet)	Maximum Rate of Diversion (MGD)
Equus Beds Aquifer		
HV-006 00388 1006	40,000	78
Cheney Reservoir		
05033 40126 42824[1]	30,668 21,973	120
Local Well Field		
SG-001 42879 42880 42881 540	1,120.1 42.82 42.39 42.39 5,357.00	37

[1]Water Right 42824 allows for pumping water from Cheney Reservoir when the pool level is above 1,420 ft. elevation and the total Equus Beds and Cheney pumping cannot exceed 92,641 acre-ft/yr.

The pollutants present in urban air come from many sources. The major contributors are mobile sources such as automobiles, trucks, buses, and trains. Other contributors are stationary sources (industrial), area sources (smaller sources such as boilers, dry cleaners, paint shops, residential fireplaces, and print shops), and natural sources (pasture fires, wheat stubble fires, and wind blown dust). The primary urban area is the City of Wichita.

The Wichita-Sedgwick County Health Department monitors air quality in Wichita and the surrounding area for both criteria pollutants and air toxins. Wichita's prevailing southwest winds dilute urban pollutants and help reduce emission concentrations from air pollution sources.

National Ambient Air Quality Standards (NAAQS) exist for six pollutants: carbon monoxide (CO), ozone (O_3), particulate matter smaller than 10μm (PM_{10}), sulfur dioxide (SO_2), nitrogen oxides (No_x), and lead (Pb). These "criteria pollutants" are the only ones for which standards have been established. The EPA assigns designations, based on an area's meeting, or "attaining" these standards. The designations are:

- Attainment - Monitoring data available for the area shows attainment with standards.
- Non-Attainment - Monitoring data shows pollutant levels above standard. (Ozone has different levels of non-attainment: marginal, moderate, serious, severe and extreme.)
- Unclassified - Monitoring data unavailable for the area*, but presumed to be attainment.*

The Wichita/Sedgwick county area has been designated "In Attainment" since 1989. Results of monitoring for criteria pollutants in the Wichita area are shown in Table 3–9.

Air toxins are generally defined as those pollutants that are known or suspected of causing cancer or other serious health effects, such as birth defects or developmental effects. Since 1989, the Wichita-Sedgwick County Health Department has been conducting a monitoring program for EPA toxins. The program consists of two parts:

(1) measuring site-specific concentrations of approximately 60

Table 3–9 Air Quality Monitoring

Chemical	Status	Monitoring Results	Comments
Carbon Monoxide	Ongoing	(continuous) Average = 40% of standard	--
Ozone	Ongoing	(continuous) Current attainment of both old and new standards; however, trend is upward for ozone, creating concern for non-attainment in 5 years if VOCs are not controlled	Allowable concentrations lowered in 1997. Trend is toward increasing levels.
Particulate Matter	Continuous and periodic PM_{10} - ongoing $PM_{2.5}$ - started in 1999	(continuous) Consistent attainment for PM_{10}. Newer standard of $PM_{2.5}$ places levels "toward the upper limit".	
Lead	Discontinued *	In Attainment	--
Sulfur Dioxide	Discontinued *	In Attainment	--
Nitrogen Oxides	Reinstated 1999	--	Monitoring reinstated in 1999, since these compounds are involved in the formation of ozone

* Airborne lead levels are monitored by occasional checking of particulate sample filters
Source: Wichita-Sedgwick County Department of Community Health

commonly-found air toxic compounds near major air pollution sources, and

(2) measuring background levels of pollutants typical of urban areas.

Monitoring results are provided to both EPA Region VII and Kansas Department of Health and Environment (KDHE), which is conducting trend analysis to determine whether air toxic levels in Wichita have changed in type or amount in the last ten years. Monitoring results show the Wichita area to be in attainment for air toxins, as well as for criteria pollutants.

3.5 NOISE

The environments potentially affected by the proposed project range from urban to suburban to rural and have correspondingly different noise conditions.

As population density increases from rural to urban environment, so does the density of sensitive noise receptors. Rural areas are characterized by isolated residences and farmsteads, and have densities of sensitive noise receptors of roughly 1 to 10 per square mile. Suburban areas have residential densities of 3 to 4 per acre with an occasional school, business area, church, or health care facility. Urban areas can have residential densities of 6 to 8 per acre and greater concentrations of schools, businesses, churches, and health care facilities.

Background noise levels increase with increasing human population density. Low noise levels characterize rural environments, where major noise sources are farm equipment and light vehicular traffic on roadways. Typical daytime and nighttime sound levels in rural areas are approximately 35 and 25 decibels (dB(A)), respectively. The majority of the project areas are in rural settings. The Equus Beds Well Field is located in rural Sedgwick and Harvey counties. The Bentley Reserve Well Field is located in rural Sedgwick County and Cheney Reservoir is located in rural Reno County.

In suburban environments, noise sources are primarily from vehicular traffic and small gasoline engines. Typical daytime and nighttime suburban sound levels are 45 and 33 dB(A), respectively. Daytime and nighttime sound levels in urban areas are typically 65 and 55 dB(A), respectively, and are generated primarily by vehicular traffic. The local well fields in the City are in suburban/urban settings. These sound levels can be put in perspective by comparison to common sound levels listed in Table 3–10.

Table 3–10 Common Sounds and Sound Levels

Source	Sound level (dB(A))
Threshold of hearing	5
Quiet rural night	23
Library	32
Quiet suburban nighttime	33
Rural daytime	35
Soft whisper at 2 m (6.6 ft.)	35
Small theater background	40
Suburban daytime	45
Dishwasher in next room	50
Large business office	55
Normal speech at 1 m (3.3 ft.)	65
Gas lawn mower at 30 m (98 ft.)	70
Shouting at 1 m (3.3 ft.)	80
Diesel truck at 15 m (49 ft.)	85
Gas lawn mower at 1 m (3.3 ft)	95
Jet flyover at 300 m (980 ft.)	105
Rock band at 5 m (16 ft.)	110

3.6 BIOLOGICAL RESOURCES

3.6.1 WETLANDS

Wetlands are valuable and sensitive areas. They provide resting, feeding, nesting and brooding habitat for a variety of fish and wildlife; support a wide diversity of plants; enhance water quality by filtering pollutants and sediment from runoff; prevent erosion; and store floodwaters. This unique combination of valuable functions has resulted in the classification of wetlands as special aquatic sites that are afforded an extra measure of protection under the Clean Water Act (CWA). Section 404 of the CWA gives the U.S. Army Corps of Engineers (Corps) the authority to regulate discharges of dredged or fill materials into waters of the United States which include wetlands, rivers, creeks, ponds, and lakes. For regulatory purposes, wetlands are defined as those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas which may occur along streams, lakes, and other low-lying areas (40 CFR 230.3, 33 CFR 328.3).

Wetlands regulated by the Corps are considered to be jurisdictional and may or may not be identical to Cowardin classified wetlands (Cowardin et al. 1979) shown on U.S. Fish And Wildlife Service's (FWS) National Wetland Inventory (NWI)

maps. The Corps considers palustrine emergent (PEM), palustrine scrub-shrub (PSS), and palustrine forested (PFO) to be jurisdictional. The remaining NWI wetlands, e.g., palustrine aquatic bed (PAB) and unconsolidated bottom (PUB), riverine lower perennial unconsolidated shore (R2US), and riverine intermittent stream bed (R4SB) are considered to be waters of the U.S.

Wetlands outside of the floodplain are less abundant and consist primarily of fringes along streams and other drainage ways, or as the remnants of old farm ponds.

Kansas Wetland

3.6.1.1 Wetland Summary

The study area within the vicinity of the eight Equus Beds ASR options, has a range of 91 to 128 wetlands as shown in Table 3–11. There are approximately 89 to 103 linear wetlands associated with the Little Arkansas River depending on the alternative. The wetlands associated with the river are located directly adjacent to the river channel. There are isolated wetlands, and wetlands associated with drainage ways, intermittent streams and creeks, which total approximately 20 acres. In addition to the wetlands, there are five ponds, which may have wetlands. These areas are located within the limits of the option areas of the Equus Beds and the Local Well Field.

The types of wetlands located within the ILWSP alternative area include emergent, forested, scrub-shrub, and combinations of those mentioned. Emergent wetlands are situated in nearly level drainage ways and depressions. Emergent wetland vegetation may include bulrushes (*Scirpus* spp.), reed canary grass (*Phalaris arundinacea*), cattails (*Typha* spp.), sedges (*Carex* spp.) and rushes (*Juncus* spp.). Forested wetlands are located on nearly level drainage ways. The composition of the forested wetlands includes silver maple (*Acer saccharinum*), willows (*Salix* spp.), and

Table 3–11 Number of Wetlands in the ILWSP Components

Component	PAB	PEM	PSS	R4SB	R2US	PFO	PUB	Total
Equus Beds Well Field ASR Options								
100/0	3	19	13	6	83	1	2	127
100/50	3	20	13	6	83	1	2	128
75/25	3	19	6	6	55	0	2	91
75/75	3	20	6	6	55	0	2	92
60/40	3	19	6	6	40	0	2	76
60/90	3	20	6	6	40	0	2	77
Local Well Field Options								
Option 1	1	8	1	0	1	1	0	12
Option 2	1	8	1	0	1	1	0	12

eastern cottonwood (*Populus deltoides*). Scrub-shrub wetlands are located in drainage ways and depressional areas. The composition of the scrub-shrub wetlands includes rose (*Rosa* spp.) willows, and dogwoods (*Cornus* spp.).

3.6.2 VEGETATION

Pre-settlement vegetation communities of south-central Kansas consisted of mixed-grass prairies, wet meadows, emergent wetlands, and some riparian forests adjacent to streams and rivers. Today, most of these communities have been converted to cropland, warm season pasture, cool season pasture, and shelter belts. Most of the fields in the project area are planted in wheat, corn, soybeans or sorghum.

Historically, mixed prairies consisted primarily of the dominant little bluestem (*Andropogon scoparius*), buffalo grass (*Buchloe dactyloides*), gama grass (*Tripsacum dactyloides*), big bluestem (*Andropogon gerardi*), and needlegrasses (*Stipa* spp.). The wide expanses of prairie were maintained by fire, grazed by large herbivores, and had well-established, dense root systems. Wet meadow communities were typically transitional zones between lowland floodplains and mixed prairie grasslands, as well as smaller swales within more upland areas. This community type consisted of such species as prairie cordgrass (*Spartina pectinata*), big bluestem (*Andropogon gerardi*), switch grass (*Panicum virgatum*), rushes (*Juncus* spp.), and sedges (*Carex* spp.).

Lowland riparian forests dominated areas immediately adjacent to rivers and streams in this part of Kansas. Today, riparian forests still exist along the edges of streams and rivers in thin bands of trees and shrubs consisting primarily of common species such as cottonwoods (*Populus deltoides*), willow (*Salix* spp.), catalpa (*Catalpa speciosa*), hackberry (*Celtis occidentalis*), elm (*Ulmus* spp.), and maple (*Acer* spp.).

3.6.3 WILDLIFE

The two alternatives, ILWSP 150 and 100 MGD, would occur in a project area contained within Reno, Harvey, Kingman, and Sedgwick counties in the State of Kansas.

Changes in land use from native and cool-season grass to both grass and woody plants have resulted in a change in wildlife within the area. Bison (*Bison bison*), once abundant in the area, are no longer found in free-ranging populations while exotic ring-necked pheasants *(Phasianus colchicus)* and fox squirrels *(Sciurus niger)*, now common, did not historically inhabit the area. General habitat types found within these counties include openland, woodland, wetland, rangeland, and lakes, streams and farm ponds. The information on habitat types found within these counties was taken from county soil surveys published by the U.S. Soil Conservation Service (1966, 1974, 1975, 1979, 1980, 1983, and 1992).

Cropland, pastures, meadows, lawns, and areas overgrown with grasses, herbs, shrubs, and vines characterize openland habitat. Cropland is typically planted to corn, wheat, sorghum, or soybeans. Grasses and legumes such as fescue (*Festuca* spp.), lovegrass (*Eragrostis* spp.), bromegrass (*Bromus* spp.), clover, and alfalfa provide food and cover for a variety of wildlife species as do wild herbaceous plants like golden-rod (*Solidago* spp.), beggarweed (*Meibomia purpurea*), and grama. Rangeland

habitat consists primarily of wild herbaceous plants and shrubs.

Woodland habitat consists of areas composed of hardwood and coniferous trees, shrubs, or some mixtures thereof. Most wooded habitat in the area occurs along waterways in riparian zones. Coniferous plants such as cedar provide food in the form of browse, seeds, or cones. Hardwoods such as the eastern cottonwood (*Populus deltoides*), oaks (*Quercus* spp.) elms (*Ulmus* spp.), hickories (*Carya* spp.), and sycamores (*Platanus occidentalis*) are often intermixed with conifers and shrubs. Shrubs produce fruit, buds, twigs, bark, or foliage used for food, cover, and shade for many species. Some shrubs found in the area include sand plum (*Prunus angustifolia*), buttonbush (*Cepalanthus occidentalis*), gooseberry (*Ribes* spp.), and golden currant (*Ribes* spp.).

Wetland habitat includes ponds, streams, ditches, marshes, and swamps.

Animal damage control in the area is widespread and handled by individual landowners or through private enterprise. People with wildlife problems in urban areas generally expect governmental assistance in contrast to rural inhabitants who do not. Common nuisance species include beavers, foxes, skunks, raccoons, coyotes, and deer.

3.6.3.1 Mammals

A variety of native mammals, which live in south-central Kansas, are expected to occur in the project area. Openland or grassland mammals include the eastern cottontail rabbit *(Sylvilagus floridanus),* thirteen-lined ground squirrel *(Spermophilus tridecemlineatus),* badger *(Taxidea taxus*), striped skunk (*Mephitis mephitis),* marmot *(Marmota monax),* red fox *(Vulpes vulpes),* and deer mouse (*Peromyscus maniculatus*). The black-tailed jack rabbit (*Lepus californicus*), blacktail prairie dog (*Cynomys ludovicianus*), and badger (*Taxidea taxus*) are commonly found in rangeland habitats.

Species that use both grassland and forest riparian areas to varying degrees (edge species) include the coyote (*Canis latrans*), raccoon (*Procyon lotor),* eastern cottontail rabbit, fox squirrel, striped skunk, little brown bat (*Myotis lucifigus*), big brown bat (*Eptesicus fuscus*), red bat (*Lasiurus borealis*), red fox, and white-tail deer (*Odocoileus virginianus*). The opossum (*Didelphis virginiana*) and occasionally mule deer (*Odocoileus hemionus*) may also be found in wooded areas (Burt and Grossenheider 1976).

Mammals that use lake, stream, river, and wetland habitats include muskrats *(Ondatra zibethica)*, beaver *(Castor canadensis)*, and mink *(Mustela vison)*.

3.6.3.2 Birds

A variety of birds breed and/or migrate in south-central Kansas and could occur in the project area. A variety of ducks, geese, herons, and shore birds inhabit wetland areas. Specifically, birds that can be found in stream, river, and wetland habitats include the great blue heron (*Ardea herodias*), snowy egret (*Egretta thula*), cattle egret (*Bubulcus ibis*), killdeer (*Charadrius vociferus*), red-winged blackbird (*Agelaius phoeniceus*), mallard (*Anas platyrhynchos*), northern shoveler (*Anas clypeata*), and blue-winged teal (*Anas discors*).

Grasslands and adjacent wooded edges provide habitat for the American goldfinch (*Carduelis tristis*), American kestrel (*Falco sparverius*), northern harrier (*Circus*

cyaneus), bobwhite quail (*Colinus virginianus)*, eastern bluebird (Sialia sialis), dickcessel, red-tailed hawk (*Buteo jamaicensis*), morning dove *(Zenaida macroura)*, eastern kingbird (*Tyrannus tyrannus*), northern cardinal (*Cardinalis cardinalis*), American robin (*Turdus migratorius*), eastern and western meadowlarks (*Sturnella magna* and *Sturnella neglecta)*, field sparrow (*Spizella pusilla*),and ring-necked pheasant. Bird species frequenting rangeland habitat are similar to grassland species and include hawks, eastern and western meadowlark, lark bunting (*Calamospiza melanocorys*), horned lark (*Eremophila alpestris*), dickcessel (*Spiza americana*), and greater prairie-chicken (*Tympanuchus cupido*).

Birds that are common in forest communities include a variety of owls, hawks, and thrushes, the red-headed woodpecker (*Melanerpes erythrocephalus*), common flicker (*Colaptes auratus*), downy woodpecker (*Picoides pubescens*), red-eyed vireo (*Vireo olivaceus*) and wild turkey (*Meleagris gallopavo*) (Peterson 1980, Bray et al. 1986).

3.6.3.3 Reptiles and Amphibians

Numerous species of amphibians and reptiles live in south-central Kansas and could occur on lands used by the water supply project.

Reptiles that can be found in grasslands and woodlands include the ornate box turtle (*Terrapene ornata*), prairie racerunner (*Cnemidophorus sexlineatus*), great plains skink (*Eumeces obsoletus*), garter snake (*Thamnophis sirtalis*), plains garter snake (*Thamnophis radix*), brown snake (*Storeria dekayi*), prairie kingsnake (*Lampropeltis calligaster*), central plains milksnake (*Lampropeltis triangulum*), bullsnake (*Pituophis melanoleucus*), ringneck snake (*Diadophus punctatus*), and eastern yellowbelly racer (*Coluber constrictor*).

Common native amphibians that use wetland and forested habitat include the tiger salamander (*Ambystoma tigrinum*), Woodhouse's toad (*Bufo woodhousei*), great plains toad (*Bufo cognatus*), plains leopard frog (*Rana blairi*), western chorus frog (*Pseudacris triseriata*), Blanchard's cricket frog (*Acris crepitans*), and bullfrog (*Rana catesbeiana*). Common native reptiles found in streams, rivers and wetlands include the northern water snake (*Nerodia sipedon*), snapping turtle (*Chelydra serpentina*), western painted turtle (*Chrysemys picta*), spiny softshell turtle (*Apalone spinifera*), and smooth softshell turtle (*Apalone mutica*) (Conant and Collins 1991).

3.6.3.4 Fish

As part of the Equus Beds Groundwater Recharge Demonstration Project, an aquatic monitoring study was conducted to establish baseline fisheries data on the Arkansas River, the Little Arkansas River, the North Fork of the Ninnescah River, and the Ninnescah River. Collection of the fisheries data included estimating biomass and abundance for fish species, and measuring and recording the habitat available to fish species (e.g. cover, food, etc.). The study for the Arkansas River system was initiated in 1995 and continued through 1997, while the Ninnescah River system was studied from 1997 to 1998.

Results of the study showed aquatic macroinvertebrate and fish communities within the Little Arkansas, Arkansas, North Fork of the Ninnescah, and the Ninnescah rivers are typical of sandy bottom streams in Kansas. The

macroinvertebrate community is composed of various taxa that are suited for warm-water streams having turbid water and shifting sand substrates. In general, the majority of the fish community is composed of forage species such as red shiners (*Cyprinella lutrensis*) and sand shiners (*Notropis ludibundus*), game species such as channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictis olivaris*), and green sunfish (*Lepomis cyanellus*), and rough fish species such as the common carp (*Cyprinus carpio*). Common fish species are "generalists," which are not limited by any specific habitat requirements to survive. The forage species are found in all available habitats in the Little Arkansas River; whereas, the game species and rough species are more typically associated with available in-stream cover. Both the macroinvertebrate and the fish communities fluctuate naturally, continually adjusting to the changing environment existing in the river.

Some of the fish species that are more common to these river systems include the river carpsucker (*Carpiodes carpio*), common carp, channel catfish, flathead catfish, green sunfish, red shiner, sand shiner, bluntnose minnow (*Pimephales notatus*), suckermouth minnow (*Phenacobius mirabilis*), and mosquito fish (*Gambusia affinis*) (Page and Burr 1991, Cross and Collins 1995). Fish species more common to the Little Arkansas River include the orange-spotted sunfish (*Lepomis humilis*), largemouth bass (*Micropterous salmoides*), white crappie (*Pomoxis annularis*), freshwater drum (*Aplodinotus grunniens*), and slenderhead darter (*Percina phoxocephala*). Fish species more common to the North Fork of the Ninnescah are the gizzard shad (*Dorosoma cepedianum*) and the plains killifish (*Fundulus zebrinus*). Many other fish species can be found in these river systems, but are not listed here (Page and Burr 1991, Cross and Collins 1995).

A few fish species were collected less frequently in sampling efforts on the Arkansas River system. Although these fish species were collected less frequently, most are still typically common to sandy bottom streams similar to the Arkansas River system. These species include the black buffalo, emerald shiner (*Notropis atherinoides*), yellow bullhead (*Ameiurus natalis*), freckled madtom (*Noturus nocturnus*), speckled chub, and black bullhead (*Ameiurus melas*).

A number of fish species were also collected less frequently in sampling efforts on the Ninnescah River system. Again, although these fish species were collected less frequently, most are still typically common to sandy bottom streams similar to the Ninnescah River system. These species include the black buffalo (*Ictiobus niger*), bigmouth buffalo (*Ictiobus cyprinellus*), smallmouth buffalo (*Ictiobus bubalus*), white crappie, shortnose gar (*Lepisosteus platostomus*), Arkansas darter (*Etheostoma cragini*), orange spotted/green sunfish hybrid (*Lepomis humilis* x *L. cyanellus*), and speckled chub (*Extrarius aestivalis*). Another species not commonly found in the Ninnescah River system was the spotted gar (*Lepisosteus oculatus*), which to date has only been collected in a few Kansas counties east of Sedgwick County.

Cheney Reservoir, formed on the Ninnescah River system, is one of the largest fisheries resources in the four-county area with 9,540 fishing acres.

Anglers annually fish for such species as the wiper (hybrid of the striped bass and white bass), striped bass, walleye, channel catfish, white crappie, black crappie (*Pomoxis nigromaculatus*) and white bass. The lake is stocked with wipers, striped bass, and walleye, of various sizes (fry, fingerling, and adults). Almost 21 million individuals of stocking fish, totaling almost 3100 pounds, were released in the reservoir from 1981-1996. No fisheries studies were conducted on Cheney Reservoir. However, the reservoir does contribute to fisheries populations downstream in the project area. Four species that are not typically common to the Ninnescah River system but are present due to fisheries management plans used in Cheney Reservoir, include the white bass (*Morone chyrsops*), striped bass (*Morone saxatilis*) white bass/striped bass hybrid (*M. chrysops* x *M. saxitilis*) also known as the wiper, and walleye (*Stizostedion vitreum*).

3.6.4 THREATENED, ENDANGERED, OR CANDIDATE SPECIES

Eight federally listed threatened, endangered, or proposed endangered (candidate) species were identified by FWS as potentially being impacted by the project. The peregrine falcon, initially included in this list of threatened and endangered species, was removed following the Federal delisting of this species in August 1999.

- Interior Least Tern (Endangered)
- Piping Plover (Threatened)
- Bald Eagle (Threatened)
- Eskimo Curlew (Endangered)
- Whooping Crane (Endangered)
- Arkansas River Shiner (Threatened)
- Topeka Shiner (Endangered)
- Arkansas Darter (Candidate)

Each species has been documented to occur or historically occurred within the four county project area. The following discussion provides both general information on each species and more specific information related to each species' usage of the Arkansas River system and associated Equus Beds aquifer, the Ninnescah River system, and Cheney Reservoir.

3.6.4.1 Interior Least Tern

The interior least tern (*Sterna antillarum athalassos*) is federally listed as endangered (50 FR 21784). This designation applies to populations in Arkansas, Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Missouri, Montana, Nebraska, New Mexico, North Dakota, South Dakota, Oklahoma, and Tennessee; Mississippi River populations in Louisiana and Mississippi; and populations over 80 kilometers (50 miles) from the Gulf Coast in Texas (FWS 1990). The interior least tern is also listed as endangered by KDWP. Population size of the interior least tern in 1990 was estimated at 5,000 individuals (FWS 1990).

The interior least tern breeds along large rivers within the interior of the United States during the summer months and retreats to more southerly areas during the winter. Historically, breeding habitat included the Mississippi and Red rivers, the Rio Grande, and their major tributaries. Breeding and nesting range included the area from Texas north to Montana and from eastern Colorado and New Mexico eastward to southern

Least Tern

Indiana. Currently, the interior least tern is still known to nest in all these areas where river banks are relatively unaltered by human activities.

Least terns spend four to five months at their breeding sites, arriving from late April to early June. Egg laying begins in late May. Nests are constructed on unvegetated or sparsely vegetated sand or gravel bars within wide river channels, along salt flats, or on artificial habitats such as sand pits (FWS 1990, Dryer and Dryer 1985, Haddon and Knight 1983, Kirsch 1987,1988,1989, Larkins 1984, Morris 1980). Nests are shallow, inconspicuous depressions in the substrate, scratched out by adults and located in the open. Terns are colonial nesters and several nests may be located in the same area. The sandbar habitats used by least terns for nesting are ephemeral and nests, eggs, and chicks are highly susceptible to loss because of high water.

The interior least tern feeds primarily on small fish, which it plucks from the surface of the shallow waters of large rivers or other water bodies. Crustaceans, insects, mollusks, and annelids are also occasionally eaten (Whitman 1988). Foraging areas are usually near nesting sites (Talent and Hill 1985). Terns will gather at low, wet sand or gravel bars at the mouths of tributaries, streams, and floodplain wet-lands with high concentrations of fish to rest and eat prior to migration.

Least terns are considered transients and occasional summer visitants in Kansas, where they can be found on barren flats and sandbars (KDWP 1993). Kansas also supports populations of breeding least terns (FWS 1990). A portion of the population in Kansas nests at Quivira National Wildlife Refuge (QNWR), which has been designated critical habitat for the least tern (Collins et al. 1995).

3.6.4.2 Piping Plover

Piping plover (*Charadrius melodus*) populations have declined dramatically since the early 1900s as a result of hunting and habitat loss (FWS 1994). In 1991, the North American population was estimated at 5,482 breeding adults (Campbell 1995). Piping plovers continue to breed throughout the Great Plains region of Canada and the United States, extending as far north as Manitoba and Alberta and as far south as Nebraska.

Credit: USFWS / Richard Kuzminski

Piping Plover

However, breeding populations have all but disappeared from the Great Lakes region where they are listed as endangered (Haig and Plissmer 1993). Piping plovers breeding on the Great Plains have been listed as federally and state threatened, but are being considered for federal endangered status. These birds winter along the Gulf coast and adjacent barrier islands.

Piping plovers are migratory shorebirds that inhabit sand beaches and sandbars of inland rivers and lakes. Nests, constructed on bare sand or gravel, consist of shallow depressions scratched in the sand or gravel and are frequently lined with small pebbles or shells (FWS 1994). Plovers begin arriving at their breeding grounds in late March and stay three to four months.

Credit: Mid America Eagle Watch

Bald Eagle

Piping plovers feed on a variety of invertebrates, such as worms, insects, crustaceans, mollusks, beetles, and grasshoppers, which they capture by picking and gleaning. Foraging activity generally occurs within a few inches on either side of the water's edge (Bent 1929, Lingle 1988).

Piping plovers may rarely be found in the project area on sandbars and barren flats on rivers during spring and fall migrations, but are more likely to be found at QNWR or Cheyenne Bottoms Wildlife Area (CBWA). Nesting was documented for the first time in 1996 along the Kansas River.

3.6.4.3 Bald Eagle

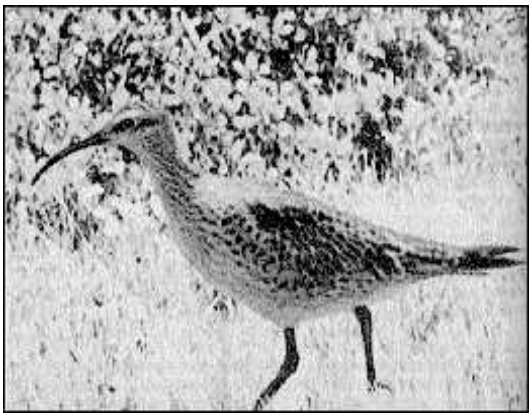
The bald eagle (*Haliaeetus leucocephalus*) occurs throughout North America and once maintained breeding populations in Canada, Alaska, and 45 of the lower 48 states. For a variety of reasons including hunting, habitat loss, pesticides (Grier et al. 1983), human disturbance (Murphy 1965, Retfalvi 1965, Juenemann 1973, Weekes 1974, Grubb 1976, Stalmaster and Newman 1978, Russell 1980, Skagen 1980, Knight and Knight 1984, Smith 1988 Anthony and Isaacs 1989), and heavy metals (Grier et al. 1983), bald eagle populations declined significantly during the 19th and 20th centuries. This decline prompted the species to be listed as federally endangered in 1978. Through research, conservation, management, and protection, the species population and breeding range is increasing. These improvements led to the species being down-listed to threatened in 1995 (60 FR 36000). Populations have been thriving enough in recent years that it is currently being considered for de-listing by the FWS. It is listed as threatened in Kansas.

Habitat requirements for bald eagles revolve around food preference and nesting behavior. The bald eagle's primary food source is fish (Grier et al.

1983). Because of their reliance on fish, eagles nest close to large water bodies including lakes, rivers, reservoirs, and oceans where large trees with strong branches or rock cliffs are present. Nests are found in a variety of tree species, including cottonwood, American elm, and sycamore. Nesting begins in mid-March and eggs are laid in late March to early April. Eagles will return year after year to the same nesting area, and often reuse a previous year's nest.

Eagles also need roosting sites consisting of large trees with horizontal limbs and open branches. Often roosting sites are located near water, but they may also be found away from eagles' feeding areas.

The majority of North American bald eagles migrate to coastal or more southerly climates during the winter. The extent of migration depends partly on the severity of the winter. Bald eagles will move as far south as necessary to find open-water feeding areas. Wintering bald eagles are found throughout the United States but are most abundant in the Midwest and West. Bald eagles are regular migratory visitors to Kansas and are known to nest in several locations throughout the state. They are most commonly observed during the winter months along the rivers or reservoirs in the state. The first recorded nest was at Clinton Lake in 1989. Nest sites have been recorded in eastern Kansas at reservoirs (Collins et al. 1995).



Credit: USGS / Photo by Don Bleitz

Eskimo Curlew

3.6.4.4 Eskimo Curlew

The eskimo curlew (*Numenius borealis*) is one of the rarest birds in North America. The species was federally listed endangered in 1967, and is thought to be close to extinction today, with only 70 confirmed sitings in the last 50 years. Historically, it occurred in enormous flocks during spring migrations from South America to the Alaskan and Canadian Arctic. Populations rapidly dwindled from 1870 to 1890 due to unrestricted market hunting. This species' lack of fear of humans and habits of traveling in large flocks made it an easy target. Conversion of grasslands to croplands further added to the decline of this species.

This species was last reported in Kansas in 1902, and thus is considered extirpated from the state. It is listed as endangered in Kansas (Collins et al. 1995).

The eskimo curlew feeds on grass-hoppers, grubs, and a variety of grassland insects. The species breeds on the arctic tundra, and over-winters on the Pampas grasslands of Argentina. The nest has been described as a shallow depression in the ground on open Arctic tundra. Nests were typically found from late May to mid-June (Campbell 1995). Curlews moved northwesterly through the midwestern tall-grass prairies during their spring migration in February to arrive at their Arctic breeding grounds by May.

3.6.4.5 Whooping Crane

The whooping crane is another rare North American bird. Historically, this species ranged from the arctic coast to central Mexico, and from Utah east to New Jersey, into South Carolina, Georgia, and Florida. It once was found near lakes, ponds, sloughs, and streams and also ranged into plains and prairies. The historic breeding grounds of the migrating population extended across north-central United States into the Canadian provinces of Manitoba, Saskatchewan, and Alberta. A non-migratory population existed in southwest Louisiana. Today, the only self-sustaining wild population breeds at Wood Buffalo National Park in Canada and over winters along the Texas Gulf Coast at Aransas National Wildlife Refuge (ANWR). The migratory corridor for this population extends through north-eastern Montana, western North Dakota, western South Dakota, central Nebraska and Kansas, and into west-central Oklahoma and east-central Texas (USFWS, 1994). The population was estimated at 146 individuals in 1994.

Credit: USFWS photo

Whooping Crane

The species was officially listed as endangered in 1967. A recovery plan is currently being coordinated between the FWS and the Canadian Wildlife Service. Critical habitat has been designated in Kansas, where it is also listed as endangered, at QNWR and CBWA (Collins et al. 1995). Current major threats to this species include hurricanes and contaminant spills along their winter habitat on the Texas coast. Powerlines and fences also pose threats to this species (FWS Red Book 1995).

The whooping crane's diet consists of the larval forms of insects, frogs, rodents, small birds, berries, plant tubers, crayfish, and waste grains from harvested cropland. An attempt was made to establish an experimental population of whooping cranes in Idaho in 1975, but it failed. An experimental reintroduction of a non-migrating population was initiated in Florida in 1993. Causes for declines of whooping cranes include hunting, specimen collection, human disturbance, and conversion of nesting habitat to various agricultural uses. Other factors which have also accelerated whooping crane declines include low reproductive potential, low hatchling survivability, and delayed successful egg fertilization (approximately 4 years) (FWS Red Book 1995).

Nesting habitat of the whooping crane includes bulrushes of the numerous poorly drained potholes of Wood Buffalo National Park. One to three eggs are laid beginning in late April and incubated over a 29-31 day period. Both parents share in the incubation and brood-rearing duties. Usually only one chick is fledged. The autumn migration starts in mid-September and lasts until mid-November. The whooping crane will migrate singly, in pairs, family groups or small flocks, and are sometimes accompanied by sandhill cranes. Over wintering habitat at ANWR

includes salt marshes, grasslands, swales, and ponds (FWS Red Book 1995). Whooping cranes also roost in riverine habitat, on isolated submerged sandbars, and in large palustrine wetlands such as those found at QNWR and CBWA. Spring migration begins in late March and continues through early May.

3.6.4.6 Arkansas Darter

The Arkansas darter (*Etheostoma cragini*) occurs only in the Arkansas River basin and in southeast Kansas. The species is currently a federal candidate species. KDWP has designated this species as state threatened, and has designated portions of the project area as critical habitat. Critical habitat within the project area has been designated on the North Fork of the Ninnescah River, starting at the Reno-Stafford county line, extending to its confluence with the South Fork of the Ninnescah River in Sedgwick County, as well as numerous perennial spring-fed reaches of named and unnamed streams south of the Arkansas River in Reno, Kingman, and Sedgwick counties. The major cause for the decline in Arkansas darter populations is water depletion from irrigation, but chemical and feedlot runoff has also contributed (Collins et al. 1995).

© Missouri Conservation Commission

Arkansas Darter

Credit: USFWS / Photo by Ken Collins

Arkansas River Shiner

The Arkansas darter prefers small prairie streams, seeps and springs that are partially overgrown with watercress and other broad-leaved aquatic plants. It also prefers shallow water with little current, as well as areas with aquatic vegetation and exposed willow roots used for cover. This species is most abundant near headwaters. Aquatic insects and other arthropods comprise the majority of the darter's diet (Pflieger 1975). This species breeds March to May and lays eggs in sandy substrate. The female abandons the eggs once deposited.

3.6.4.7 Arkansas River Shiner

Historically, the Arkansas River shiner (*Notropis girardi*) was abundant in the tributaries of the Arkansas River system throughout southwest Kansas. It may be extirpated from the state, however, and may be almost entirely restricted to a 500-mile stretch of the Canadian River system in Oklahoma, Texas, and New Mexico.

The species is currently federally threatened with federal critical habitat designated in the mainstem of the Arkansas River above and below the City of Wichita. KDWP has designated this species as state endangered, and has designated portions of the project area, including all of the Arkansas River in Harvey and Sedgwick counties, as critical habitat. The portion of the main stem of the Ninnescah River in Sedgwick County is also designated critical habitat (Collins et al. 1995). The major cause for this species' decline is water depletion

from irrigation, but competition with nonnative fishes (Collins et al. 1995) probably also contributed to its decline.

The Arkansas River shiner's preferred habitat is the protected "leeward" sides of sand ridges, formed by steady shallow water flow. It historically inhabited the main channels of wide, shallow, sandy-bottomed rivers and larger streams of the Arkansas River basin.

The Arkansas River shiner spawns from June to August when streams approach flood stage. The eggs drift near the surface in the swift current of open channels. The eggs develop rapidly and the hatchlings swim to sheltered areas within three to four days (Collins et al. 1995). This species feeds facing upstream and captures organisms washed out of shifting sand (Cross and Collins 1995).

Credit: Photo by Jim Rathert

Topeka Shiner

3.6.4.8 Topeka Shiner

The Topeka shiner is currently federally listed as an endangered species (FWS 1999). The Topeka shiner was once wide-spread in Kansas, but is now restricted to small streams in the Flint Hills (both Kansas and Neosho drainages) and a few streams elsewhere in the state (Willow Creek, Wallace County; Cherry Creek, Cheyenne County; and single streams in Jefferson and Johnson counties). Most of the remaining populations of this species are in Kansas. It formerly occurred in at least twelve counties in central and western Kansas, where it has not been found recently (Cross and Collins 1995). The species primarily occurs as isolated, fragmented populations now inhabiting less than ten percent of its original range (FR 63, vol. 240).

The Topeka shiner prefers open pools near the headwaters of streams that maintain a stable water level due to weak springs or percolation through riffles. The water in these pools is usually clear, except for plankton blooms that develop through the summer months. The Topeka shiner spawns from late May to July, and the young mature in one year. The maximum life span is two or three years (Cross and Collins 1995). Its diet consists of insects and zoo-plankton.

3.6.5 STATE-LISTED SPECIES

In addition to the aforementioned species, four species occurring within the project area are listed as state threatened or endangered by KDWP: the speckled chub (*Extrarius aestivalis*), eastern spotted skunk (*Spilogale putorius interrupta*), white-faced ibis (*Plegadis chihi*), and snowy plover (*Charadrius alexandrinus*).

3.6.5.1 Speckled Chub

The southern population of the speckled chub is currently listed as state endangered in the Arkansas River drainage. This population has been decreasing because of de-watering of Kansas rivers and streams, but feedlot, oil, and pesticide runoff have also contributed to its decline. Low water dams and other stream obstructions have fragmented the habitat of the speckled

Credit: Wisconsin Dept. of Natural Resources

Speckled Chub

chub, thus making recolonization of upstream areas difficult if not impossible (Collins et al. 1995).

Critical habitat of the speckled chub in the project area includes all of the Arkansas River in Harvey and Sedgwick counties, the mainstem of the North Fork of the Ninnescah River from Cheney Reservoir Dam to its confluence with the South Fork of the Ninnescah, Sedgwick County, and the main-stem of the Ninnescah River from its origin to its confluence with the Arkansas River in Sumner County (Collins et al. 1995).

The species inhabits the shallow channels of large, permanent flowing, sandy streams of the lower Arkansas River watershed. Its preferred habitat is a substrate of clean, fine sand, and it avoids areas of calm water and silted stream bottoms. The breeding season of the speckled chub is May to August when water temperatures exceed 70 degrees Fahrenheit. The diet of the speckled chub is unknown, but probably consists of larval insects (Collins et al. 1995).

3.6.5.2 Eastern Spotted Skunk

The eastern spotted skunk is currently state listed as threatened. Critical habitat has been designated outside the project area, in Sedgwick County's Cowskin Creek and Big Slough drainage basins, west and south of Wichita. Changes in agricultural practices are the primary reason for this species' decline in recent years.

The preferred habitat of the spotted skunk in central and western Kansas is riparian habitat. It uses fence rows, out-buildings, hollow logs, and rock and brush piles as den sites. The spotted skunk breeds in March and April, and two to nine kittens are born in May or June. It eats a variety of foods, including berries, carrion, seeds, fruits, birds, bird eggs, and mice (Collins et al. 1995). It is almost entirely nocturnal.

Eastern Spotted Skunk

3.6.5.3 White-faced Ibis

The white-faced ibis (*Plegadis chihi*) is currently listed as state threatened. In Kansas this species is a rare spring and fall migrant and summer resident. Preferred habitat includes permanent wetland areas, but the ibis will use scattered temporary pools. This species is most likely to be found at CBWA and at QNWR, both of which have been designated critical habitat, and are northwest and west of the counties in the project area (Collins et al. 1995). This

species may, however, utilize temporary wetlands around the streams and rivers in the project area as well as wetland habitat at Cheney Reservoir.

Though white-faced ibis populations have been declining in recent years due to wetland drainage and pesticide use around wetlands, the populations in Kansas have been increasing. It nests at both CBWA and QNWR. The white-faced ibis is a colonial nester and it builds nests in cattail and bulrush marshes. Three to five eggs are laid and incubated for 21 days. The young fledge in six weeks. The white-faced ibis feeds on a variety of insects, salamanders, leeches, snails, crayfish, and small fishes (Collins et al. 1995).

3.6.5.4 Snowy Plover

The snowy plover (*Charadrius alexandrinus*) is currently listed as state threatened in Kansas, and can be found in appropriate sparsely vegetated salt flats, sandbars, and beaches during migrations in the spring and fall. Their numbers have been reduced dramatically throughout the range due to de-watering, river channelization, and river damming. These activities have reduced flooding and sand-bar formation, and allow vegetation to encroach upon existing habitats (Collins et al. 1995).

The species primarily nests in Kansas at QNWR, and occasionally at CBWA and along rivers and stream of southwest and central Kansas where appropriate habitat is available. The nest is scratched out as a depression in the sand and nesting occurs from mid-March through late summer. Incubation takes 24-28 days. The snowy plover feeds upon insects and aquatic invertebrates picked from open flats. Critical habitat exists for this species at QNWR and on the Cimarron River in Clark, Comanche, and Meade counties (Collins et al. 1995).

Credit: Texas Wetland Information Network (WetNet)

White-faced Ibis

3.7 SOCIOECONOMICS

The social and economic conditions within the Wichita area and surrounding region are the factors ultimately responsible for the increased demand for water and the need to expand water production capacity. The region of influence (ROI) for this socioeconomic study includes the counties of Harvey, Sedgwick and Butler, although the primary focus will be in Sedgwick County.

3.7.1 POPULATION AND HOUSING

Population. The Wichita metropolitan area has experienced steady population growth over the last 10 years. Since 1990, the

metropolitan area has grown on average 1.3 percent annually, compared to 0.7 percent for Kansas and 1 percent for the United States. Butler County, with an average annual population growth of 2.4 percent, is the fastest growing county in Kansas. Sedgwick and Harvey counties rank 11th and 12th in population growth with each averaging 1.2 percent annual increases in population (CEDBR, 1999). The estimated 1999 population for the ROI is 548,714 (US Census Bureau). Sedgwick County makes up more than 80 percent of the total. Population in the ROI grew 13 percent from 1990 to 1999, an increase of slightly over 63,400. Butler County experienced the largest increase at 24 percent. The estimated 1999 population for the City of Wichita's Water Service Area is 380,674.

Housing. Housing includes all apartments, houses, and mobile homes available whether they are owner-occupied, rented, or vacant. In 1990, there were 202,521 housing units in the ROI, of which 92.2 percent were occupied and 7.8 percent were vacant. The number of housing units (single and multi-family) in Sedgwick County alone was 170,159 (Slater and Hall, 1996). The number of housing units (single and multi-family) within the city of Wichita in 1990 was 123,249 (Slater and Hall, 1996). In 1997, the estimated number of housing units in the Wichita Metropolitan Area was 217,472 (CEDBR, 1997), an increase of 7.4 percent.

Residential and commercial construction has been thriving in Wichita for several years. Compared to these record-setting years, construction activity slowed in 1999; yet the amount of construction activity is still at historically high levels. In 1999, activity was due to remodeling and repairs; of which the value in the first half was 19 percent above the same period in 1998. This increase was generated by the destruction caused by the May 1999 tornadoes in Haysville and south Wichita. About 3,500 residential units were damaged and 600 were destroyed (CEDBR, 1999).

Recent data on residential and total construction permits issued by the City of Wichita is provided in Table 3–12. In 1998, 1,535 permits were issued for singe-family structures. More than one-third of these housing starts were in the northwest quadrant of the city. More dwelling units were added in 1998 (3,137) than in any year since 1984. More large multi-family dwelling units were added in 1998 (1,468) than in the previous eight years combined. At least three new apartment complexes were to be completed in 1999, which would add approximately 1,000 units to the market.

Table 3–12 Construction Permits Issued by City of Wichita

	1996	1997	1998
Residential Permits	1,639	1,733	2,104
Total Construction Permits[1]	5,744	6,600	6,566

[1]Includes residential, non-residential, additions, remodels, and repairs
Source: CEDBR, 1999

A significant change in the construction pattern of the Wichita metropolitan area is the growth occurring in the unincorporated areas of Sedgwick County. In 1980, only 16.5 percent of the county's construction activity was in the

unincorporated area. In 1997, that figure had grown to 32 percent. Construction totaled $314.7 million in 1997, up 16.1 percent from 1996. The City of Wichita accounted for 42 percent of the construction activity in the metropolitan area. (Nickel, 2000)

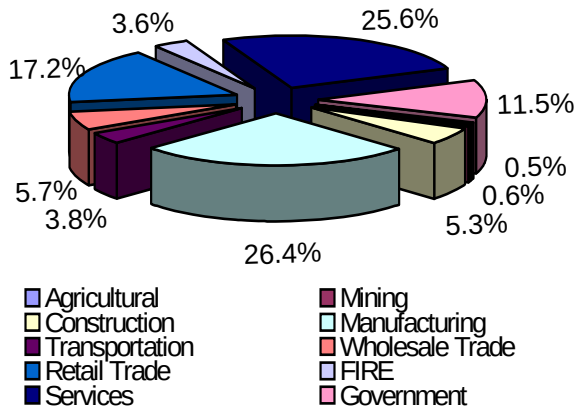
3.7.2 ECONOMIC ACTIVITY

The economy of the ROI is diverse, including services, agricultural, government, and manufacturing sectors. Wichita's employment includes a broad mix of business types, with a strong base of relatively high paying manufacturing jobs. A list of Wichita's major employers includes the Boeing Co., Raytheon Aircraft Co., Cessna Aircraft Co., Coleman Co. Inc., Bank of America, Bombardier Aerospace Learjet, Via Christi Regional Medical Center, Wesley Medical Center, Koch Industries and Southwestern Bell Telephone. However, any listing of the area's largest private employers cannot reveal the large numbers of small and mid-sized companies providing a wide variety of goods and services to markets around the globe. The 1996 County Business Patterns show approximately 11,206 business establishments in Sedgwick County with fewer than 100 employees (City of Wichita).

The largest industrial employment sector consists of manufacturing, accounting for 26.4 percent of the 1998 employment. Services account for 25.6 percent; followed by Wholesale and Retail Trade at 22.8 percent. Government is also a large part of the economy at 11.5 percent (Figure 3–12). (IPPBR, 1999)

Employment from 1989 to 1998 in the ROI increased by 47,498 or 20.5 percent. Services reported the largest gain, 18,951, at 36.2 percent. Manufacturing recorded an increase of 10,261. Government, Construction and Retail Trade all added over 5,000 workers while Wholesale Trade expanded by 2,707. Agriculture witnessed an increase of 570. Three areas that experienced losses were Mining; Transportation, Communications and Public Utilities (TCPU); and Finance, Insurance and Real Estate (FIRE). FIRE declined 974, or 8.8 percent. Mining lost 445 workers while Transportation and Public Utilities saw a drop of 155.

Figure 3-12 1998 Percent Employment by Industry



The estimated labor force for the Wichita Metropolitan Statistical Area (MSA) in 1999 was 290,160 (KDHR, 2000). The 1999 unemployment rates for Sedgwick County, the City of Wichita, and the Wichita MSA were 3.4 percent, 3.7 percent, and 3.3 percent respectively (Table 3–13). February 2000 unemployment rates for Sedgwick County, the City of Wichita, and the Wichita MSA were 4.1 percent, 4.5 percent, and 4.0 percent respectively (KDHR, 2000). Wichita's unemployment rate has been lower than the national average, 4.5 percent, since 1995.

Table 3–13 February 2000 Labor Force Estimates

County/City	Labor Force	Employment	Unemployment Rate	1999 Average Unemployment Rate
Harvey	18,117	17,498	3.4	2.6
Sedgwick	241,628	231,674	4.1	3.4
City of Wichita	183,316	175,121	4.5	3.7
Wichita MSA	291,862	280,199	4.0	3.3

Total employment grew 3.9 percent in 1998 in the Wichita MSA. Total employment is expected to continue to grow at an average annual rate of 1.1 percent between 1999 and 2004.

Agriculture. The top five commodities by crop area in Kansas are wheat, sorghum, hay, corn and soybeans. Sedgwick County annually ranks in the top 10 percent in acres of crops harvested and value of crops produced. Approximately 22 million acres are harvested each year in Kansas; of that, 5 percent is in Sedgwick, Harvey, and Reno counties. Wheat is the largest crop harvested, followed by corn, sorghum, and soybeans.

Crop production in Sedgwick, Harvey, and Reno counties has risen 8 percent over the last five years with wheat showing the largest increase (Figure 3–13). Average yield per acre for wheat, corn, soybeans, and sorghum is 41, 146, 39, and 70 bushels, respectively.

Prices received by farmers for their wheat, corn, and soybean crops increased in 1996, but have since fallen below prices received in 1991 (Figure 3–14). The average price for wheat, corn, and soybeans from 1991 to present is $3.34, $2.38, and $5.95 per bushel, respectively.

Figure 3-13 Crop Yield Trends for Sedgwick, Reno, and Harvey Counties

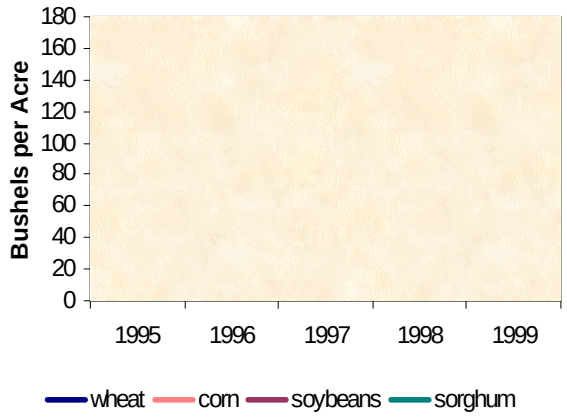
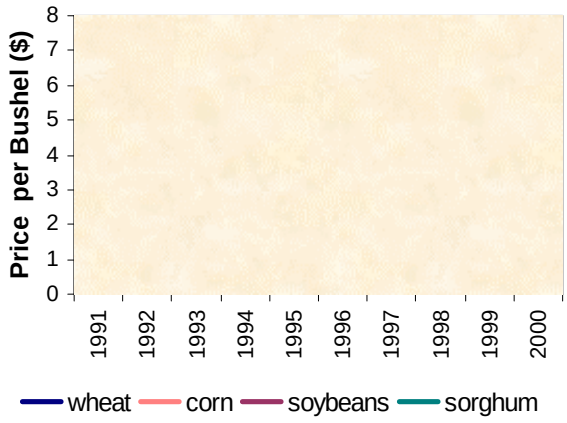


Figure 3-14 Price Trends per Commodity



Personal Income. Total personal income for Sedgwick County had an average annual growth rate of 5.2 percent

for the decade ending in 1996. For 1998 through 2004, total personal income is expected to grow at an average annual rate of 4.7 percent. If inflation remains in the range of 1.5 percent, real growth of personal income would average 3.2 percent for the period 1998-2004 (CEDBR, 1999).

Personal income is affected by a number of factors, including social security, farm income, rental income, stocks, interest, and employee earnings. The largest share by far is the earnings of employees. Downturns in manufacturing employment have historically been offset by more rapid growth in other sectors. This pattern could be expected to continue, blunting the impact of any unexpected downturn in manufacturing. Receipts of unemployment insurance also moderate personal income during periods when workers may be temporarily displaced.

Income. Comprehensive income statistics were available for the city, county, and metropolitan area of Wichita (Slater and Hall, 1996). Table 3–14 shows the per capita income and the median household income for each of the affected counties, the City of Wichita, and the Wichita MSA.

Table 3–14 Income Statistics for Both ILWSP Alternatives

	Per capita Income (1997) ($)[2]	Median Household Income ($)[1 & 2]
Harvey	23,148	37,405
Sedgwick	24,870	36,845
Butler	21,991	41,667
City of Wichita	36,218	N/A
Wichita MSA	24,434	38,057

[1]Slater and Hall 1996
[2]CEDBR, 1999

3.7.3 PUBLIC SERVICES

Public services entail transportation, education, healthcare, and law enforcement. The following sections give a brief description of these services for the Wichita metropolitan area.

Transportation. The major transportation routes in the Wichita metropolitan area are three interstate highways and one U.S. highway. Interstate 35 is located along the southwest edge of Wichita, running in a southwest/north-east direction. Interstate 135 is located in central Wichita, running north/south, connecting with Highway 96 and I-35 on each end. Interstate 235 forms a loop around the west side of Wichita connecting with Highway 96 and I-135. U.S. Highway 54 is located in central Wichita, running east/west.

Wichita has a public transportation system serving approximately 6,500 people per day, and over 2 million passengers on a fixed route bus service, and over 172,000 disabled passengers on paratransit vans annually. The transit system currently operates 50 buses and 25 wheel-chair lift vans; on 18 fixed routes, 1 point deviation route, 13 demand-response paratransit routes operated by the Wichita Transit Department, and 8 paratransit vans operated under a lease program with other social service agencies (City of Wichita).

Rail freight companies in Wichita include two major rail companies, Union Pacific and Burlington Northern-Santa Fe, and several smaller companies. Passenger service is available from Amtrak through Newton, Kansas, which is

less than 30 miles north of Wichita and 33 miles east of Hutchinson.

Scheduled air transportation services are provided at Mid-Continent Airport, which is located in southwest Wichita. The airport has three main runways that are 10,300 feet, 7,302 feet and 6,301 feet long. The airport is currently used by 12 major airlines for passenger and freight operations, and seven cargo air companies. Passenger volume during 1997 was 1,414,334. Airfreight during 1997 was 38,737 tons.

There are five other airports in the Wichita metropolitan area, which serve a variety of small companies and individual plane owners. Jabara Airfield is located northeast of Wichita and has one concrete runway that is 6,100 feet. Beech Airfield is located east of Wichita, has one 8,000-foot runway, and is open to limited public use. Riverside Airfield is located northwest of Wichita and has one 2,900-foot runway that will be expanded in the future. The Maize Airfield is also located northwest of Wichita. It is an unpaved and unlighted grass strip used by student pilots and antique airplane pilots. The Westport Airfield is located in southwest Wichita and has a 2,500-foot asphalt runway, and a 3,200-foot grass runway.

Law Enforcement. The Wichita Police Department is the largest police agency in the State of Kansas with an authorized staff of 626 commissioned officers and 201 civilian employees. State, county, and city law enforcement officials serve the Wichita metropolitan area. The Kansas Highway Patrol has approximately 34 commissioned officers in the Wichita area. Park City has 13 officers and noncommissioned reserves. The Rosehill police department has 7 officers. The Andover police department has 12 officers.

Healthcare. Wichita is a first-class regional medical center with five acute-care hospitals, including the two campuses of the Via Christi Regional Medical Center. In addition to these major treatment facilities, Wichita has five freestanding specialty or rehabilitation hospitals and dozens of outpatient clinics. Wichita is also home to the Center for Improvement of Human Functioning, an international bio-medical research and educational organization specializing in nutritional medicine and preventive care (City of Wichita).

The Wichita metropolitan area has 14 hospitals with a total of 2,648 beds, and an occupancy rate of 528/100,000 (Slater and Hall, 1996). Given a population of approximately 500,000 people, the proportion of hospital beds filled is nearly 100 percent. There are 28 nursing homes and assisted living facilities in Wichita, which have a total of 2,280 beds. The Sedgwick County Health Department offers a variety of services at six locations. These services include a family planning clinic, sexually transmitted diseases (STD) clinic, childhood immunizations, and pre-natal care and child dental care.

Education. Eight unified school districts (USD) serve the City of Wichita. USD 259 is the largest in the city. It experienced steady enrollment declines from the 1991/92 school year through the 1995/96 school year, losing more than 2,500 students. Since that time, enrollment has started to rebound,

with an increase of more than 1,700 students over the past 3 years.

In addition to the public school districts, there are approximately 40 private schools serving preschool through high school students, as well as those needing special education. Twelve colleges and universities in the local area serve Wichita, including Wichita State University, University of Kansas-School of Medicine, Friends University, Newman University, and the Wichita Area Technical College (City of Wichita).

The Wichita Public School system has 56 grade schools, 17 middle schools and 14 high schools. Total enrollment as of February 1998 was approximately 47,450. Pre-kindergarten enrollment was 1,199 students, kindergarten enrollment was 4,286 students, grade school enrollment was 19,121 students, middle school enrollment was 10,406 students, and high school enrollment was 12,430 students.

The Bentley/Halstead school district has two grade schools, one middle school and one high school. There was a total enrollment of 810 students as of February 1998. Bentley grade school had 210 students, with an average classroom size of 15 students, and Halstead grade school had 194 students. There were a total of 120 students in the middle school. The high school had 286 students, with an average classroom size of 24 students.

Benton public school district has four schools, three elementary schools serving grades K-8, and one high school. The elementary school enrollment as of February 1998 was 1,488 students, with an average classroom size of 24 students per classroom. The high school enrollment was 438 students, with an average of 22 students per classroom.

The Andover public school district has two primary schools, one intermediate school, one high school, and one middle school. The primary school enrollment as of February 1998 was 819 students, with an average of 23 students per classroom. The intermediate school enrollment was 445 students, with an average of 25 students per classroom. The middle school enrollment was 706 students, with an average of 24 students per classroom. The high school enrollment was 840 students, with an average of 24 students per classroom.

The Rosehill public school district has one primary school, one intermediate school, one middle school, and one high school. Primary school enrollment was 409 students, intermediate school enrollment was 431 students, middle school enrollment was 452 students, and high school enrollment was 490 students. Mean classroom size for grades K-12 was 23-26 students. Average classroom size in 1995 was 21 students in the grade schools and 16 students in the middle and high schools.

***Surrounding Communities*.** Halstead is a small community located on U.S. Highway 50, which runs east and west, with a total population of 2,243 in 1998. The community has 844 housing units, one hospital, one nursing home with 17 beds, and three schools with a student enrollment of 761.

Sedgwick is a small community located just minutes off a major intersection on I-135, U.S. 50, and Highway 96 with a total population of 1,599 in 1998. The community has 517 housing units, and

one nursing home with 79 beds, and two schools with a student enrollment of 482.

3.7.4 WATER RATES

In 1996, the City established an inverted water rate structure. This structure set a monthly minimum water service charge, regardless of whether or not any water was used, based on water service size. In addition, the water rate structure uses an Average Winter Consumption (AWC) rate. This rate is defined as the arithmetic mean monthly consumption computed by adding the metered consumption on bills rendered during the months of December, January, February, and March and then dividing this sum by the number of billings rendered during these same months. Each customer's AWC is recalculated in April of each year.

To encourage water conservation, the Director of Water and Sewer has the authority to negotiate and execute contracts with retail customers seeking to qualify for the conservation contract rate. This rate provides for a significant annual water savings by charging all water use at the retail volume conservation contract rate.

Customers seeking to qualify for the conservation contract rate must make written application detailing methods to be employed to conserve water, the time frame for implementation, and the expected savings derived from that implementation. Each January, those customers that entered in the agreement are to report the results of their efforts. The Director determines if the customer met the goal and a billing is rendered to the customer reconciling charges for the proportion of the customer's prior year consumption that did not meet that goal. Customers exceeding the water conservation goals may use the excess savings as a credit toward next year's water savings goal. This rate is only made available to customers who can demonstrate potential water savings considered economically significant to the City of Wichita as determined by the Director.

Since 1990 the water rates have experienced an average increase of approximately 3.4 percent each year. From 1990 to 1995, the water rates increased 3 to 6 percent, then remained unchanged until 1998. The rates from 1998 to 2000 have increased at 5 percent per year.

Sewer rates have experienced a similar trend to the water rates. Table 3–15 shows the historic water rate increases between 1990 and 2000 for the City of Wichita.

Table 3–15 Historical Water Rate Increases

Year	Rate Increase
1990-1991	6%
1991-1992	6%
1992-1993	3%
1993-1994	6%
1994-1995	3%
1995-1996	0%
1996-1997	0%
1997-1998	0%
1998-1999	5%
2000	5%

3.8 ENVIRONMENTAL JUSTICE

The purpose of an environmental justice analysis is to insure that predominantly low-income and minority communities do not suffer a disproportionate share of any adverse environmental impacts resulting from [federal] actions that are not offset

by project benefits. Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" requires each Federal agency to identify and address such potential impacts of its programs, policies, and activities. This process also requires that these parties have had adequate access to participate in project planning.

In accordance with "Final Guidance for Incorporating Environmental Justice concerns in EPA's NEPA Compliance Analyses" (USEPA 1998), this determination is made by reviewing demographic data for the study area, and comparing the percentages of both minority and low-income persons in that population to the percentage present at national levels. Standardized guidelines provide percentages for comparison. The guidelines for determining low-income were identified from the Bureau of the Census, Series P-60 on Income and Poverty. The poverty rate for the nation in 1990 was 13.1 percent. If the percentage of persons below the poverty level equals or exceeds 13.1 in an area, the area is then considered to be "low-income".

Minority populations, as defined by the Council for Environmental Quality, include members of the following population groups: American Indian or Alaska Native; Asian or Pacific Islander; Black, not of Hispanic origin, and Hispanic. For purposes of Environmental Justice analyses, the Council states that a minority population should be identified where either: "a minority population in the affected area exceeds 50 percent, or the minority population in the affected area is meaningfully greater than the minority population percentage in the general population."

Table 3–16 summarizes 1990 census data on minority and low-income populations in the areas that would be impacted by each component of the proposed project. The components include the Equus Beds Well Field and Recharge Basin, the Bentley Reserve Well Field, and both options of the Local Well Fields, in addition to the general project area. Figure 3–15 indicates the locations of the well sites for the Local Well Field Component in relation to the various census tracts that were included in the analysis.

The City of Wichita had a 1990 population of 304,011, of which 11.3 percent were Black, 1.2 percent were American Indian or Alaska Native, 2.6 percent were Asian and Pacific Islander, and 5 percent were Hispanic of all races. These percentages serve as the bench-mark for comparison to the study areas. The percentage of persons below the poverty level in Wichita in 1990 was 12.5 percent, 1 percent higher than the state of Kansas, but less than that of the nation.

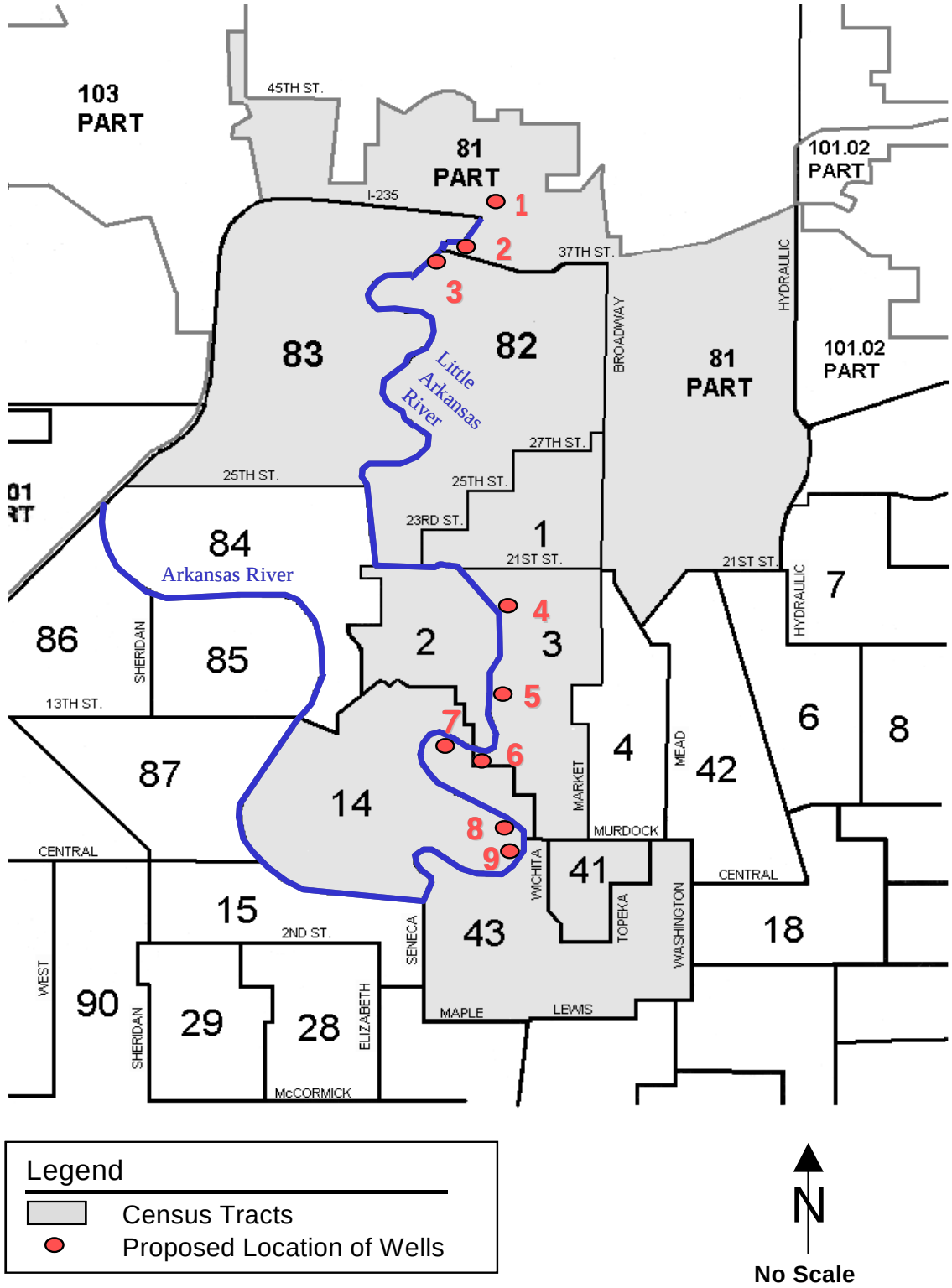
3.9 CULTURAL RESOURCES

To understand the history of human occupation in the project area, it must be considered within the prehistory of the larger Central Great Plains region of the United States. This region is bounded on the west by the Rocky Mountains, on the east by the Missouri River, on the north by the Niobrara River, and on the south by the Arkansas River. The area includes the modern states of Kansas and Nebraska, the eastern plains of Colorado, and the southeastern portion of Wyoming. Within the state of Kansas, the Central Great Plains region is divided

Table 3-16 1990 Minority and Low-Income Populations

Location	Portion of ILWSP Impacting the Location	Total Population	White	Black	American Indian and Alaska Native	Asian and Pacific Islander	Hispanic (all races)	Percentage of Persons Below Poverty Level	Percentage of Families Below Poverty Level	Disadvantaged Community
State of Kansas	-	2,477,574	2,231,986 (90.1%)	143,076 (5.8%)	21,965 (0.9%)	31,750 (1.3%)	93,670 (3.8%)	11.5	7	-
City of Wichita	Location of Local Well Field Expansion	304,011	250,176 (82.3%)	34,301 (11.3%)	3,527 (1.2%)	7,773 (2.6%)	15,250 (5%)	12.5	9.5	NO
Sedgwick County	Location of Local Well Field Expansion and southern end of Equus Beds Well Field; also Bentley Reserve Well Field and minor portion of Cheney Reservoir	403,662	34,5173 (85.5%)	36,061 (8.9%)	4,556 (1.1%)	8,728 (2.2%)	17,435 (4.3%)	10.9	8.3	NO
Harvey County	Location of majority of Equus Beds Well Field and Little Arkansas River Wells	31,028	29,300 (94.4%)	551 (1.8%)	145 (0.5%)	212 (0.7%)	1,616 (5.2%)	8.5	5.5	NO
Butler County	Location of portion of Cheney Reservoir	50,580	49,311 (97.5%)	367 (0.7%)	459 (0.9%)	169 (0.3%)	742 (1.5%)	7	5.9	NO
Reno County	Location of major portion of Cheney Reservoir	62,389	58,612 (93.9%)	1,712 (2.7%)	359 (0.6%)	210 (0.3%)	2,478 (4%)	10.8	7.9	NO
Kingman County	Location of minor portion of Cheney Reservoir	8,292	8,213 (99%)	9 (0.1%)	24 (0.3%)	10 (0.1%)	77 (0.9%)	1.6	9	NO
City of Bentley	Adjacent to 3-acre Recharge Basin Site	360	353 (98.1%)	2 (0.6%)	2 (0.6%)	0	8 (2.2%)	7	5	NO
City of Burrton	Northwest of Equus Beds	866	848 (97.9%)	11 (1.3%)	6 (0.7%)	1 (0.1%)	6 (0.7%)	9	6	NO
City of Halstead	West of Intake Wells on Little Arkansas River	2,015	1,962 (97.4%)	19 (0.9%)	8 (0.4%)	6 (0.3%)	59 (2.9%)	6.2	8.5	NO
City of Sedgwick	East of Intake Wells on Little Arkansas River	1,438	1,402 (97.5%)	10 (0.7%)	7 (0.5%)	2 (0.1%)	53 (3.7%)	14.1	0	percentage of persons below poverty level greater than standard of 13.1
Equus Beds Well Field and Recharge Basin Component										
Includes Lake, Lakin, and Eagle Townships	Location of Recharge Wells and Recharge Basin in the Equus Beds Well Field	1,413	1,382 (97.8%)	4 (0.3%)	20 (1.4%)	3 (0.2%)	15 (1.1%)	11.9	3.7	NO
Bentley Reserve Well Field										
Eagle Township	Location of Bentley Reserve Well Field	895	878 (98.1%)	2 (0.2%)	11 (1.2%)	0	14 (1.6%)	6.1	0	NO
Local Well Field Component (Option 1)										
Census Tracts 3, 14, 81, 82, and 83 in the City of Wichita (See Figure 3-14).	Well Sites 1-9 and piping for the Upper and Lower Sections. The piping for the Lower Section of Option 1 is the same as Option 2, but also heads west along Stackman Road, and ends further west at the Water Treatment Plant near Botanica and Sim Memorial Park (additional 4,000 linear feet).	23,832	20,526 (86.1%)	858 (3.6%)	308 (1.3%)	354 (1.5%)	2,747 (11.5%)	14	10.8	Percentage of persons below poverty level is greater than the standard of 13.1 %. Percenage of Hispanics in the area is larger than that in the City of Wichita (11.5% vs. 5%).
Local Well Field Component (Option 2)										
Census Tracts 3, 14, 81, 82, and 83 in the City of Wichita (See Figure 3-14).	Well Sites 1-9 and piping for Upper and Lower Sections. Proposed pipeline for Option 2 runs along west side of Little Arkansas River, from about East 19th Street, south through Minisa Park, south to 12th Street N & Jefferson, then west, between North Oak Park Road and the Little Arkansas River, ending in Oak Park. Same pipeline also splits near East 13th Street south of Minisa Park, south along Jefferson, then crosses the river, continues along the river through Central Riverside Park, ending between Stackman Road and Little Arkansas River.	23,832	20,526 (86.1%)	858 (3.6%)	308 (1.3%)	354 (1.5%)	2,747 (11.5%)	14	10.8	Percentage of persons below poverty level is greater than the standard of 13.1 %. Percentage of Hispanics in the area is larger than that in the City of Wichita (11.5% vs. 5%).

Figure 3-15 Census Tracts in Area of Local Well Field



into a number of smaller physiographic regions based upon differences in landforms. Of these areas, the proposed project cuts through three: the Flint Hills, the Arkansas River Lowland, and the Wellington-McPherson Lowland.

Human occupation of the Central Great Plains can be divided into six broad time periods or stages based upon differences in how people interacted with their environment. Through time, different adaptations produced variations in settlement patterns, cultural materials, and subsistence economics. These time periods, from earliest to latest are: Paleo-Indian, Archaic, Early Ceramic, Middle Ceramic, Late Ceramic, and Historic. Particular artifacts, settlement patterns and house types, as well as the exploitation of different plant and animal species characterize each period. Although each period has been given a name, and is identified by a number of particular characteristics, the periods do not represent isolated cultures, but rather a continuation of cultural development through time. Each period was influenced by those proceeding it as well as the development of new technologies, innovations, and the influx of materials and ideas from neighboring regions.

3.9.1 THE PALEO-INDIAN PERIOD (10,000-6,000 BC)

The start of this period is traditionally marked by a noticeable warming trend toward the end of the Ice Age. People of this period typically traveled together in small bands, hunting now-extinct, large Ice Age animals, and collecting various types of plants and smaller animals. The typical hunting tool was a spear, tipped with a large leaf-shaped chipped-stone projectile point. Groups were highly mobile, and collected berries, seeds, roots, small game, clams, and other locally available plant and animal resources to supplement their diet. This period has been divided into three stages, based primarily upon changes in projectile point forms over time: Llano (10,000 - 9,000 BC); Folsom (9,000 - 8,000 BC); and Plano (8,000 - 6,000 BC).

The earliest well-documented evidence of human activity in the Central Great Plains is based on several sites attributed to the Llano complex (10,000-9,000 BC). This culture is identified by a distinctive projectile point type with a centrally flaked flute known as “Clovis” found near the remains of large Ice Age animals, particularly the mammoth. The Clovis point is the earliest known projectile point in North America and is identified as a spear point rather than an arrow point. Other artifacts recovered from Llano sites and related to the hunting and butchering of mammoth are cylindrical bone and ivory fore-shafts/projectile points, scrapers, knives, cobble choppers, gravers, bifaces, and hammerstones (Brown and Simmons 1987:IX-4). No sites attributed to the Llano culture have yet been excavated in Kansas. This phase is represented only by isolated surface finds of Clovis projectile points, and no direct association of extinct Ice Age animal remains and Llano artifacts has been documented (Logan 1998:33; O’Brien 1984:28).

The Folsom complex (9,000-8,000 BC) follows Llano, and is also characterized by the presence of a distinctive projectile point in association with extinct Ice Age animal remains. In this case, however, the leaf-shaped “Folsom” point, with an extended central flute, has replaced the Clovis point, and a now-extinct form of bison has replaced mammoth as the primary source of food and raw materials. Surface finds of Folsom projectile points

have been recorded throughout Kansas, although they appear to be concentrated in the northeast and southwest corners of the state (Brown and Simmons 1987: figure 9.7). The Twelve-Mile Creek site (14LO2) located in Scott County, west-central Kansas, may represent the only excavated Folsom complex in the state. This site has produced several skeletons of extinct bison in direct association with a leaf-shaped projectile point. The identification of the point as Folsom, however, is uncertain (O'Brien 1984:28).

The next phase of cultural development dates from 8,000-6,000 BC and is called Plano. It is characterized by a wide variety of chipped stone projectile point and knife forms. The most widely hunted animal resources are now-extinct forms of bison, horse, and camel at early sites, and the modern form of bison at sites dated to 7,000 BC and later. The Plano complex consists of a group of Paleo-Indian cultures each represented by a characteristic chipped stone projectile point/knife form. Those present in the Kansas area are: Plainview, Hell Gap, Meserve/Dalton, Milnesand, Midland, Agate Basin, Scottsbluff, and Eden. The new forms are characterized by parallel flaking along the tool edges, but lack the central flute of the Clovis and Folsom types. The fluted projectile point is no longer the preferred type throughout the region; rather, this wide variety of new leaf-shaped forms is present.

Due to the scarcity of excavated Plano sites in Kansas, almost all of the information regarding this phase is observed from nearby states. Six well-documented Paleo-Indian sites in Kansas are the Tim Adrian, the DB, the Norton Bone Bed, the Laird, the Sutter, and an unnamed site in Sedgwick County. The Tim Adrian site (14NT604) is a possible Hell Gap quarry site in northwestern Kansas (Brown and Simmons, 1987). In northwestern Kansas is the DB site, a briefly occupied upland site (Logan 1998). Another western Kansas Paleo-Indian site is the Norton Bonebed (14SC6) in Scott County (Hill 1993). The Sutter site (14JN309) is a possible Fredrick complex containing leaf-shaped projectile points with parallel flaking. Site (14SG515), a possible Cody complex containing Scottsbluff and Eden points and a Cody knife, is located in Sedgwick County near Wichita (Brown and Simmons 1987). Although the Paleo-Indian period is poorly known in the Central Great Plains and in Kansas, the absence of known sites does not exclude their existence in the state, and within the project area. It has been suggested that the absence of recorded sites may be due to two factors: 1) a lack of intensive surveys in the western two-thirds of the state; and 2) the difficulty of locating Paleo-Indian sites in the eastern two-thirds of the state due to their burial beneath other soil deposits (Brown and Simmons 1987:IX-11). Although the majority of Paleo-Indian sites are butchering and kill sites of large game, Wheat (1978) has defined four types of human behavior which would result in the formation of different types of sites: 1) mass kill sites; 2) butchering sites; 3) long-term campsites; and 4) short-term campsites. It is possible that all of these forms are present in Kansas.

Mastodon, mammoth and bison remains have been recorded in Harvey and Sedgwick counties. The presence of Paleo-Indian projectile points and the remains of Ice Age animals hunted by these peoples indicates the potential for Paleo-Indian sites in these areas of Kansas. Brown and Simmons (1987:XX-6) suggest the "probability for bison jump

and animal trap sites being present [particularly in western Kansas] is high."

3.9.2 THE ARCHAIC PERIOD (6,000 BC TO AD 1)

The people of the Archaic period practiced a way of life centered on hunting and gathering, with a dependence at least in part on bison as a key component of their diet (Hofman 1996:80). Due to the extinction of Ice Age animals in the late Pleistocene approximately 9,000-8,000 years ago, hunting strategies shifted to smaller game animals including the modern bison, as well as deer and elk, and a greater dependence upon wild plant foods. This change is characterized as a shift from an economy focused on large game, to one based on a wide variety of resources (Logan 1998:34). During this period, hunter-gatherer groups were dependent entirely on the exploitation of wild plant and animal resources. Populations continued a high level of nomadism, but became more focused on the seasonal exploitation of resources located in specific areas. Settlements became more regional through this period and populations increased. Pit houses appeared in upland hunting-processing camps (bison kill areas), and new food storage and processing technologies developed. Grinding slabs became a common feature of the prehistoric tool kit as seed processing became important. At approximately 5,500 BC, people began to experiment with the manufacture of ceramic objects. The number of chipped-stone tool types increased as tools were manufactured for a variety of specialized uses, and the atlatl, or throwing stick, became common.

Evidence of human occupation in Kansas during the Archaic is as difficult to come by as that of the previous period. Few Archaic cultures have been defined for the area, and those that have are based on only a few excavated sites. With the exception of the Flint Hills region, which contains a fairly well-known Archaic complex, there are no clearly defined cultures within the project area. Within the Flint Hills region, five cultural complexes/phases have been defined: the Logan Creek complex; Munkers Creek phase; Nebo Hill phase; Chelsea phase; El Dorado phase; and Walnut phase.

3.9.3 THE EARLY CERAMIC PERIOD (AD 1-1000)

In the Plains, the Early Ceramic Period, or Plains Woodland, is the equivalent of the Woodland stage farther east. It was during this period that there was a trend toward increased sedentism, intensified horticultural activity, expanding regional exchange networks, and the elaboration of ceremonial activities and mortuary practices which characterizes the Woodland stage (Griffin 1967). The origins of these trends can be traced to the Late Archaic, but the elaboration of cultural elements became the hallmark for the period. In addition to these trends, technological changes were also occurring such as the adoption of bow and arrow weaponry and widespread use of ceramic vessels for storage and cooking. These developmental trends form the basis for distinguishing the Early, Middle, and Late Woodland substages. Regional variations in the time and extent to which these traditions were expressed make this tripartite subdivision used in the east difficult to employ in certain areas such as the Plains.

Unlike the Late Archaic settlement system, small, short duration camps adjacent to specific environmental locales typify the Early Woodland occupations in

the Midwest. This suggests that small social groups using seasonally occupied specialized extraction camps were exploiting resources within defined localities (Roper 1979; Emerson and Fortier 1986; Seeman 1986).

The Early Ceramic stage is generally associated with the initial development of ceramic technology. The ceramics are generally described as thick, stone-tempered with cordmarked exteriors (Montet-White 1968; Farnsworth and Asch 1986; Adair 1996), similar to the Fox Lake ware and Crawford ware types of the Midwest. Other characteristics of the stage include development of the bow and arrow technology and subsistence adaptations (Adair 1996).

Most of the eight cultural manifestations found in Kansas that are attributed to Early Ceramic stage are poorly understood. Keith complex sites are found on the High Plains, generally between the Arkansas and Platte rivers (Johnson and Johnson 1998). The ceramic technology is unique in that the vessels were conical in shape and generally had very thick, cord-marked walls. The tempering agent in the pottery vessels tended to be calcite in those sites northwest of the project domain. Projectile points range in styles from large dart points, typically associated with use of an atlatl, to small corner notched arrow points associated with the use of a bow. Keith complex sites are generally small campsites or special purpose sites on ridges and terraces overlooking rivers and tributary streams.

On the eastern periphery of the project domain are the Greenwood and Butler phases. The Butler phase was defined by the excavations at the Snyder site in El Dorado Reservoir and dates between A.D. 200-800 (Grosser 1970, 1973); but, a review of the cultural materials suggest that the Greenwood and Butler phases are connected. The Greenwood phase, as defined by Witty (1980), covers much of the Flint Hills and western Osage Cuestas. The main diagnostic artifact of this phase is the limestone-tempered Verdigris type pottery.

Several Plains Woodland sites have been recorded, many as yet unofficially, within the Little Arkansas River valley of the project domain. Many of these sites have characteristics of both Keith complex and Greenwood/Butler phases, yet may be distinct enough to be identified as a distinct cultural manifestation. These sites are generally campsites on terraces or sand dunes near the Little Arkansas River channel, or on ridges overlooking many of the small playa lakes in the area. The ceramics are sand-tempered, conical vessels made from the locally available sandy clays. Chipped stone tools include dart points and small, corner-notched arrow points made from locally available river cobbles and upland quartzite cobbles. A few items have been identified as being from chert sources in the Flint Hills, but these are very few.

3.9.4 THE MIDDLE CERAMIC PERIOD (AD 1000-1500)

The Middle Ceramic stage is probably the best understood prehistoric stage in Kansas. Sites attributed to this stage are typically grouped under the Central Plains Tradition or Village Tradition. During some of the original archaeology conducted in the region, archaeologists focused on this stage (Wedel 1959; Strong 1939). Until recently, it was thought that these sites contained villages of several contemporaneous houses. Recent work on the Solomon River phase of north-central Kansas shows that these

people did not live in villages, but were in broadly scattered homesteads (Latham 1996; Blakeslee 1999).

The Smoky Hill phase is found in the north and northeastern segments of the project domain. Smoky Hill peoples resided in semi-rectangular earth lodges situated on terraces along rivers and tributary streams. These Swidden-foragers exploited nearly every edible animal and plant found in their respected localities (Logan 1998; Blakeslee 1999). Smoky Hill phase ceramics include globular jars and bowls. The exterior of the pottery is generally cord-marked and tempered with sand or grit.

Other Middle Ceramic cultures in the area of the project includes the Pratt Complex in the Arkansas River lowlands. Recent research of this complex has shown that the Pratt Complex people were likely associated with the Southern Plains Village Tradition (C. Tod Bevitt, personal communication, 1999).

South of the project domain is another Middle Ceramic culture referred to as the Bluff Creek complex. Little in-depth research has been published on this complex, but appears to be related to the Southern Plains Village Tradition.

A few Middle Ceramic sites have been recorded in or near the project area. These sites are generally small material scatters on terraces of the Little Arkansas, Saline, Smoky Hill, and Solomon rivers and their tributaries. It is likely that house remains are present at several of these sites and a number of other sites yet unrecorded are within the project area.

3.9.5 THE LATE CERAMIC PERIOD (AD 1500-1800)

The Late Ceramic stage is essentially the proto-historic period in Kansas. Post-contact sites are generally those that date from the time of the first appearance of Euro-American trade goods. These early trade items are viewed as horizon markers, including a wide range of materials made from copper, brass, iron, glass and even stone in the form of gunflints. Throughout this period trade relations waxed and waned between the various tribes and the Euro-Americans. Certain groups became more prominent in the trade networks. Cultures identified in this stage represent direct association with historic groups like the Wichita, Kansa, and Pawnee, among others. The most common Late Ceramic culture found in and around the project area are Great Bend aspect village sites. The most prominent sites of this aspect are villages found in the upper Little Arkansas River drainage in Rice and McPherson counties. Other concentrations of these sites are found in Marion and Cowley counties. These large villages included wood framed, grass-covered houses and a variety of other features including arbors and numerous subsurface storage pits.

Campsites and other special purpose sites associated with the Late Ceramic stage have also been recorded in and near the project area. These camps are usually identified by light to moderate scatters of chipped stone, pottery, and faunal debris. The northern edge of the project area was well known as the preferred bison hunting ground for the historic Pawnee, but recent work in this region has identified Great Bend aspect hunting camps in this area as well (Latham 1996). Other Late Ceramic sites

in this area is affiliated with the White Rock phase, a western Oneota component. White Rock could be associated with a historic group like the Kansa or Otoe.

In addition to evidence of a Native American presence in the area, Euro-American sites begin to appear in the archaeological record during this period. Coronado's *entrada* into the Central Great Plains began in 1541, and French trappers/explorers arrived in the area about 1740. These explorations into the region left evidence in the form of campsites, hunting sites, refuse piles, discarded weapons and armament, trails, etc.

3.9.6 THE HISTORIC PERIOD (POST 1800)

Although documented exploration of the Central Great Plains region begins with the Spanish expedition of 1541, a substantial number of Euro-American sites do not appear in the area until after AD 1800. This date, therefore, effectively records the onset of the Historic period. Although historic Native American tribes represented by the Wichita, Cheyenne, Comanche, Kiowa, and Kiowa Apache were still present in the area, the largest number of archaeological sites of this period can be attributed to Euro-American settlement. Euro-American sites are represented by agricultural settlements, bridges and fords, civic sites, 19th and 20th century artifact scatters, historic trails, isolated finds of agricultural implements, cemeteries, agricultural outbuildings, and other sites (Logan 1998:44-45). Two 19th century military forts, Ellsworth and Harker, are present near the project area as are a number of historic trails.

With Kansas given territorial status in 1854, Euro-American settlement increased, as did the number of Euro-American sites. Indian removal policies of the period resulted in the removal of the Potawatomi, Kickapoo, and other tribes first to reservations and later to Oklahoma. With the granting of state status in 1861 and the end of the Civil War in 1865, Euro-American settlement in the region increased dramatically. In the 1870s, the cattle business boomed, and the "cowboy era" arrived in Kansas along with the railroad. These developments also left their mark in the form of recorded historic sites.

3.9.7 RECORDED SITES AND SPECIFIC SITE TYPES

Recorded Sites. As of August 8, 2002, the number of recorded archaeological sites within the counties affected by the alternatives of the proposed project are as follows: Harvey - 59; Reno - 32; and Sedgwick - 123. These numbers provide a rough comparison of the density of known sites within the project area as of that date. Although helpful in predicting the possibility of encountering unrecorded sites in some areas, these figures do not indicate the presence or absence of sites in any given location.

A number of specific site types have also been documented within the area crossed by the proposed project, and within the surrounding area utilized by indigenous peoples. These are: lithic quarries/collection stations; rock shelters; tipi rings, stone alignments, and earthen construction; human burial areas; and rock art sites.

Lithic Quarries/Collection Stations. Although little systematic excavation of quarry sites has taken place in Kansas, a number of sites have been recorded in

the Flint Hills region of the project area. This region is known for the presence of chert or flint outcrops utilized by Native American peoples; and, although only one of the recorded sites is close to the project area, there is the potential for locating as yet unrecorded quarry sites in the area. Butler County has four sites located within the region of the project. (Brown and Simmons 1987:XX-2).

Rock shelters. Rock shelters have been recorded primarily in the southeast and north-central half of Kansas. There are no recorded sites within the region of the project area (Brown and Simmons 1987:XX-2). The potential for locating unrecorded sites of this type is dependent upon the presence of rock outcrops of sufficient size to offer protection to Native peoples, and therefore locations suitable for habitation.

Tipi Rings, Stone Alignments, and Earthen Construction. The occurrence of recorded tipi rings, stone alignments, and earthen construction are rare due to extensive cultivation of the Kansas landscape. Prior to Euro-American occupation these features were undoubtedly more common and sites may still occur in more arid or dissected regions less subject to destructive cultivation. Earthen “council circles” attributed to astronomical registers have been recorded in McPherson county at the Paint Creek or Udden site (14MP1), and at the Sharps Creek or Swenson site (14MP301). These two sites are represented by a low central mound 20-30 meters in diameter surrounded by a shallow ditch or a series of oblong depressions. The maximum relief of the features is 44-88 centimeters (Brown and Simmons 1987:XX-6).

Human Burial Areas. Earthen mounds and ossuaries, or areas set aside for the placement of human remains, are usually attributed to the Late Archaic and Ceramic periods. A number of human burial areas have been recorded near the project area, and a significant number of burial sites have been previously excavated in Kansas. Additionally, numerous isolated occurrences of fragmentary human bones have been recorded. Reno County has one burial site recorded within the region of the proposed project area (Brown and Simmons 1987:XX-7). Although isolated human burials and fragmentary remains can be found in almost any setting, the larger burial sites tend to occur in conjunction with large village sites, often located on the banks of major rivers or their tributaries.

Rock Art Sites. A number of rock art sites have been recorded in Kansas, particularly along the eastern edge of the Smoky Hills region. Smaller concentrations are also found in the southeast corner and the south-central portion of the state. The distribution of sites appears to correspond to the availability of suitable rock outcrops. All recorded rock art sites represent petroglyphs (figures pecked into the rock), except for the presence of one pictograph (figures painted on the rock). Nearly all of the rock art is considered part of the pan-Plains incised rock art tradition dating from just before European contact through the Historic period. None of the counties affected by the proposed project contains recorded rock art sites (Brown and Simmons 1987:XXI-1 to XXI-4).

Habitation Sites. Habitation sites contain cultural deposits related to the seasonal occupation and may include

subsurface features. Residential structures and task-specific activities may be represented by organic staining of the soil. Site size can range from moderate to extensive and may include multiple landforms. Density of cultural debris and diversity of tool classes are generally moderate to high. Two types of habitation sites may be found in the project corridor.

Residential Base or Village. Residential base sites form the hub of subsistence activities, the locus out of which foraging parties originate and where most processing, manufacturing, and maintenance activities take place. Residential base camps may be identified archaeologically as large sites with a high artifact density and a wide diversity of tools and other artifacts. Features related to site activities are usually present.

Field Camp. These camps serve as temporary operational centers for a task group that maintains itself while away from the residential base. The individual sites may be further differentiated according to the nature of the resources to be procured and the size of the social group the task force is supplying. Sub-surface features may be present at such sites.

Lithic Scatters/Task Specific Sites. These sites are associated with the procurement of a limited number of locally available resources and/or the reduction of raw lithic materials. Sub-surface features, structures, organic staining, or cultural deposits of substantial integrity related to seasonal occupation are not generally found at such sites. Site size is generally small, a result of a short-term occupation. Density of cultural debris and diversity of artifact classes are limited severely due to the nature of the activities evident. Artifact content often consists entirely of task-specific expedient tools, occasionally supplemented with broken or discarded, curated tools. Lithic scatters often fall below the threshold of visibility even with excellent survey conditions. Cultural resources identified as isolated finds often may be examples of lithic scatters. In rugged terrain, these sites often occur on landforms that offer only a small area suitable for occupation, such as small benches and ridge spurs. Sites included in this category may include some preliminary food processing sites, lithic procurement and/or reduction sites, small kill and processing sites, and artifact scatters.

Bison Kill Sites. Bison kill sites are essentially task sites, since they are just that “bison kill sites”; therefore, due to the uniqueness of these sites, they are treated separately when categorizing sites. Such sites can have great range in size and number of individuals present. They are usually associated with favorable terrain for impoundments or jumps. Impoundments can often be traps found in the natural environment, including steep-walled ravines, draws, or arroyos and other areas where the animals can be trapped or become bogged down. Jump sites are generally found at the bases of steep to moderately steep ravines and canyons where the herd can be driven off. Kill sites with significant integrity are generally found buried in sediments. Many such kill sites have been recorded in the Panhandle region, but none within the project domain.

Sacred, Specialized Ceremonial, or Mortuary Sites. Sites in this category are those that served specialized ceremonial functions. Examples include cemeteries, cairns, mounds, and

petroglyph and pictograph sites. Such sites may or may not be spatially separated from habitation sites. Sacred sites are often difficult to recognize archaeologically. According to the *Handbook of American Indian Religious Freedom,* Native Americans have historically observed the following as sacred sites where:

- the ancestors arose from the earth
- the clan received its identity
- ones ancestors are buried
- the people receive revelation
- the culture hero left ritual objects for the people
- the people make pilgrimages and vision quests
- the gods dwell
- animals, plants, minerals, or waters with special powers are found (Vecsey 1991:222)

Additional categories for sacred sites have been added by Linea Sundstrom (1996:2), including:

- places frequented by the spirits of ones' ancestors
- where esteemed members of a group died or were buried
- where miraculous or mythical events took place
- where ceremonies were held in the past
- places recognized as sacred by other groups

Sacred sites found across the landscape can be of two types, general and specific. These places often included springs, round stones (especially in areas at some distance from streams and other water sources), fossil outcrops, or places with rock art or stone effigies (Sundstrom 1996).

3.10 VISUAL RESOURCES

Topography, vegetation, and land use are the primary determinants of visual character. The unique combination of vegetation, topography, and manmade features create the aesthetic quality of a site. These components work together to create the landscape of a specific area.

The various components of the water supply alternatives are located in places with differing visual characteristics. The Equus Beds and Bentley Reserve well fields are located on a flat to gently rolling area and in a rural setting consisting of row crops and pasture. The landscape is currently dotted with existing well structures as well as other structures such as small barns, metal sheds, irrigation systems, and oil pump jacks. East of the well fields is the Little Arkansas River with its braided channel, sand bars, and forested islands; to the west is the Arkansas River. The location of the Local Well Field expansion is in the west to northwestern portion of Wichita along the Little Arkansas River and the Wichita Valley Center Floodway, a mostly urban to suburban area.

Cheney Reservoir is located in a rural setting. Few trees are present along the east shore because of the shallow soils; those found are fast growing, short-lived varieties such as cottonwood and willow. More trees can be found along the west shore due to better soils.

With the exception of the City of Wichita, and the towns of Sedgwick, Bentley, and Halstead, land in the project area is primarily used for agricultural activities; over 93 percent of the area is classified agricultural or grassland. These activities include growing crops, raising livestock, and producing hay. Of the remainder, less than 3 percent is residential.

Reservoirs and rivers in the project area are used for recreational activities such as fishing, boating, and swimming.

3.11 RECREATIONAL RESOURCES

Major recreational facilities in the City of Wichita include 97 park facilities, each of which have varied and multiple uses. Such facilities include amphitheaters (2), basketball courts (37), children's play areas (62), drinking fountains (106), picnic areas (33), fishing ponds (11), recreation centers (11), restroom facilities (74), swimming pools (14), tennis courts (79), and an assorted variety of other facilities (Wichita Department of Parks and Recreation, 1995). Other public and privately owned recreation resources in Wichita and the surrounding area are found in Table 3–17.

3.11.1 CHENEY RESERVOIR

Constructed by the U.S. Bureau of Reclamation (Reclamation) in 1965, Cheney Reservoir is second only to El Dorado Lake in size and annual recreational use. Although no minimum pool for recreation is included in Cheney Reservoir, recreation was an authorized secondary purpose of the original Wichita Project. The initial funding for recreation facility development using 1960 price levels was $338,000. In recent years, public recreation use of the reservoir has averaged around 1 million visitors annually (Reclamation 2002).

Cheney Reservoir and associated facilities are a major source of recreation for residents in regional area, particularly those of Wichita. Most of the reservoir (75 percent) is located in Reno County. Cheney Reservoir State Park currently encompasses almost 2,000 acres, while nearly 10,000 acres of land and water comprise the Wildlife Management Area. The reservoir itself covers approximately 9,600 acres and has about 67 miles of shoreline. The City of Wichita operates the dam, outlet area, and pumping station area. Except for those areas, all other land and water surface areas are leased to the State of Kansas for wildlife and parks purposes through the year 2014.

Known for its wind, Cheney Reservoir is one of the top ten windsurfing and sailing areas in the world. The reservoir draws many windsurfers from Canada, and is home to the largest sailing club in Kansas.

Table 3–17 Major Recreational Facilities in Wichita Metropolitan Area

81 Speedway
Botanica, The Wichita Gardens
Century II Convention Center
Cheney Reservoir, State Park and Wildlife Management Area
Exploration Place
Golf Courses (17)
Joyland Amusement Park
Lake Afton
Omnisphere & Science Center
Sedgwick County Park
Sedgwick County Zoo & Botanical Gardens
Wichita Center for the Arts
Wichita Greyhound Park
Wichita International Raceway
Wichita Symphony Orchestra
Wichita Thunder Hockey Team
Wichita Wings Indoor Soccer
Wichita Wranglers Baseball

Source: Wichita Area Chamber of Commerce, 1998

The City of Wichita has an active bike trail development program and is considering a proposed bike link between the reservoir's northern tip and Hutchinson, approximately 14 miles away. In its 1989 Comprehensive Bicycle Plan, the City proposed a link between Cheney Reservoir along 21st Street to the Sedgwick County Zoo, and on to the Arkansas River, Northeast Expressway, and Canal Route bikeway system.

Considered an important state resource, the KDWP spent over $3.5 million in the last 6 years for facility renovations at Cheney Reservoir. The Master Plan for Cheney Reservoir, in conjunction with the Bureau of Reclamation, was revised in 1997. Recommendations of the 1997 master plan were to increase or improve several types of facilities within the park. These recommendations included adding 659 camping sites, 158 picnic tables, 5 boat ramps (lanes), 11 miles of biking trails, 2 dump stations, 2 fish cleaning stations, 15 fishing docks/jetties/piers, and 6 courtesy docks. A list of facilities at the Cheney Reservoir are in Table 3–18.

Visitor Characterization - Cheney Reservoir, located close to major population centers, is expected to continue to experience heavy use. Accessible to a large population base, it tends to draw high numbers of users in short periods of time and experience overcrowding on peak days. Most visitors travel from within a 50 to 75-mile radius, including the cities of Wichita, Hutchinson, or Kingman, and counties of Reno, Sedgwick, or Kingman. Visitor count for the park (excluding the Wildlife Area) was 619,221 persons in 2001 generating $524,251.00 in revenue. Visitors and associated revenue collected for the last five years at Cheney Reservoir State Park are presented in

Table 3–18 Major facilities at Cheney Reservoir State Park and Wildlife Management Area

Waterborne Facilities	7
Vault Restrooms	8
Showers w/ Restrooms	1
Number of Areas	3
Dump Stations	2
Group Picnic Areas	1
# Tabled Picnic Areas	15
Campsites - All & Inclusive	282 + 250 non-designated areas
Picnic Sites – individual tables	207
Campsites with Water Hookups	185
Campsites with Electric Hookups	185
Swim Areas	4
Bath Change House	1
Road Miles Unpaved	12.7
Road Miles Paved	20.1
Miles of Bicycle Trails	0.96
Miles of Hiking Trails	0.27
Marinas	2
Fishing Docks, Jetties, Piers	5
Launching Lanes	20
Courtesy Docks	1
Boat Ramps	9

Source: Cheney Reservoir Master Plan, 1997

Table 3-19. Visitors of the park for the year 2002 including the holidays of Memorial Day, 4th of July, and Labor Day are presented in Table 3-20.

Table 3–19 Cheney Reservoir State Park Visitors and Revenue Collected 1997-2001

Year	Visitors	Revenue
1997	556,502	$369,250.00
1998	480,120	$384,865.00
1999	581,467	$428,165.00
2000	592,656	$425,036.00
2001	619,221	$524,251.00

Table 3–20 Visitors at Cheney Reservoir State Park through September of 2002 & Major Holidays

Year	Visitors
January	13,826
February	12,693
March	12,857
April	23,532
May	94,501
June	125,068
July	98,025
August	80,876
September	57,476
Memorial Day	35,895
4th of July	34,159
Labor Day	26,442

An active lake association enjoys membership of over 350 families, with a sailing club membership of over 200 families. Peak-season is Memorial Day to the Fourth of July, the time when park admission receipts provide 50 percent of the year's revenue.

Unlike El Dorado, Cheney Reservoir also serves the City of Hutchinson, further intensifying day-use demand. Because of its proximity to more urban recreationalists, Cheney Reservoir is more suitable for additional group-use activities that involve camping or picnicking. Indications are that the demand for group camping from scouting, church, YM/YWCA's, RV clubs, and other organizations is unmet.

Cheney Reservoir is and will continue to be a major fishing and hunting area. As indicated by Annual Permit holders and comments at public meetings in the cities of Cheney, Hutchinson, and Wichita, shoreline and streambed conditions are major issues at Cheney Reservoir. The following recreational issues identified are:

- Need to create fisheries through enhanced shoreline and stream bed (riffles) habitat
- Better access for shoreline fishermen
- Stabilization of shoreline to prevent loss of land area due to wind/wave erosion

The KDWP has undertaken a five-year $450,000 shoreline stabilization contract with Reclamation. Shallow water in the upper reaches and in nearly every cove limit these areas to fishing activities, while higher density recreation activities, including personal watercraft use, focus on the main, open body of water. User surveys indicate the number of shoreline fishing access points and boat ramps in both the upper reaches and the main body of the reservoir should be increased.

Water levels in the reservoir vary, according to season, rainfall, and other factors. If climate conditions cause evaporation and transpiration to accelerate, water levels are reduced. In the latter part of the summer, Cheney Reservoir is a shallow lake. The need for

more boat ramps and fishing access points becomes more acute with the likelihood of a wider range of future water drawdown levels. However, improving the water depth near the reservoir's shore can be accomplished through dredging.

Key factors impacting Cheney Reservoir's future development are reservoir water elevations and projected fluctuations at full water supply demand. The extent of the downward fluctuations at full demand could increase in the future (during drought periods), while the flatness of the shoreline would continue to magnify typical flooding, water access and proximity problems.

3.11.2 BENTLEY RESERVE WELL FIELD

The City of Wichita owns the 80-acre, now-abandoned Bentley Reserve Well Field in rural Eagle Township, just north of Highway 96. Since its abandonment as a water source, the City had constructed picnic shelters, provided maintenance, and used part of the site as a camping and riverside picnic area for city employees. In 1999, the City leased the picnic site to the KDWP for use as a fishing area, while property closer to the actual well sites was leased as pasture land to a local farmer.

Additional recreational activities as reported by the City's Well Field maintenance staff in this area include the illegal discharge of firearms by highway users at picnic and well field facilities for target practice, and other various forms of vandalism on the property. Public access to this site will be restricted when the site is developed as a water supply source.

3.11.3 LOCAL WELL FIELD

Sites currently identified for the Local Well Field expansion are along the Little Arkansas River. According to the Comprehensive Plan for the City of Wichita, most of the river corridor is designated "Open Space", meaning recreational and aesthetic is the desired use. The City owns about half of this corridor, while the other half is privately owned. In some areas, homes are situated within 50 feet of the river's edge.

3.11.4 EQUUS BEDS WELL FIELD

The City of Bentley, located south of the Equus Beds well field, currently has organized recreation which is limited to Little League baseball. The City of Bentley is currently considering annexation of approximately 61 acres to the north, for residential use and would include a recreational facility as part of the development.