Oklahoma Comprehensive Water Plan

OCWP

Central

Watershed Planning Region

Report

Version 1.1

Oklahoma Water Resources Board

The objective of the Oklahoma Comprehensive Water Plan is to ensure a dependable water supply for all Oklahomans through integrated and coordinated water resources planning by providing the information necessary for water providers, policy-makers, and end users to make informed decisions concerning the use and management of Oklahoma's water resources.

This study, managed and executed by the Oklahoma Water Resources Board under its authority to update the Oklahoma Comprehensive Water Plan, was funded jointly through monies generously provided by the Oklahoma State Legislature and the federal government through cooperative agreements with the U.S. Army Corps of Engineers and Bureau of Reclamation.

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The online version of this 2012 OCWP Watershed Planning Region Report (Version 1.1) includes figures that have been updated since distribution of the original printed version. Revisions herein primarily pertain to the seasonality (i.e., the percent of total annual demand distributed by month) of Crop Irrigation demand. While the annual water demand remains unchanged, the timing and magnitude of projected gaps and depletions have been modified in some basins. The online version may also include other additional or updated data and information since the original version was printed.

Cover photo: Sunset on Lake Hefner, by Chris Neel, OWRB Staff

Oklahoma Comprehensive Water Plan

Central Watershed Planning Region

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Statewide OCWP Watershed Planning Region and Basin Delineation

Introduction

The Oklahoma Comprehensive Water Plan (OCWP) was originally developed in 1980 and last updated in 1995. With the specific objective of establishing a reliable supply of water for state users throughout at least the next 50 years, the current update represents the most ambitious and intensive water planning effort ever undertaken by the state. The *2012 OCWP Update* is guided by two ultimate goals:

1. Provide safe and dependable water supply for all Oklahomans while improving the economy and protecting the environment.

2. Provide information so that water providers, policy makers, and water users can make informed decisions concerning the use and management of Oklahoma's water resources.

In accordance with the goals, the *2012 OCWP Update* has been developed under an innovative parallel-path approach: inclusive and dynamic public participation to build sound water policy complemented by detailed technical evaluations.

Also unique to this update are studies conducted according to specific geographic boundaries (watersheds) rather than political boundaries (counties). This new strategy involved dividing the state into 82 surface water basins for water supply availability analysis (see the OCWP *Physical Water Supply Availability Report*). Existing watershed boundaries were revised to include a United States Geological Survey (USGS) stream gage at or near the basin outlet (downstream boundary), where practical. To facilitate consideration of regional supply challenges and potential solutions, basins were aggregated into 13 distinct Watershed Planning Regions.

> The primary factors in the determination of reliable future water supplies are physical supplies, water rights, water quality, and infrastructure. Gaps and depletions occur when demand exceeds supply, and can be attributed to physical supply, water rights, infrastructure, or water quality constraints.

This Watershed Planning Region report, one of 13 such documents prepared for the *2012 OCWP Update*, presents elements of technical studies pertinent to the Central Region. Each regional report presents information from both a regional and multiple basin perspective, including water supply/demand analysis results, forecasted water supply shortages, potential supply solutions and alternatives, and supporting technical information.

> As a key foundation of OCWP technical work, a computer-based analysis tool, "Oklahoma H2O," was created to compare projected demands with physical supplies for each basin to identify areas of potential water shortages.

Integral to the development of these reports was the Oklahoma H2O tool, a sophisticated database and geographic information system (GIS) based analysis tool created to compare projected water demand to physical supplies in each of the 82 OCWP basins statewide. Recognizing that water planning is not a static process but rather a dynamic one, this versatile tool can be updated over time as new supply and demand data become available, and can be used to evaluate a variety of "what-if" scenarios at the basin level, such as a change in supply sources, demand, new reservoirs, and various other policy management scenarios.

Primary inputs to the model include demand projections for each decade through 2060, founded on widely-accepted methods and peer review of inputs and results by state and federal agency staff, industry representatives, and stakeholder groups for each demand sector. Surface water supply data for each of the 82 basins is based on 58 years of publicly-available daily streamflow gage data collected by the USGS. Groundwater resources were characterized using previously-developed assessments of groundwater aquifer storage and recharge rates.

Additional and supporting information gathered during development of the *2012 OCWP Update* is provided in the *OCWP Executive Report* and various OCWP supplemental reports. Assessments of statewide physical water availability and potential shortages are further documented in the OCWP *Physical Water Supply Availability Report*. Statewide water demand projection methods and results are detailed in the OCWP *Water Demand Forecast Report*. Permitting availability was evaluated based on the OWRB's administrative protocol and documented in the OCWP *Water Supply Permit Availability Report*. All supporting documentation can be found on the OWRB's website.

Regional Overview

The Central Watershed Planning Region includes nine basins (for reference, numbered 50, 51, 56-58, 60-62, and 64). The region is located in the Central Lowland physiography province, encompassing 10,142 square miles in central Oklahoma, spanning from southern Woods County to Hughes and Pontotoc Counties in the southeastern portion of the region and including all or portions of Alfalfa, Woodward, Garfield, Major, Kingfisher, Logan, Blaine, Dewey, Creek, Lincoln, Okmulgee, Canadian, Oklahoma, Okfuskee, Caddo, Seminole, Pottawatomie, Grady, Cleveland, McClain, and Garvin Counties.

The region displays many of the physical diversities of the state. The extremes range from the metropolitan areas of Oklahoma City in Oklahoma County to the more forested areas of the southeast, the open farmland in the central and western areas, and the sand hills in the far western portion of the region.

The region's climate is moist and sub-humid with the mean annual temperature ranging from 59° F to 62° F. Annual average precipitation ranges from 26 inches in the northwest to 46 inches in the southeastern corner. Annual lake evaporation ranges from 50 to 62 inches and exceeds precipitation. Frequent droughts cause severe crop damage while severe flooding also occurs as the result of concentrated areas of heavy precipitation. Thunderstorms accompanied by high winds, hail, and heavy rain increase the likelihood of flash flooding, emphasizing the necessity of watershed protection and flood prevention projects.

The largest cities in the region include Oklahoma City (2010 population of 579,999), Norman (110,925), Edmond (81,405), Midwest City (54,371), and Moore (55,081). The greatest demand is from Municipal and Industrial water use.

By 2060, this region is projected to have a total demand of 442,890 acre-feet per year (AFY), an increase of approximately 107,250 AFY (32%) from 2010.

Central Regional Summary

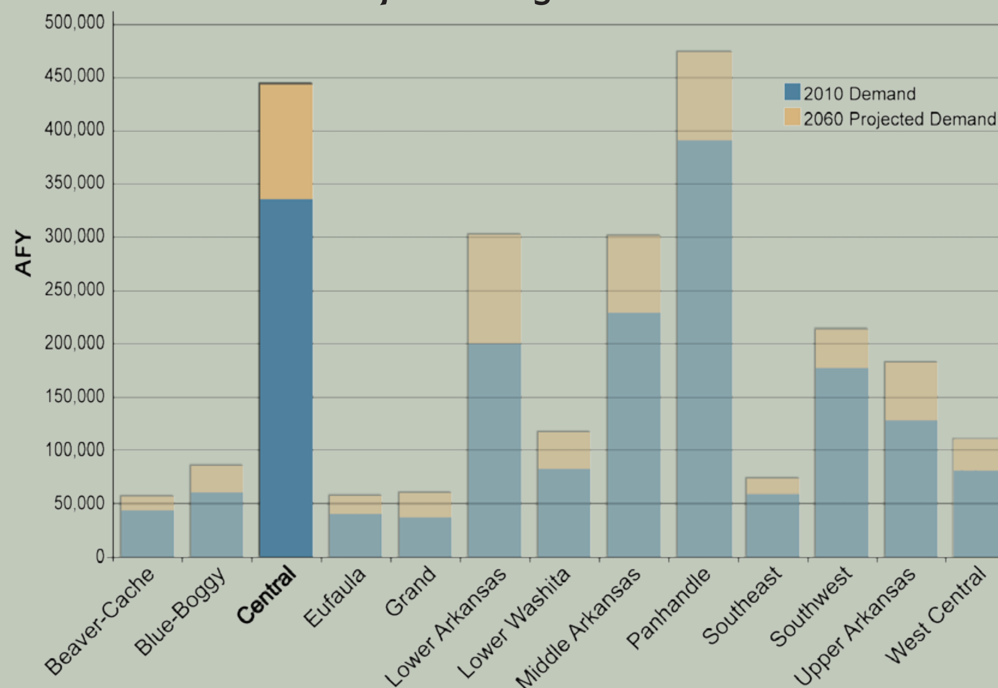
Synopsis

- The Central Watershed Planning Region relies on surface water supplies (including reservoirs), out-of-basin supplies, and alluvial and bedrock groundwater.
- It is anticipated that water users in the region will continue to rely on these sources to meet future demand.
- By 2020, surface water supplies may be insufficient at times to meet demand in all basins in the region, except Basins in 60 and 62.
- By 2020, alluvial and bedrock groundwater storage depletions may occur and eventually lead to higher pumping costs, the need for deeper wells, and potential changes to well yields or water quality.
- To reduce the risk of adverse impacts on water supplies, it is recommended that gaps and storage depletions be decreased where economically feasible.
- Additional conservation could reduce surface water gaps and groundwater storage depletions, eliminating bedrock groundwater depletions in Basin 50 and alluvial groundwater storage depletions in Basins 50 and 62.
- Aquifer storage (recharge) and recovery in Basins 50 and 51 could be considered to store variable surface water supplies, increase groundwater storage, and reduce adverse effects of localized storage depletions.
- Development of dependable groundwater sources, out-of-basin supplies, and/or new reservoirs could be used as alternatives to mitigate surface water gaps. These supply sources could be used without major impacts to groundwater storage.

Central Region Demand Summary

Current Water Demand:	335,640 acre-feet/year (18% of state total)
Largest Demand Sector:	Municipal & Industrial (62% of regional total)
Current Supply Sources:	56% SW 23% Alluvial GW 21% Bedrock GW
Projected Demand (2060):	442,890 acre-feet/year
Growth (2010-2060):	107,250 acre-feet/year (32%)

Current and Projected Regional Water Demand



The Central Region accounts for 18% of the state's total water demand. The largest demand sectors are Municipal and Industrial (62% of the region's overall 2010 demand), Crop Irrigation (17%), and Thermoelectric Power (11%).

Water Resources & Limitations

Surface Water

Surface water supplies, including reservoirs, are used to meet 56% of the Central Region's demand. Surface water supply shortages are expected by 2020 in all basins in the region, except Basins 60 and 62. Shortages are expected to have a moderate to high probability of occurring. The region is supplied by five major rivers: the Canadian, Cimarron, Little, Deep Fork, and North Canadian. Large reservoirs have been built on these rivers and their tributaries to provide public water supply, flood control, and recreation. There are two major federal reservoirs in the Central Region: Arcadia, built by the U.S. Army Corps of Engineers and Thunderbird, constructed by the Bureau of Reclamation. Large municipal water supply lakes in the region include Oklahoma City's three area lakes—Overholser, Stanley Draper, and Hefner—and Shawnee's Twin Lakes. There are 15 additional significant lakes in the region with normal storage ranging from 709 AF (El Reno Lake) to 23,000 AF (Lake Konawa). Surface water in Basins 50 and 51 is fully allocated, limiting diversions to existing permitted amounts. All other basins in the region are expected to have available surface water for new permits to meet local demand through 2060. Surface water quality in the region is variable and considered poor in several basins relative to other basins in the state. Multiple rivers, creeks, and reservoirs in the region are impaired for Public and Private Water Supply use and Agricultural use due to high levels of oil and grease, chloride, total dissolved solids (TDS), and chlorophyll-*a*.

Alluvial Groundwater

Alluvial groundwater is used to meet 23% of the demand in the region. The majority of currently permitted groundwater withdrawals in the region are from the Cimarron River, Canadian River, and North Canadian River alluvial aquifers. Each has more than 2.7 million AF of storage in the region. There are also substantial water rights in the Gerty Sand alluvial aquifer and multiple minor aquifers. If alluvial groundwater continues to supply a similar portion of demand in the future, storage depletions from these aquifers may occur throughout the year. The largest storage depletions are projected to occur in the summer. The availability of permits is not expected to constrain the use of alluvial groundwater supplies to meet local demand through 2060.

Bedrock Groundwater

Bedrock groundwater is used to meet 21% of the demand in the region. The majority of currently permitted bedrock groundwater withdrawals in the region are from the Garber-Wellington aquifer. This aquifer has more than 55.6 million AF of storage in the Central Region. There are also substantial water rights in multiple major and minor aquifers. Recharge to major aquifers is expected to be sufficient to meet some of the region's bedrock groundwater demand through 2060. Bedrock groundwater storage depletions may occur in Basins 50, 51, 57, and 64, typically by 2020. The availability of permits is not expected to constrain the use of bedrock groundwater supplies to meet local demand through 2060. However, an ongoing multi-year study of the Garber-Wellington may result in a change to the 2 AFY/acre share currently allowed under temporary permits.

Water Supply Limitations

Surface water limitations were based on physical availability, water supply availability for new permits, and water quality. Groundwater limitations were based on the total size and rate of storage depletions in major aquifers. Groundwater permits are not expected to constrain the use of groundwater through 2060, and insufficient statewide groundwater quality data are available to compare basins based on groundwater quality. Basins with the most significant water supply challenges statewide are indicated by a red box. The remaining basins with surface water gaps or groundwater storage depletions were considered to have potential limitations (yellow). Basins without gaps and storage depletions were considered to have minimal limitations (green). Detailed explanations of each basin's supplies are provided in individual basin summaries and supporting data and analysis.

Water Supply Limitations
Central Region

Water Supply Options

To quantify physical surface water gaps and groundwater storage depletions through 2060, use of existing out-of-basin and local supplies was assumed to continue in current (2010) proportions. Surface water supplies, reservoirs, out-of-basin supplies, and groundwater supplies are expected to continue to supply the majority of demand in the Central Region. Surface water users may have physical surface water supply shortages (gaps) in the future in all basins except in Basins 60 and 62. Alluvial groundwater storage depletions of major and minor aquifers are also projected in the future and may occur in most basins in the region by 2020. Bedrock groundwater storage depletions may occur in Basins 50, 51, 57, and 64. The development of additional alluvial and bedrock groundwater supplies could be an effective long-term water supply option, except in portions of the North Canadian River alluvial aquifer.

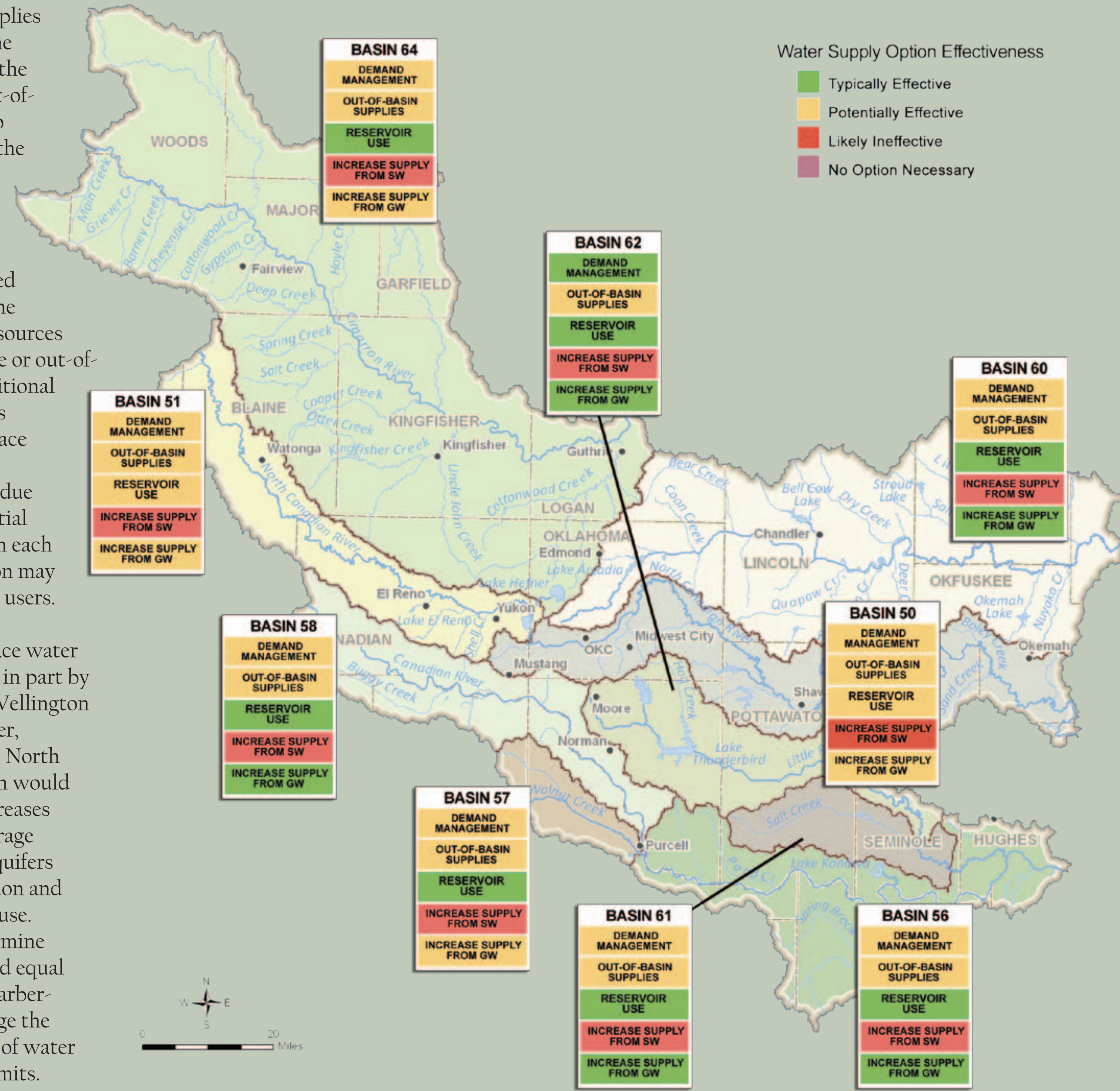
Water conservation could aid in reducing projected gaps and groundwater storage depletions or delaying the need for additional infrastructure. Moderately expanded conservation activities could reduce gaps and storage depletions throughout the region, and could eliminate bedrock groundwater storage depletions in Basin 50 and alluvial groundwater storage depletions in Basin 62. Future reductions could occur from substantially expanded conservation activities. These measures would require a shift from crops with high water demand (e.g., corn for grain and forage crops) to low water demand crops (e.g., sorghum for grain or wheat for grain) along with increased efficiency and increased public water supplier conservation. In basins with lower frequencies of shortages, temporary drought management measures may be an effective water supply option.

New reservoirs and expanded use of existing reservoirs could enhance the dependability of surface water supplies and reduce gaps in some basins in the region. Several small municipal reservoirs may have unpermitted yield available for new users; however, these supplies are small compared to the demand in the region.

Oklahoma City currently receives substantial supplies from the Blue-Boggy Watershed Planning Region via the Atoka pipeline. The City of Ada also receives out-of-basin supplies from Byrds Mill Spring and the Arbuckle-Simpson aquifer in the Blue-Boggy Region. These out-of-basin supplies are expected to continue to provide water to the region in the future. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified 16 potentially viable sites in the Central Region. These water sources could serve as in-basin storage or out-of-basin supplies to provide additional supplies to reduce the region's and surrounding regions' surface water gaps and groundwater storage depletions. However, due to the distance of these potential reservoirs to demand points in each basin, this water supply option may not be cost-effective for many users.

The projected growth in surface water use could instead be supplied in part by increased use of the Garber-Wellington aquifer, Canadian River aquifer, Cimarron River aquifer or the North Canadian River aquifer, which would result in small or minimal increases in projected groundwater storage depletions. However, these aquifers do not underlie the entire region and water quality may limit their use. Also, ongoing studies to determine the maximum annual yield and equal proportionate share for the Garber-Wellington aquifer may change the current amount (2 AFY/acre) of water allowed under temporary permits.

Water Supply Option Effectiveness
Central Region



This evaluation was based upon results of physical water supply availability analysis, existing infrastructure, and other basin-specific factors.

Water Supply

Physical Water Availability

Surface Water Resources

Surface water supply has historically been used to meet just over half of the demand in the Central Region. The region's major rivers include the Canadian, Cimarron, and North Canadian. Many streams in this region experience a wide range of flows, including both periodic no flow conditions and flooding events.

The North Canadian River (320 miles long in the Central Region) flows from the Panhandle Region through Basins 50 and 51 in the Central Region. Total dissolved solids (TDS) and chloride levels are relatively high and Oklahoma City wastewater return flows constitute a large percentage of the North Canadian River's total flow.

The Deep Fork River, a major tributary to the North Canadian River, originates in the Central Region and is 140 miles long in Basin 60. The river is generally of fair quality with moderate mineral content. However, the chloride content may reach high levels during certain periods of the year.

As important sources of surface water in Oklahoma, reservoirs and lakes help provide dependable water supply storage, especially when streams and rivers experience periods of low seasonal flow or drought.

The Canadian River (190 miles long in the Central Region) enters the Central Region from the West Central Region. Major tributaries in the region include Walnut Creek (25 miles long), The Little River (110 miles long), which originates near the western border of Basin 62, exiting at the eastern border and bisecting a small portion of Basin 61, then entering Basin 56 to its confluence with the Canadian River. Salt Creek (70 miles long), originating primarily in basin 61, is a major tributary to the Little River. The Canadian River and its tributaries are located in Basins 56, 57, 58, 61, and 62. The river typically experiences high levels of chloride and total dissolved solids.

The mainstem of the Cimarron River runs for 150 miles through Basin 64. Major tributaries include Turkey Creek (70 miles long) and Cottonwood

Reservoirs
Central Region

Reservoir Name	Primary Basin Number	Reservoir Owner/ Operator	Year Built	Purpose[1]	Normal Pool Storage	Water Supply		Irrigation		Water Quality		Permitted Withdrawals	Remaining Water Supply Yield to be Permitted
						Storage	Yield	Storage	Yield	Storage	Yield		
					AF	AF	AFY	AF	AFY	AF	AFY	AFY	AFY
Arcadia	60	USACE	1986	FC, WS, R	29,544	23,090	12,320	---	---	---	---	12,500	0
Bell Cow	60	City of Chandler	1990	FC, WS, R	15,613	---	4,558	---	---	---	---	4,144	414
Chandler	60	City of Chandler	1954	WS, R	2,778	2,778	---	0	0	0	0	882	---
El Reno	51	City of El Reno	1966	FC, R	709	---	---	0	0	0	0	---	---
Guthrie	64	City of Guthrie	1919	WS, R	3,875	---	---	---	---	---	---	771	---
Hefner[2]	64	City of Oklahoma City	1947	WS, R	68,868	75,000	---	0	0	0	0	0	---
Holdenville	56	City of Holdenville	1931	WS, R	11,000	11,000	---	0	0	0	0	3,150	---
Konawa	56	OG&E	1968	CW	23,000	---	---	0	0	0	0	8,000	---
Liberty	64	City of Guthrie	1948	WS, R	2,740	---	---	0	0	0	0	893	---
Meeker	60	City of Meeker	1970	WS, FC, R	1,976	---	202	0	0	0	0	407	0
Okemah	60	City of Okemah	N/A	WS, R	10,392	10,392	2,200	---	---	---	---	1,779	421
Overholser[3]	51	City of Oklahoma City	1919	WS, R	13,913	17,000	5,000	0	0	0	0	80,000	0
Prague City	60	City of Prague	1984	WS, FC, R	2,415	---	549	0	0	0	0	549	0
Purcell	57	City of Purcell	1930	WS, R	2,600	---	---	---	---	---	---	---	---
Shawnee Twin Lakes	50	City of Shawnee	1935/1960	WS, R	34,000	34,000	4,400	---	---	---	---	8,000	0
Stanley Draper[4]	62	City of Oklahoma City	1962	WS, R	87,296	100,000	---	0	0	0	0	0	---
Stroud	60	City of Stroud	1968	WS, FC, R	8,800	---	1,299	---	---	---	---	1,100	199
Tecumseh	50	City of Tecumseh	1934	WS, R	1,118	---	---	0	0	0	0	418	---
Thunderbird	62	Bureau of Rec./COMCD	1965	FC, WS, R, FW	105,644	105,900	21,700[5]	0	0	0	0	21,600	100
Wes Watkins	50	Pottawatomie Co. Dev. Auth.	1997	FC, WS, R	14,065	---	---	0	0	0	0	5,000	---
Wetumka	50	City of Wetumka	1939	WS, R	1,839	---	---	---	---	---	---	750	---

No known information is annotated as "---"

1 The "Purposes" represent the use(s), as authorized by the funding entity or dam owner(s), for the reservoir storage when constructed.

WS=Water Supply, R=Recreation, HP=Hydroelectric Power, IR=Irrigation, WQ=Water Quality, FW=Fish & Wildlife, FC=Flood Control, LF=Low Flow Regulation, N=Navigation, C=Conservation, CW=Cooling Water

2 Terminal storage for Oklahoma City; receives water from the North Canadian River.

3 Permitted withdrawals include allocations from the North Canadian watershed and Canton Lake.

4 Terminal storage for Oklahoma City; receives water from the Blue-Boggy Region via the Atoka pipeline.

5 Baseline yield is 15,600 AFY; the 21,700 AFY yield reflects conjunctive use of supplemental water from groundwater resources during periods of drought.

Creek (60 miles long). Water quality is degraded by naturally occurring salt sources in the upper reaches near the Harper/Woods County line.

In the Central Region, streamflow is generally intermittent. Existing reservoirs in the region increase the dependability of surface water supply for many public water systems and other users. Some reservoirs provide terminal storage for out-of-basin supplies. There are two major federal reservoirs in the region. Lake Arcadia in Basin 60 was completed in 1986 on the Deep Fork River by the U.S. Army Corps of Engineers for water supply, recreation, and fish and wildlife purposes. The lake provides 12,320 AFY of dependable yield, which is allocated to the City of Edmond. Lake Thunderbird in Basin 62 was built in 1965 on the Little River by the U.S. Bureau of Reclamation. Project purposes include flood control, water supply, recreation, and fish and wildlife. Most of Thunderbird's water supply yield is allocated to the Central Oklahoma Master Conservancy District, which supplies municipal and industrial water to its member cities (Norman, Midwest City and Del City).

There are six major municipal lakes in the Central Region. Three were constructed by the City of Oklahoma City, one by the City of Shawnee, and the other two by the NRCS, one of which is operated by the Pottawatomie County Development Authority and the other by the City of Chandler. Lake Stanley Draper, in Basin 62, was constructed in 1962 by Oklahoma City and is located on East Elm Creek. The impoundment is used primary as terminal storage for water conveyed from Atoka Lake and McGee Creek in the Blue-Boggy Watershed Planning Region via the 90 mgd Atoka Pipeline. While Lake Stanley Draper has little dependable yield of its own, it can provide a dependable yield of about 86,000 AFY comprised of deliveries from Atoka and McGee Creek minus losses.

Oklahoma City's other two lakes in the Central Region, Lake Overholser in Basin 51 and Lake Hefner in Basin 64, are operated to utilize the City's water right allocations from Canton Lake in the Panhandle Watershed Planning Region and the North Canadian River. Lake Overholser was built in 1919 on the North Canadian River for the purposes of water supply and recreation. The lake has a dependable yield of 5,000 AFY, which is supplemented by releases from Canton Lake via the North Canadian River. Lake Hefner was constructed on Bluff Creek in 1943 by Oklahoma City for the purposes of offstream water supply storage and recreation. The lake serves as terminal storage for diversions from the North Canadian River and releases from Canton Lake via a canal that diverts water from the river near Lake Overholser. The system provides a dependable yield of 80,000 AFY to Oklahoma City and is fully allocated.

Shawnee Twin Lakes were constructed by the City of Shawnee on South Deer Creek in Basin 50. These two lakes, one constructed in 1935 and one in 1960, are connected by a canal and have a combined yield of 4,400 AFY that is fully allocated to the City of Shawnee. Wes Watkins Reservoir, also in Basin 50, was constructed in 1997 by the NRCS for the purposes of flood control, water supply and recreation. The lake is operated by the Pottawatomie County Development Authority. Bell Cow Lake is located in Basin 60 and was also constructed by the NRCS for the purposes of flood control, water supply and recreation. Built in 1990, the lake is operated by the City of Chandler and provides a dependable yield of 4,558 AFY, most of which is allocated to Chandler.

Some of the other significant lakes in the region include: Lake Wetumka and Tecumseh Lake in Basin 50; El Reno Lake in Basin 51; Konawa and Holdenville Lakes in Basin 56; Purcell Lake in Basin 57; Meeker, Prague City, Stroud, Chandler, and Okemah Lakes in Basin 60; and Guthrie and Liberty Lakes in Basin 64.

There are many other small Natural Resources Conservation Service (NRCS), municipal and privately owned lakes in the region that provide water for public water supply, agricultural water supply, watershed protection, flood control and recreation.

Major reservoirs in the Central Region include Arcadia, Thunderbird, Overholser, Hefner, Shawnee Twin Lakes, Wes Watkins, Stanley Draper, and Bell Cow. These lakes may serve multiple purposes, such as water supply, irrigation, recreation, hydropower generation, and flood control. Reservoirs designed for multiple purposes typically possess a specific volume of water storage assigned for each purpose.

Water Supply Availability Analysis

For OCWP physical water supply availability analysis, water supplies were divided into three categories: surface water, alluvial aquifers, and bedrock aquifers. Physically available surface water refers to water currently in streams, rivers, lakes, and reservoirs.

The range of historical surface water availability, including droughts, is well-represented in the Oklahoma H2O tool by 58 years of monthly streamflow data (1950 to 2007) recorded by the U.S. Geological Survey (USGS). Therefore, measured streamflow, which reflects current natural and human created conditions (runoff, diversions and use of water, and impoundments and reservoirs), is used to represent the physical water that may be available to meet projected demand.

The estimated average and minimum annual streamflow in 2060 were determined based on historic surface water flow measurements and projected baseline 2060 demand (see Water Demand section). The amount of streamflow in 2060 may vary from basin-level values, due to local variations in demands and local availability of supply sources. The estimated surface water supplies include changes in historical streamflow due to increased upstream demand, return flows, and increases in out-of-basin supplies from existing infrastructure. Permitting, water quality, infrastructure, non-consumptive demand, and potential climate change implications are considered in separate OCWP analyses. Past reservoir operations are reflected and accounted for in the measured historical streamflow downstream of a reservoir. For this analysis, streamflow was adjusted to reflect interstate compact provisions in accordance with existing administrative protocol.

The amount of water a reservoir can provide from storage is referred to as its yield. The yield is considered the maximum amount of water a reservoir can dependably supply during critical drought periods. The unused yield of existing reservoirs was considered for this analysis. Future potential reservoir storage was considered as a water supply option.

Groundwater supplies are quantified by the amount of water that an aquifer holds ("stored" water) and the rate of aquifer recharge. In Oklahoma, recharge to aquifers is generally from precipitation that falls on the aquifer and percolates to the water table. In some cases, where the altitude of the water table is below the altitude of the stream-water surface, surface water can seep into the aquifer.

For this analysis, alluvial aquifers are defined as aquifers comprised of river alluvium and terrace deposits, occurring along rivers and streams and consisting of unconsolidated deposits of sand, silt, and clay. Alluvial aquifers are generally thinner (less than 200 feet thick) than bedrock aquifers, feature shallow water tables, and are exposed at the land surface, where precipitation can readily percolate to the water table. Alluvial aquifers are considered to be more hydrologically connected with streams than are bedrock aquifers and are therefore treated separately.

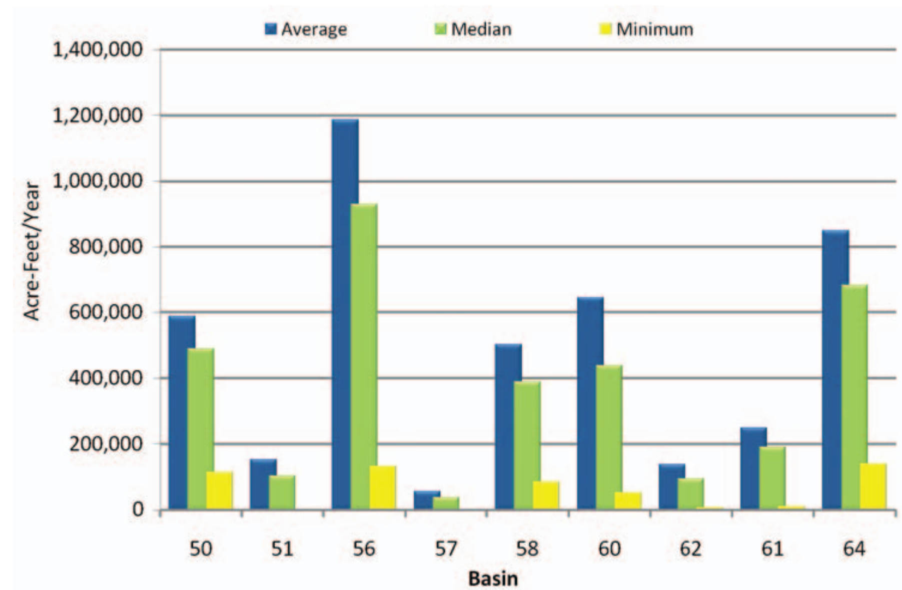
Bedrock aquifers consist of consolidated (solid) or partially consolidated rocks, such as sandstone, limestone, dolomite, and gypsum. Most bedrock aquifers in Oklahoma are exposed at land surface either entirely or in part. Recharge from precipitation is limited in areas where bedrock aquifers are not exposed.

For both alluvial and bedrock aquifers, this analysis was used to predict potential groundwater depletions based on the difference between the groundwater demand and recharge rate. While potential storage depletions do not affect the permit availability of water, it is important to understand the extent of these depletions.

More information is available in the OCWP *Physical Water Supply Availability Report* on the OWRB website.

Surface Water Flows (1950-2007)

Central Region



Surface water sources supply about half of the demand in the Central Region. Surface water gaps can occur due to seasonal, long-term hydrologic (drought), or localized variability in surface water flows. Several large reservoirs have been constructed to reduce the impacts of drier periods on surface water users.

Estimated Annual Streamflow in 2060

Central Region

Streamflow Statistic	Basins								
	50	51	56	57	58	60	62	61	64
	AFY								
Average Annual Flow	541,500	123,000	1,082,900	55,700	420,200	631,000	127,900	239,500	796,400
Minimum Annual Flow	55,800	0	87,200	0	62,900	36,100	0	3,200	86,100

Annual streamflow in 2060 was estimated using historical gaged flow and projections of increased surface water use from 2010 to 2060.

Groundwater Resources

Three major bedrock aquifers underlie the Central Watershed Planning Region: Rush Springs, Garber-Wellington, and Vamoosa-Ada. Five major alluvial aquifers underlie the region: Canadian River, Cimarron River, Enid Isolated Terrace, Gerty Sand, and North Canadian River.

Withdrawing groundwater in quantities exceeding the amount of recharge to the aquifer may result in aquifer depletion and reduced storage. Therefore, both storage and recharge were considered in determining groundwater availability.

The Garber-Wellington aquifer underlies portions of Basins 50, 51, 56, 58, 60, 61, 62, and 64. The formation consists of fine-grained sandstone interbedded with siltstone and shale. Depth to water varies from less than 100 feet to 250 feet; saturated thickness ranges from 150 to 650 feet. Wells generally yield from 200 to 400 gpm. Water quality is generally good but in some areas concentrations of nitrate, arsenic, chromium, and selenium may exceed drinking water standards.

The Vamoosa-Ada aquifer underlies portions of Basins 50, 56, 60, 61, and 62. The formation consists of 125 to 1,000 feet of interbedded sandstone, shale, and conglomerate. Wells commonly yield 25 to 150 gpm. Water quality is generally good and suitable for use as public supply, although iron infiltration and hardness are problems in some areas and there are local problems due to contamination resulting from past oil and gas activities.

The Rush Springs aquifer underlies a portion of Basin 58. The formation consists of a fine-grained sandstone aquifer with some shale, dolomite, and gypsum. Thickness of the aquifer ranges from 200 to 300 feet. Wells commonly yield 25 to 400 gpm. The water tends to be very hard, requiring water softening to address aesthetic issues for public water supply use. In some areas nitrate and sulfate concentrations exceed drinking water standards, limiting its use for drinking water.

Areas without delineated aquifers may have groundwater present. However, specific quantities, yields, and water quality in these areas are currently unknown.

The North Canadian River alluvial aquifer underlies portions of Basins 50, 51, and 64.The formation consists of fine- to coarse-grained sand with minor clay and silt and local lenses of basal gravel overlain by dune sand. Formation thickness averages 30 feet in the alluvium with a maximum of 300 feet in the terrace deposits. Yields range between 300 and 600 gpm in the alluvium and 100 to 300 gpm in the terrace formations. The water is a very hard calcium bicarbonate type with TDS concentrations of up to 1,000 mg/L.

The Cimarron River alluvial aquifer underlies a portion of Basin 64. The formation tends to consist of silt and clay deposits changing downward to sandy clay, sand, and fine gravel. Maximum thickness reaches 80 feet with well yields ranging between 100 and 200 gpm in the alluvium and 100 and 500 gpm in the terrace deposits. The terrace deposits are overlain by sand dunes. The water is very hard and is classified as calcium magnesium bicarbonate type. Extensive pumping can make this formation susceptible to salt water intrusion.

The Canadian River alluvial aquifer underlies portions of Basins 51, 56, 57, 58, 61, and 62. The formation consists of clay and silt downgrading to fine- to coarse-grained sand with lenses of basal gravel. Formation thickness ranges from 20 to 40 feet in the alluvium with a maximum of 50 feet in the terrace deposits. Yields in the alluvium range between 100 and 400 gpm and between 50 and 100 gpm in the terrace. Although the water is a very hard calcium bicarbonate type with TDS concentrations of approximately 1,000 mg/L, it is generally suitable for most municipal and industrial uses.

Permits to withdraw groundwater from aquifers (groundwater basins) where the maximum annual yield has not been set are "temporary" permits that allocate 2 AFY/acre. The temporary permit allocation is not based on storage, discharge or recharge amounts, but on a legislative (statute) estimate of maximum needs of most landowners to ensure sufficient availability of groundwater in advance of completed and approved aquifer studies. As a result, the estimated amount of Groundwater Available for New Permits may exceed the estimated aquifer storage amount. For aquifers (groundwater basins) where the maximum annual yield has been determined (with initial storage volumes estimated), updated estimates of amounts in storage were calculated based on actual reported use of groundwater instead of simulated usage from all lands.

Groundwater Resources
Central Region

Aquifer			Portion of Region Overlaying Aquifer	Recharge Rate	Current Groundwater Rights	Aquifer Storage in Region	Equal Proportionate Share	Groundwater Available for New Permits
Name	Type	Class[1]	Percent	Inch/Yr	AFY	AF	AFY/Acre	AFY
Canadian River	Alluvial	Major	9%	2.0	71,500	2,706,000	temporary 2.0	1,117,400
Cimarron River	Alluvial	Major	11%	2.3	152,500	3,425,000	temporary 2.0	1,257,200
Enid Isolated Terrace	Alluvial	Major	<1%	2.3	1,300	33,000	0.5	2,600
Garber-Wellington	Bedrock	Major	27%	1.6	212,900	55,618,000	temporary 2.0	3,096,200
Gerty Sand	Alluvial	Major	1%	1.0	12,100	161,000	0.65	34,000
North Canadian River	Alluvial	Major	6%	1.0-5.0	79,800	3,295,000	0.8-1.3	312,200
Rush Springs	Bedrock	Major	1%	1.8	5,500	942,000	temporary 2.0	92,200
Vamoosa-Ada	Bedrock	Major	9%	1.4	6,800	8,015,000	2.0	1,203,400
East-Central Oklahoma	Bedrock	Minor	7%	2.8	4,100	6,771,000	temporary 2.0	864,900
El Reno	Bedrock	Minor	35%	0.75	31,300	11,649,000	temporary 2.0	4,457,200
Fairview Isolated Terrace	Alluvial	Minor	<1%	0.75	700	78,000	temporary 2.0	50,800
Isabella Isolated Terrace	Alluvial	Minor	<1%	0.75	700	26,000	temporary 2.0	11,800
Loyal Isolated Terrace	Alluvial	Minor	<1%	0.75	1,000	63,000	temporary 2.0	24,500
North-Central Oklahoma	Bedrock	Minor	1%	1.0	1,200	688,000	temporary 2.0	176,600
Non-Delineated Groundwater Source	Alluvial	Minor			4,400			
Non-Delineated Groundwater Source	Bedrock	Minor			7,600			

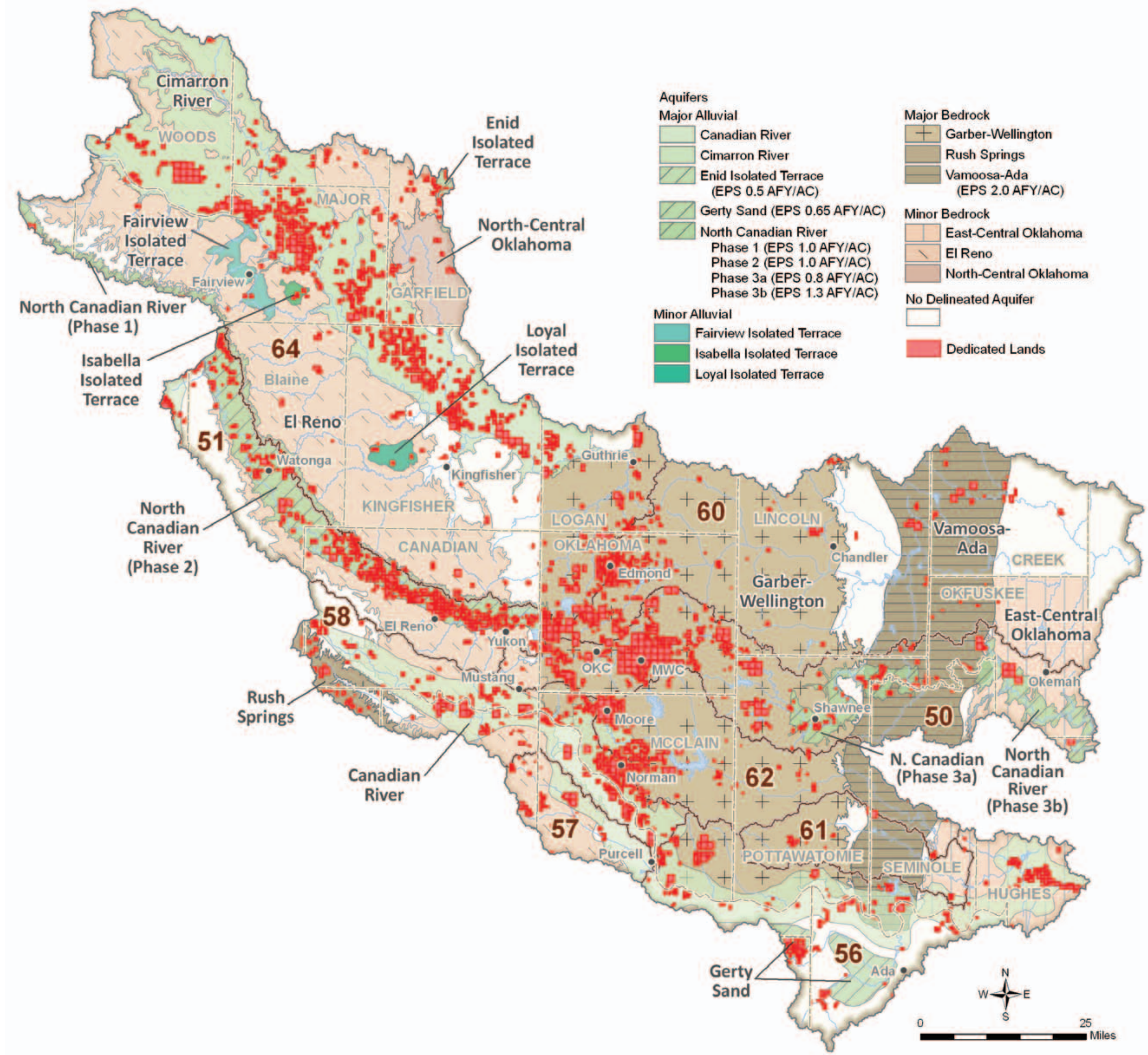
1 Bedrock aquifers with typical yields greater than 50 gpm and alluvial aquifers with typical yields greater than 150 gpm are considered major.

The Gerty Sand alluvial aquifer underlies a portion of Basin 56. The formation consists of gravel, sand, silt, clay, and volcanic ash. The saturated thickness varies from 5 to 75 feet, averaging 28 feet. Depth to water ranges from 10 to 110 feet. Typical well yields vary from 100 to 450 gpm with some wells yielding as much as 850 gpm. Water quality is fair to good and moderately hard with TDS values usually less than 1,000 mg/L.

The Enid Isolated Terrace alluvial aquifer underlies a small portion of Basin 64. The formation is composed of terrace deposits that consist of discontinuous layers of clay, sandy clay, sand, and gravel.

Minor bedrock aquifers in the region include the East-Central Oklahoma, El Reno, and North-Central Oklahoma aquifers. Minor alluvial aquifers include the Fairview Isolated Terrace, Isabella Isolated Terrace, and Loyal Isolated Terrace. Minor aquifers may have a significant amount of water in storage and high recharge rates, but generally low yields of less than 50 gpm per well. Groundwater from minor aquifers is an important source for domestic and stock water use for individuals in outlying areas not served by rural water systems, but yields might be insufficient for high volume users.

Groundwater Resources
Central Region



Permit Availability

For the OCWP water availability analysis, "permit availability" pertains to the amount of water that could be made available for withdrawals under permits issued in accordance with Oklahoma water law.

If water authorized by a stream water right is not put to beneficial use within the specified time, the OWRB may reduce or cancel the unused amount and return the water to the public domain for appropriation to others.

Projections indicate that there will be no surface water available for new permits in Basins 50 and 51, but surface water will be available for new permits through 2060 in all other basins in the Central Region. For groundwater, equal proportionate shares in the Central Region range from 0.5 acre-feet per year (AFY) per acre to 2 AFY per acre.

Surface Water Permit Availability

Oklahoma stream water laws are based on riparian and prior appropriation doctrines. Riparian rights to a reasonable use of water, in addition to domestic use, are not subject to permitting or oversight by the OWRB. An appropriative right to stream water is based on the prior appropriation doctrine, which is often described as "first in time, first in right." If a water shortage occurs, the diverter with the older appropriative water right will have first right among other appropriative right holders to divert the available water up to the authorized amount.

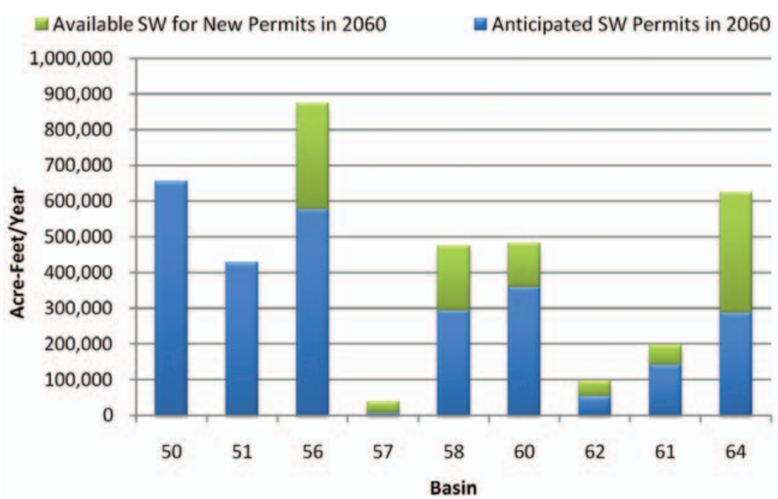
To determine surface water permit availability in each OCWP planning basin in 2060, the analysis utilized OWRB protocol to estimate the average annual streamflow at the basin's outlet point, accounting for both existing and anticipated water uses upstream and downstream, including legal obligations, such as those associated with domestic use and interstate compact requirements.

Groundwater Permit Availability

Groundwater available for permits in Oklahoma is generally based on the amount of land owned or leased that overlies a specific aquifer. For unstudied aquifers, temporary permits are granted allocating 2 AFY/acre. For studied aquifers, an "equal proportionate share" (EPS) is established based on the maximum annual yield of water in the aquifer, which is then allocated to each acre of land overlying the groundwater basin. Once an EPS has been established, temporary permits are then converted to regular permits and all new permits are based on the EPS.

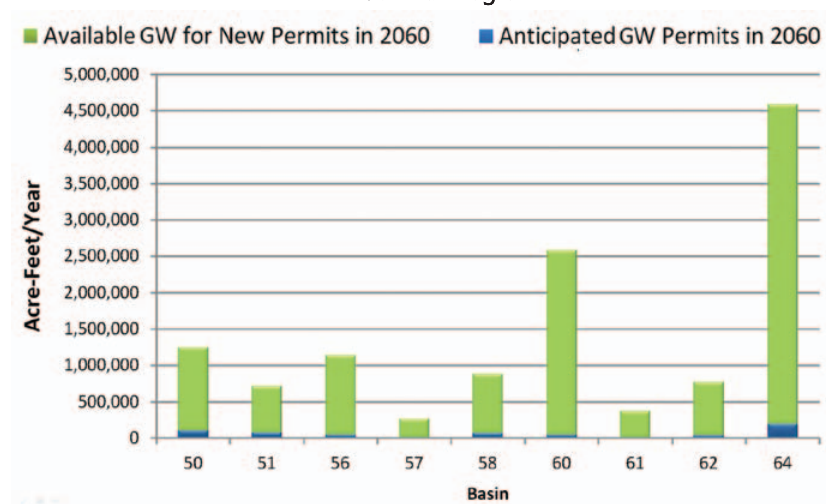
For OCWP analysis, the geographical area overlying all aquifers in each basin was determined and the respective EPS or temporary permit allocations were applied. Total current and anticipated future permit needs were then calculated to project remaining groundwater permit availability.

Surface Water Permit Availability
Central Region



There is no surface water available for new permits in Basins 50 and 51, but projections indicate that there will be surface water available for new permits through 2060 in all other basins in the Central Region.

Groundwater Permit Availability
Central Region



Projections indicate that the use of groundwater to meet in-basin demand is not expected to be limited by the availability of permits through 2060 in the Central Region.

Water Quality

Water quality of the Central Watershed Planning Region is defined by numerous minor and major water supply reservoirs and the middle Cimarron and lower Canadian River watersheds. The area is co-dominated by two ecoregions, the Central Great Plains (CGP) to the west and the Cross Timbers (CT) to the east. Several additional ecoregions intersect the periphery of the planning region, but their impact is minimal and they will not be addressed in this discussion.

The western half of the planning region is characterized to a great extent by the Prairie Tablelands as well as several other intervening CGP ecoregions—the Pleistocene Sand Dunes/Sandsage Grassland, and Gypsum Hills. The Cimarron and North Canadian Rivers drain the area from northwest to southeast, and the Canadian River intersects the area in the south. The Prairie Tablelands are nearly level, underlain by shale, sandstone, and siltstone. They are dominated by cropland with dense mixed grass prairies. Streams are typically turbid and silt-dominated with some sand, lying in broad, shallow, low gradient channels with highly incised banks. The tributaries of the major rivers best exemplify water quality in the tablelands. These include Buggy Creek along the Canadian, and from west to east on the Cimarron, Eagle Chief, Turkey, Kingfisher, and Cottonwood Creeks. Salinity is high throughout the watersheds. Mean conductivities range from 1,029 µS/cm on Cottonwood Creek to near 2,300 µS/cm on Kingfisher Creek, while Buggy Creek is 1,100 µS/cm. Nutrient concentrations are also high. Mean concentrations of total phosphorus (TP) and total nitrogen (TN) range from 0.18 and 2.05 ppm on Kingfisher Creek to 0.98 and 4.08 ppm on Cottonwood Creek. Buggy Creek is similar with mean TP and TN of 0.38 and 2.0 ppm. Water clarity is poor to very poor, with mean turbidity ranging from 65 NTU on Eagle Chief Creek to 184 NTU on Cottonwood Creek; Buggy Creek is 160 NTU. Ecological diversity is average and highly impacted by siltation/sedimentation, habitat degradation, and channelization.

Conversely, the Pleistocene Sand Dunes have more permeable sandy soils interlaced with springs and inter-dune wetlands. Streams have incised, highly erodible banks but are typically sandy. The northern and eastern banks of the major river systems are influenced heavily by the features and are typically sandier than many of their tributaries. The Cimarron and North Canadian best exemplify the area, as well as El Reno Lake in the North Canadian watershed. Salinity on the Cimarron is very high and steadily decreases from west to east. Near Waynoka, mean conductivity is nearly 29,000 µS/cm, but at Guthrie, it decreases to 8,730 µS/cm. Salinity on the North Canadian (including El Reno Lake) and Canadian is much lower with mean conductivities of 1,350-1,400 µS/cm. Nutrient concentrations increase steadily along the Cimarron. Near Waynoka, the river is mesotrophic, with low TP and TN mean concentrations of 0.05 and 0.69 ppm. The river gradually becomes eutrophic to hyper-eutrophic; at Guthrie, TP and TN increase to 0.36 and 1.95 ppm. The North Canadian and Canadian are also hyper-eutrophic, with TP ranging from 0.20-0.22 ppm and TN from 0.99-1.24 ppm. El Reno Lake is hyper-eutrophic and nitrogen-limited. Water clarity is excellent to average on the Cimarron with mean turbidity values of 6 NTU near Waynoka and 33 NTU near Guthrie. The North Canadian has good clarity (18

Lake Trophic Status

A lake's trophic state, essentially a measure of its biological productivity, is a major determinant of water quality.

Oligotrophic: Low primary productivity and/or low nutrient levels.

Mesotrophic: Moderate primary productivity with moderate nutrient levels.

Eutrophic: High primary productivity and nutrient rich.

Hypereutrophic: Excessive primary productivity and excessive nutrients.

Ecoregions
Central Region

The Central Planning Region is a transitional area between the Central Great Plains and Cross Timbers. Water quality is highly influenced by both geology and land use practices, and is generally poor to good depending on drainage and location.

NTU) while the Canadian is average (40 NTU). El Reno Lake has poor clarity. Ecological diversity is good in the Canadian watersheds but can be impacted by habitat degradation, channelization, and sedimentation. Conversely, diversity in the Cimarron is low and is naturally impacted by higher than normal salinity and also by flow modification and sedimentation.

The Gypsum Hills are characterized by breaks, escarpments, gorges, ledges, caves, and canyons. Geological features were formed by the differential erosion of underlying gypsum, shale, dolomite, fine sand, and rock salt. The features create flora and fauna that are unique within the CGP. The area is covered by mixed grass prairie and intermittent tree groves. Streams are typically bedrock/gravel/cobble, with habitat that is typically more diverse than surrounding areas. Griever Creek has relatively high salinity (mean conductivity = 2,870 µS/cm), and poor water clarity (58 NTU). However, nutrient concentrations are low with mean TP of 0.11 and TN of 0.70 ppm.

The Northern Cross Timbers extend from roughly the center of the Oklahoma City metropolitan area south to Purcell and east through the remainder of the region. The Northern Timbers are densely forested and covered by a variety of flora including oak savanna, scrub oak forest, eastern red cedar, and intervening grasslands. Land use is mixed with rangeland, cropland, urban, and intense oil/natural gas production, which has led to higher than normal salinity in some watersheds. Streams are typically contained in shallow, sandy channels and are normally moderately to heavily incised. However, deep pools, riffles, and rocky substrates exist in various parts of the area. Ecological diversity is mixed and can be affected by habitat degradation, flow modification, channelization, and sedimentation/siltation. The area is best exemplified by the lower North Canadian and Canadian River watersheds, including the Deep Fork River and Little River, as well as numerous municipal and regional water supply lakes including Arcadia, Bell Cow, Chandler, Holdenville, Konawa, Meeker, Okemah, Prague

Water Quality Standards Implementation
Central Region

BUMP monitoring sites and streams with TMDL studies completed or underway. The Oklahoma Conservation Commission has begun a watershed implementation project on Lake Thunderbird to address non-point source runoff through low-impact development. The Oklahoma Department of Environmental Quality has completed TMDL studies on North Canadian River, Turkey Creek, and Little Turkey Creek. Several other TMDL studies are underway or scheduled.

Water Quality Standards and Implementation

The Oklahoma Water Quality Standards (OWQS) are the cornerstone of the state's water quality management programs. They are a set of rules promulgated under the federal Clean Water Act and state statutes to maintain and protect the quality of state waters. The OWQS designate beneficial uses for streams, lakes and other bodies of surface water, and for groundwater that has a mean concentration of Total Dissolved Solids of 10,000 milligrams per liter or less. Beneficial uses are the activities for which a waterbody can be used based on physical, chemical, and biological characteristics as well as geographic setting, scenic quality, and economic considerations. Beneficial uses include such categories as Fish and Wildlife Propagation, Public and Private Water Supply, Primary (or Secondary) Body Contact Recreation, Agriculture, and Aesthetics. The OWQS also contain standards for maintaining and protecting these uses. The purpose of the OWQS is to promote and protect as many beneficial uses as are attainable and to assure that degradation of existing quality of waters of the state does not occur.

The OWQS are applicable to all activities which may affect the water quality of waters of the state, and are to be utilized by all state environmental agencies in implementing their programs to protect water quality. Some examples of these implementation programs are: permits for point source (e.g. municipal and industrial) discharges into waters of the state; authorizations for waste disposal from concentrated animal feeding operations; regulation of runoff from nonpoint sources; and corrective actions to clean up polluted waters.

More information about OWQS and the latest revisions can be found on the OWRB website.

Water Quality Impairments

A waterbody is considered to be impaired when its quality does not meet the standards prescribed for its beneficial uses. For example, impairment of the Public and Private Water Supply beneficial use means the use of the waterbody as a drinking water supply is hindered. Impairment of the Agricultural use means the use of the waterbody for livestock watering, irrigation or other agricultural uses is hindered. Impairments can exist for other uses such as Fish and Wildlife Propagation or Recreation.

The Beneficial Use Monitoring Program (BUMP), established in 1998 to document and quantify impairments of assigned beneficial uses of the state's lakes and streams, provides information for supporting and updating the OWQS and prioritizing pollution control programs. A set of rules known as "use support assessment protocols" is also used to determine whether beneficial uses of waterbodies are being supported.

In an individual waterbody, after impairments have been identified, a Total Maximum Daily Load (TMDL) study is conducted to establish the sources of impairments—whether from point sources (discharges) or non-point sources (runoff). The study will then determine the amount of reduction necessary to meet the applicable water quality standards in that waterbody and allocate loads among the various contributors of pollution.

For more detailed review of the state's water quality conditions, see the most recent versions of the OWRB's BUMP Report, and the *Oklahoma Integrated Water Quality Assessment Report*, a comprehensive assessment of water quality in Oklahoma's streams and lakes required by the federal Clean Water Act and developed by the ODEQ.

Water Quality Impairments
Central Region

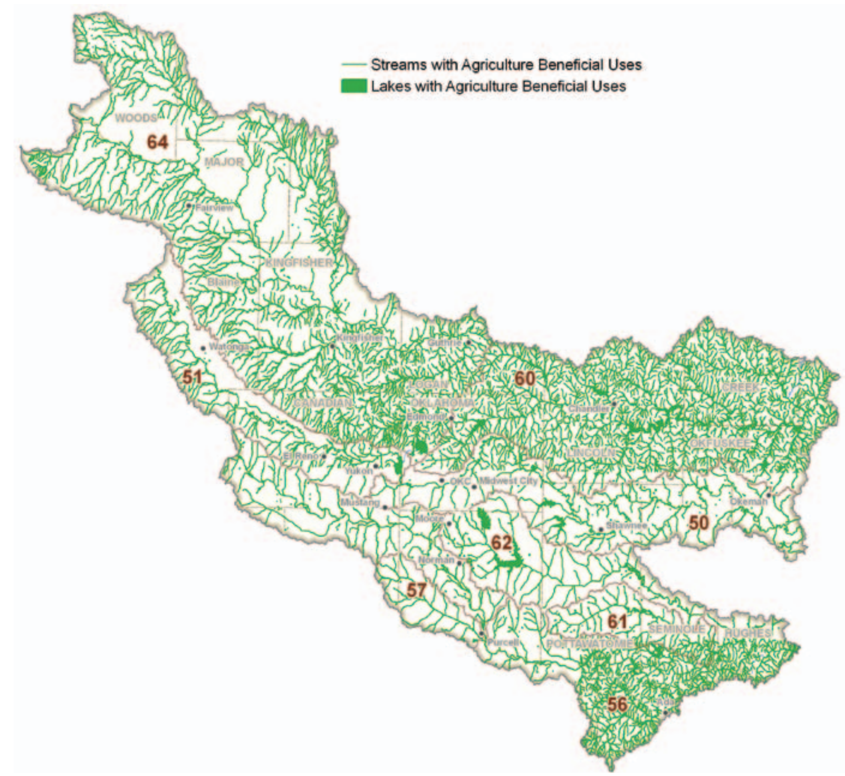
Regional water quality impairments are based on the 2008 *Integrated Water Quality Assessment Report*. Many surface waters in this region are impacted by urbanization, including increased nutrients and sediment as well as stream habitat alterations due to increases in impervious surfaces.

City, Shawnee Twins, Stanley Draper, Stroud, Thunderbird, Tecumseh, Wes Watkins, and Wetumka. Stream salinity, although still considered high, decreases notably from the upper portions of the watersheds. The Canadian watershed is higher with a mean conductivity of 975-1,070 µS/cm on the mainstem and 1,210 on the Little River. The North Canadian is lower, with conductivity ranging from 720-850 µS/cm on the mainstem and 675-815 µS/cm on the Deep Fork. Reservoir salinity is typically low to moderate with some reservoirs ranging from 75-275 µS/cm while others have values as high as 350-450 µS/cm (Bell Cow and Thunderbird). Lake Konawa is high, with an approximate mean of 1,100 µS/cm. Stream nutrient concentrations are relatively high throughout the area and decrease at downstream sites as the watershed moves away from the Oklahoma City metropolitan area. The TP means are 0.31-0.36 ppm (Canadian), 0.68-0.94 ppm (North Canadian), and 0.19-0.34 ppm (Deep Fork). The TN means are 1.47-1.81 ppm (Canadian), 2.72-4.24 ppm (North Canadian), and 1.04-2.19 ppm (Deep Fork). The TP and TN means for Little River are relatively low at 0.16 and 0.83 ppm. While the Deep Fork and Little River remain oligotrophic, all other waters are hyper-eutrophic. All lakes are phosphorus limited and are mesotrophic or eutrophic (Arcadia, Bell Cow, Chandler, Konawa, Thunderbird, and Wes Watkins). Stream water clarity is nearly always poor to very poor and decreases downstream. Turbidity means are 52 NTU (Little River) 49-53 NTU (Canadian), 70-124 NTU (North Canadian), and 38-80 NTU (Deep Fork). Reservoir clarity is diverse and is categorized as poor (Meeker Secchi depth = 10 cm), average (Thunderbird = 53 cm), good (Prague City = 74 cm), and excellent (Stroud = 126 cm).

Dividing the Prairie Tablelands and Northern Cross Timbers is the Cross Timbers Transition. The transition is a hybrid mix of rough plains covered by prairie grasses and oak/elm and cedar forests, with cropland and rangeland as land uses. In this areas of the transition, the major land use is urban, as much of the Oklahoma City metropolitan area overlays the ecoregion. Streams are typically rockier and less muddy than other streams in the region. Ecological diversity is higher than areas to the west but lower than regions to the east and is affected by habitat degradation, channelization, flow modifications,

Surface Waters
with Designated Beneficial Use for Public/Private Water Supply
Central Region

Surface Waters
with Designated Beneficial Use for Agriculture
Central Region



and sedimentation/siltation. The North Canadian and Canadian pass through the area and several major and minor water supply lakes exist there, including Guthrie, Liberty, Hefner, Overholser and Purcell. Stream salinity is high, ranging from 915 µS/cm (North Canadian) to 1,260 (Canadian). Lake salinity is moderate (Purcell = 400 µS/cm) to high (Hefner = 1,100 µS/cm). With the North Canadian having higher nutrient concentrations, rivers are hyper-eutrophic. The TP and TN mean concentrations range from 0.47-1.18 ppm and 2.70-4.31 ppm. All reservoirs are phosphorus limited, with the exception of Purcell Lake (eutrophic), and are hyper-eutrophic. Stream clarity is good on the North Canadian (34 NTU) but poor on the Canadian (80 NTU). Lake clarity is typically average (Liberty = 42 cm) to good (Hefner = 92 cm), but Overholser nears poor (32 cm).

Although a statewide groundwater water quality program does not exist in Oklahoma, various aquifer studies have been completed and data are available from various sources. As stated earlier in this document, the Central Region is underlain by several major and minor bedrock and alluvial aquifers. In most alluvial aquifers, water quality is good with variable dissolved solid contents. Except for hardness and localized nitrate problems, alluvial groundwater is appropriate for domestic, irrigation, industrial, and municipal use. Alluvial aquifers are highly vulnerable to contamination from surface activities due to their high porosities and permeabilities and shallow water tables.

The Rush Springs aquifer borders the southern edge of the region. Although comparatively hard, most of the water derived from it is suitable for domestic, municipal, irrigation, and industrial use with total dissolved solids (TDS) values generally less than 500 ppm. However, sulfate and nitrate concentrations exceed drinking water standards in some areas.

The Garber-Wellington runs through the central portion of the region and underlies much of the Oklahoma City metropolitan area. Water ranges from hard to very hard, and in general, concentrations of dissolved solids, chloride, and sulfate are low. Water from the aquifer is normally suitable for public water supply, but concentrations of nitrates, sulfate, chloride, fluoride, arsenic, chromium, and selenium may exceed drinking water standards in localized areas.

Water from the Garber-Wellington (Central Oklahoma) aquifer is typically suited for public water supply but, in some areas, concentrations of nitrate, arsenic, chromium, and selenium exceed drinking water standards. Elevated concentrations of nitrate can occur in shallow water, which can be a concern for domestic well users. Elevated concentrations of arsenic, chromium, and selenium occur in deep parts of the aquifer, mostly affecting public water supply wells. The highest concentrations of arsenic tend to occur in the western portion of the aquifer where it is overlain by younger rocks.

The Vamoosa-Ada runs adjacent to the Garber-Wellington and underlies portions of Lincoln, Okfuskee, Seminole, and Pottawatomie Counties. Water quality is generally good, but iron infiltration and hardness are problems. Chloride and sulfate concentrations are generally low, and except for areas of local contamination resulting from past oil and gas activities, water is suitable for use as public supply.

Surface Water Protection

The Oklahoma Water Quality Standards (OWQS) provide protection for surface waters in many ways.

Appendix B Areas are designated in the OWQS as containing waters of recreational and/or ecological significance. Discharges to waterbodies may be limited in these areas.

Source Water Protection Areas are derived from the state's Source Water Protection Program, which analyzes existing and potential threats to the quality of public drinking water in Oklahoma.

The **High Quality Waters** designation in the OWQS refers to waters that exhibit water quality exceeding levels necessary to support the propagation of fishes, shellfishes, wildlife, and recreation in and on the water. This designation prohibits any new point source discharges or additional load or increased concentration of specified pollutants.

The **Sensitive Water Supplies (SWS)** designation applies to public and private water supplies possessing conditions making them more susceptible to pollution events, thus requiring additional protection. This designation restricts point source discharges in the watershed and institutes a 10 μg/L (micrograms per liter) chlorophyll-a criterion to protect against taste and odor problems and reduce water treatment costs.

Outstanding Resource Waters are those constituting outstanding resources or of exceptional recreational and/or ecological significance. This designation prohibits any new point source discharges or additional load or increased concentration of specified pollutants.

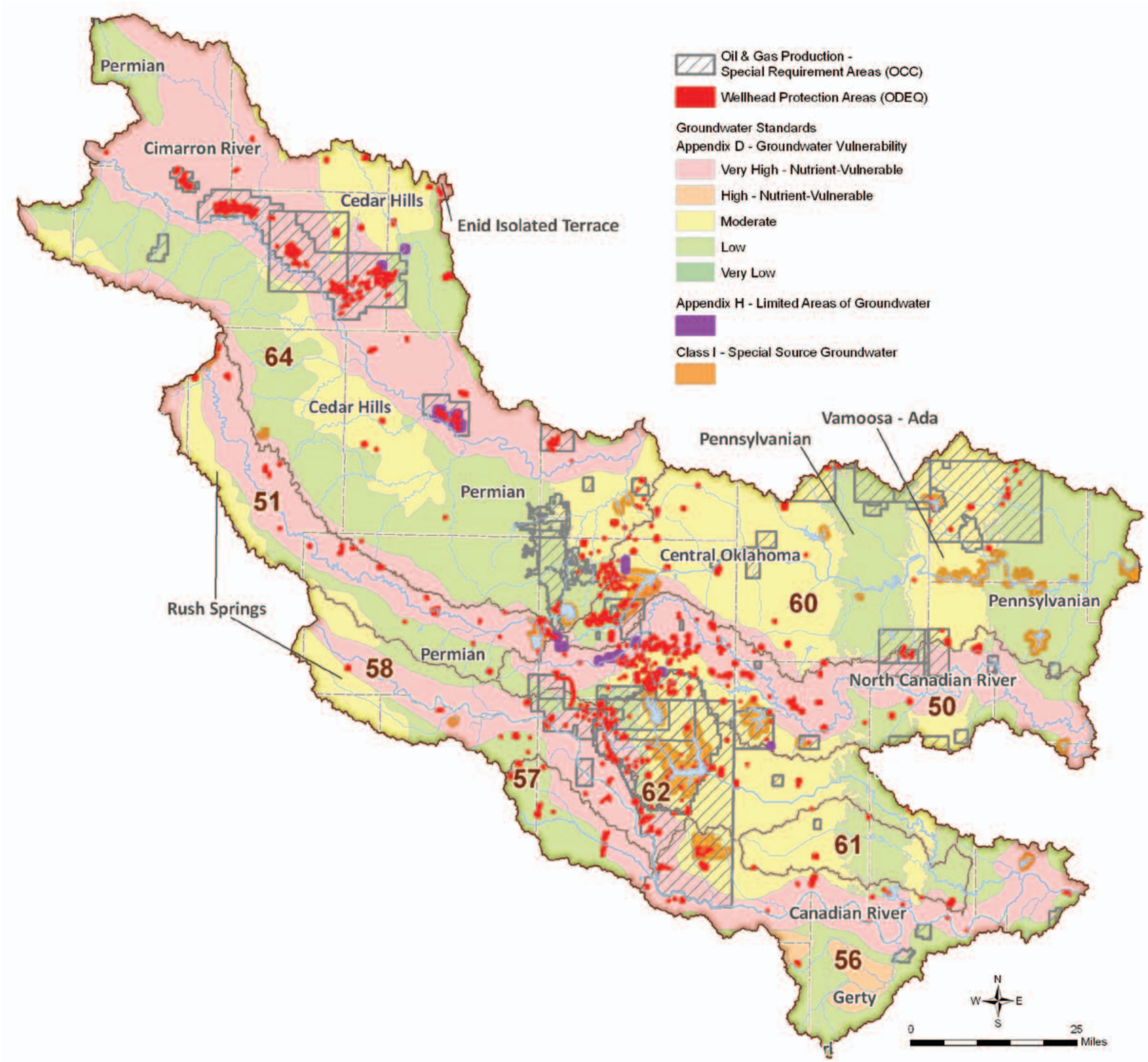
Waters designated as **Scenic Rivers** in Appendix A of the OWQS are protected through restrictions on point source discharges in the watershed. A 0.037 mg/L total phosphorus criterion is applied to all Scenic Rivers in Oklahoma.

Nutrient-Limited Watersheds are those containing a waterbody with a designated beneficial use that is adversely affected by excess nutrients.

Surface Water Protection Areas
Central Region

Because Wes Watkins Reservoir and Lake Wetumka are public water supply reservoirs and have relatively small watersheds, they could potentially benefit from SWS designations. This designation could provide protection from new or increased loading from point sources in the watersheds. This additional protection would also provide limits for algae (chlorophyll-a) that can cause taste and odor problems and increased treatment costs.

Groundwater Protection Areas
Central Region



Various types of protection are in place to prevent degradation of groundwater and address vulnerability. The Cimarron, North Canadian, and Canadian alluvial aquifers have been identified by the OWRB as highly vulnerable.

Groundwater Protection

The Oklahoma Water Quality Standards (OWQS) sets the criteria for protection of groundwater quality as follows: "If the concentration found in the test sample exceeds [detection limit], or if other substances in the groundwater are found in concentrations greater than those found in background conditions, that groundwater shall be deemed to be polluted and corrective action may be required."

Wellhead Protection Areas are established by the Oklahoma Department of Environmental Quality (ODEQ) to improve drinking water quality through the protection of groundwater supplies. The primary goal is to minimize the risk of pollution by limiting potential pollution-related activities on land around public water supplies.

Oil and Gas Production Special Requirement Areas, enacted to protect groundwater and/or surface water, can consist of specially lined drilling mud pits (to prevent leaks and spills) or tanks whose contents are removed upon completion of drilling activities; well set-back distances from streams and lakes; restrictions on fluids and chemicals; or other related protective measures.

Nutrient-Vulnerable Groundwater is a designation given to certain hydrogeologic basins that are designated by the OWRB as having high or very high vulnerability to contamination from surface sources of pollution. This designation can impact land application of manure for regulated agriculture facilities.

Class 1 Special Source Groundwaters are those of exceptional quality and particularly vulnerable to contamination. This classification includes groundwaters located underneath watersheds of Scenic Rivers, within OWQS Appendix B areas, or underneath wellhead or source water protection areas.

Appendix H Limited Areas of Groundwater are localized areas where quality is unsuitable for default beneficial uses due to natural conditions or irreversible human-induced pollution.

NOTE: The State of Oklahoma has conducted a successful surface water quality monitoring program for more than fifteen years. A new comprehensive groundwater quality monitoring program is in the implementation phase and will soon provide a comparable long-term groundwater resource data set.

Water Quality Trends Study

As part of the *2012 OCWP Update*, OWRB monitoring staff compiled more than ten years of Beneficial Use Monitoring Program (BUMP) data and other resources to initiate an ongoing statewide comprehensive analysis of surface water quality trends.

Reservoir Trends: Water quality trends for reservoirs were analyzed for chlorophyll-a, conductivity, total nitrogen, total phosphorus, and turbidity at sixty-five reservoirs across the state. Data sets were of various lengths, depending on the station's period of record. The direction and magnitude of trends varies throughout the state and within regions. However, when considered statewide, the final trend analysis revealed several notable details.

- Chlorophyll-a and nutrient concentrations continue to increase at a number of lakes. The proportions of lakes exhibiting a significant upward trend were 42% for chlorophyll-a, 45% for total nitrogen, and 12% for total phosphorus.
- Likewise, conductivity and turbidity have trended upward over time. Nearly 28% of lakes show a significant upward trend in turbidity, while nearly 45% demonstrate a significant upward trend for conductivity.

Stream Trends: Water quality trends for streams were analyzed for conductivity, total nitrogen, total phosphorus, and turbidity at sixty river stations across the state. Data sets were of various lengths, depending on the station's period of record, but generally, data were divided into historical and recent datasets and analyzed separately and as a whole. The direction and magnitude of trends varies throughout the state and within regions. However, when considered statewide, the final trend analysis revealed several notable details.

- Total nitrogen and phosphorus are very different when comparing period of record to more recent data. When considering the entire period of record, approximately 80% of stations showed a downward trend in nutrients. However, if only the most recent data (approximately 10 years) are considered, the percentage of stations with a downward trend decreases to 13% for nitrogen and 30% for phosphorus. The drop is accounted for in stations with either significant upward trends or no detectable trend.
- Likewise, general turbidity trends have changed over time. Over the entire period of record, approximately 60% of stations demonstrated a significant upward trend. However, more recently, that proportion has dropped to less than 10%.
- Similarly, general conductivity trends have changed over time, albeit less dramatically. Over the entire period of record, approximately 45% of stations demonstrated a significant upward trend. However, more recently, that proportion has dropped to less than 30%.

Typical Impact of Trends Study Parameters

Chlorophyll-a is a measure of algae growth. When algae growth increases, there is an increased likelihood of taste and odor problems in drinking water as well as aesthetic issues.

Conductivity is a measure of the ability of water to pass electrical current. In water, conductivity is affected by the presence of inorganic dissolved solids, such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). Conductivity in streams and rivers is heavily dependent upon regional geology and discharges. High specific conductance indicates high concentrations of dissolved solids, which can affect the suitability of water for domestic, industrial, agricultural, and other uses. At higher conductivity levels, drinking water may have an unpleasant taste or odor or may even cause gastrointestinal distress. High concentration may also cause deterioration of plumbing fixtures and appliances. Relatively expensive water treatment processes, such as reverse osmosis, are required to remove excessive dissolved solids from water. Concerning agriculture, most crops cannot survive if the salinity of the water is too high.

Total Nitrogen is a measure of all dissolved and suspended nitrogen in a water sample. It includes kjeldahl nitrogen (ammonia + organic), nitrate, and nitrite nitrogen. It is naturally abundant in the environment and is a key element necessary for growth of plants and animals. Excess nitrogen from polluting sources can lead to significant water quality problems, including harmful algal blooms, hypoxia, and declines in wildlife and habitat.

Total Phosphorus is one of the key elements necessary for growth of plants and animals. Excess phosphorus leads to significant water quality problems, including harmful algal blooms, hypoxia, and declines in wildlife and habitat. Increases in total phosphorus can lead to excessive growth of algae, which can increase taste and odor problems in drinking water as well as increased costs for treatment.

Turbidity refers to the clarity of water. The greater the amount of total suspended solids (TSS) in the water, the murkier it appears and the higher the measured turbidity. Increases in turbidity can increase treatment costs and have negative effects on aquatic communities by reducing light penetration.

Reservoir Water Quality Trends

Central Region

Site / Parameter	Arcadia (1989-2007)	Chandler (1995-2008)	Guthrie (1994-2006)	Hefner (1996-2006)	Holdenville (1994-2007)	Meeker (1994-2009)	Okemah (1994-2007)	Overholser (1994-2006)	Shawnee Twin #1 (1995-2006)	Shawnee Twin #2 (1995-2008)	Stanley Draper (1994-2006)	Stroud (1994-2006)	Thunderbird (1995-2009)
Chlorophyll-a (mg/m3)	NT	↑	NT	↑	↑	↑	NT	↑	NT	NT	NT	NT	↑
Conductivity (us/cm)	NT	↑	↑	↑	↑	↑	↑	NT	↑	↑	NT	↑	↑
Total Nitrogen (mg/L)	↑	↑	↑	NT	↑	↑	↑	↑	↓	NT	NT	NT	↑
Total Phosphorus (mg/L)	↓	↑	↓	NT	NT	NT	NT	NT	NT	↓	↓	↓	↑
Turbidity (NTU)	NT	↑	↑	NT	↑	NT	NT	↑	NT	↓	↓	NT	↑

Increasing Trend ↑ **Decreasing Trend** ↓ NT = No significant trend detected

Trend magnitude and statistical confidence levels vary for each site. Site-specific information can be obtained from the OWRB Water Quality Division.

A notable concern in the Central Region is:

- Significant upward trend for chlorophyll-a, conductivity, turbidity and total nitrogen at numerous reservoirs

Stream Water Quality Trends

Central Region

Site	Deep Fork River near Beggs		Little River near Sasakwa		North Canadian River near El Reno		North Canadian River near Shawnee		North Canadian River near Wetumka	
Parameter	All Data Trend (1946-1993, 1998-2009)[1]	Recent Trend (1998-2009)	All Data Trend (1951-1993, 1998-2009)[1]	Recent Trend (1998-2009)	All Data Trend (1950-1993, 1998-2009)[1]	Recent Trend (1998-2009)	All Data Trend (1968-1996, 1997-2009)[1]	Recent Trend (1997-2009)	All Data Trend (1951-1995, 1999-2009)[1]	Recent Trend (1999-2009)
Conductivity (us/cm)	↓	NT	NT	↑	NT	↓	↓	↓	NT	NT
Total Nitrogen (mg/L)	↓	↑	↓	NT	↓	↑	↓	↑	↑	↑
Total Phosphorus (mg/L)	↓	NT	↓	↓	↓	NT	↓	↑	↓	↑
Turbidity (NTU)	↑	NT	NT	NT	↑	NT	↑	↓	↑	NT

Increasing Trend ↑ **Decreasing Trend** ↓ NT = No significant trend detected

Trend magnitude and statistical confidence levels vary for each site. Site-specific information can be obtained from the OWRB Water Quality Division.

1 Date ranges for analyzed data represent the earliest site visit date and may not be representative of all parameters.

Notable concerns in the Central Region are:

- Significant upward trend for recent turbidity and nutrient data at various stations on the Canadian, Cimarron, Deep Fork, and North Canadian Rivers
- Significant upward trends in conductivity on both the Canadian and Cimarron Rivers

Water Demand

The Central Region accounts for about 18% of the total statewide water demand. Regional demand will increase by 32% (107,250 AFY) from 2010 to 2060. Municipal and Industrial use will continue to be the largest demand sector.

By 2060, Municipal and Industrial (M&I) demand is projected to account for approximately 58% of the Central Region's total demand. Currently, 62% of the region's M&I demand is supplied by surface water, 12% by alluvial groundwater, and 26% by bedrock groundwater.

Crop Irrigation demand is expected to account for 16% of the region's total 2060 demand. Currently, 25% of the demand from this sector is supplied by surface water, 58% by alluvial groundwater, and 17% by bedrock groundwater. Predominant irrigated crops in the Central Region include pasture grasses, corn, and sod.

Thermoelectric Power demand is projected to account for 14% of the total 2060 demand. There are a number of plants using water for thermoelectric power generation; the three largest are Oklahoma Gas and Electric Co's Seminole plant and McClain Energy Facility and InterGen North America's Redbud Power Plant. Currently, 89% of the demand from this sector is supplied by surface water, 10% by alluvial groundwater, and 1% by bedrock groundwater.

Oil and Gas demand is projected to account for 5% of the total 2060 demand. Currently, 68% of the demand from this sector is supplied by surface water, 12% by alluvial groundwater, and 20% by bedrock groundwater.

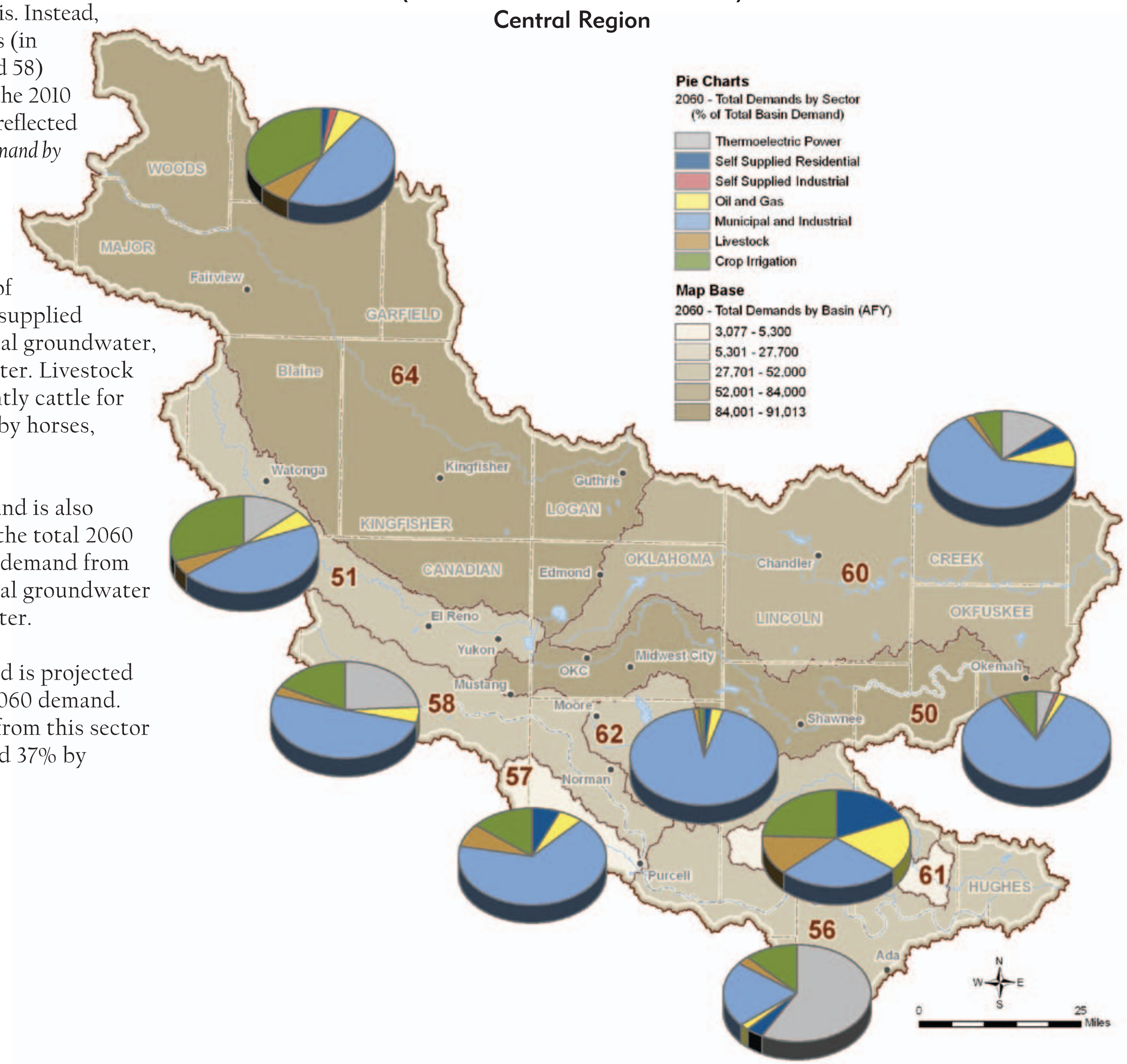
The demand forecast developed in accordance with the O&G work group estimates that 2050 and 2060 demands in seven counties will drop below the 2010 demand level (due to Woodford Shale being played out). As a conservative approach, this assumption is not explicitly carried over into the Gap Analysis. Instead, where applicable, basin demands (in the Central Region, Basins 51 and 58) are assumed to never fall below the 2010 base year demand levels. This is reflected in the Region and Basin *Total Demand by Sector* tables.

Livestock demand is projected to account for 3% of the total 2060 demand. Currently, 26% of the demand from this sector is supplied by surface water, 54% by alluvial groundwater, and 20% by bedrock groundwater. Livestock use in the region is predominantly cattle for cow-calf production, followed by horses, hogs, and dairy cows.

Self-Supplied Residential demand is also projected to account for 3% of the total 2060 demand. Currently, 70% of the demand from this sector is supplied by alluvial groundwater and 30% by bedrock groundwater.

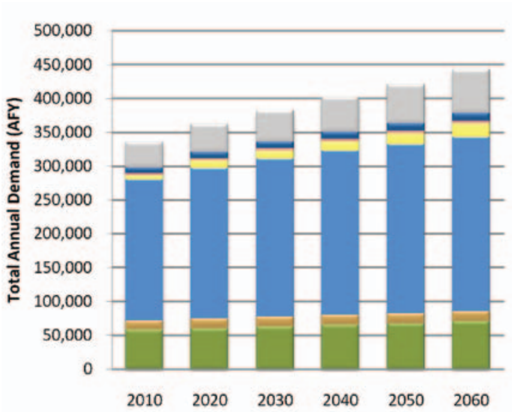
Self-Supplied Industrial demand is projected to account for 1% of the total 2060 demand. Currently, 63% of the demand from this sector is supplied by surface water and 37% by bedrock groundwater.

Total 2060 Water Demand by Sector and Basin
(Percent of Total Basin Demand)
Central Region

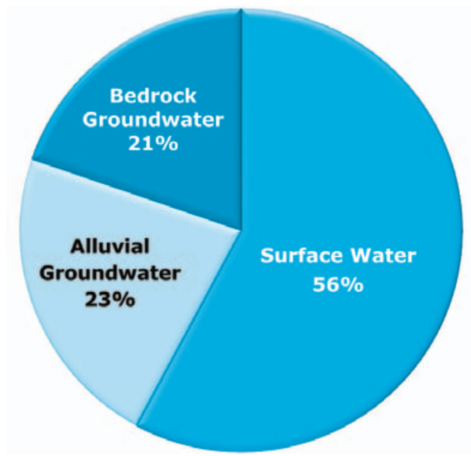


Projected water demand by sector. Municipal and Industrial is expected to remain the largest demand sector in the region, accounting for 58% of the total regional demand in 2060.

Total Water Demand by Sector
Central Region



Supply Sources Used to Meet Current Demand (2010)
Central Region



The Central Region's water needs account for about 18% of the total statewide demand. Regional demand will increase by 32% (107,250 AFY) from 2010 to 2060. Municipal and Industrial use will continue to be the largest demand sector.

Total Water Demand by Sector
Central Region

Planning Horizon	Crop Irrigation	Livestock	Municipal & Industrial	Oil & Gas[1]	Self-Supplied Industrial	Self-Supplied Residential	Thermoelectric Power	Total
	AFY							
2010	58,100	13,850	208,390	7,100	2,420	8,680	37,100	335,640
2020	60,700	14,020	222,260	12,450	2,420	9,370	41,390	362,620
2030	63,290	14,190	233,370	12,900	2,510	9,990	46,180	382,430
2040	65,890	14,360	242,520	14,680	2,690	10,580	51,520	402,240
2050	67,880	14,530	249,970	17,240	2,870	11,140	57,470	421,100
2060	71,080	14,700	257,500	20,700	3,060	11,730	64,120	442,890

1 The demand forecast developed in accordance with the O&G work group estimates that 2050 and 2060 demands in seven counties will drop below the 2010 demand level (due to Woodford Shale being played out). As a conservative approach, this assumption is not explicitly carried over into the Gap Analysis. Instead, where applicable, basin demands (in the Central Region, Basins 51 and 58) are assumed to never fall below the 2010 base year demand levels. This is reflected in the Region and Basin Total Demand by Sector tables.

Water Demand

Water demand refers to the amount of water required to meet the needs of people, communities, industry, agriculture, and other users. Growth in water demand frequently corresponds to growth in population, agriculture, industry, or related economic activity. Demands have been projected from 2010 to 2060 in ten-year increments for seven distinct consumptive water demand sectors.

Water Demand Sectors

- **Thermoelectric Power:** Thermoelectric power producing plants, using both self-supplied water and municipal-supplied water, are included in the thermoelectric power sector.
- **Self-Supplied Residential:** Households on private wells that are not connected to a public water supply system are included in the SSR sector.
- **Self-Supplied Industrial:** Demands from large industries that do not directly depend upon a public water supply system are included in the SSI sector. Water use data and employment counts were included in this sector, when available.
- **Oil and Gas:** Oil and gas drilling and exploration activities, excluding water used at oil and gas refineries (typically categorized as Self-Supplied Industrial users), are included in the oil and gas sector.
- **Municipal and Industrial:** These demands represent water that is provided by public water systems to homes, businesses, and industries throughout Oklahoma, excluding water supplied to thermoelectric power plants.
- **Livestock:** Livestock demands were evaluated by livestock group (beef, poultry, etc.) based on the 2007 Agriculture Census.
- **Crop Irrigation:** Water demands for crop irrigation were estimated using the 2007 Agriculture Census data for irrigated acres by crop type and county. Crop irrigation requirements were obtained primarily from the Natural Resource Conservation Service Irrigation Guide Reports.

OCWP demands were not projected for non-consumptive or instream water uses, such as hydroelectric power generation, fish and wildlife, recreation and instream flow maintenance. Projections, which were augmented through user/stakeholder input, are based on standard methods using data specific to each sector and OCWP planning basin.

Projections were initially developed for each county in the state, then allocated to each of the 82 basins. To provide regional context, demands were aggregated by Watershed Planning Region. Water shortages were calculated at the basin level to more accurately determine areas where shortages may occur. Therefore, gaps, depletions, and options are presented in detail in the Basin Summaries and subsequent sections. Future demand projections were developed independent of available supply, water quality, or infrastructure considerations. The impacts of climate change, increased water use efficiency, conservation, and non-consumptive uses, such as hydropower, are presented in supplemental OCWP reports.

Present and future demands were applied to supply source categories to facilitate an evaluation of potential surface water gaps and alluvial and bedrock aquifer storage depletions at the basin level. For this baseline analysis, the proportion of each supply source used to meet future demands for each sector was held constant at the proportion established through current, active water use permit allocations. For example, if the crop irrigation sector in a basin currently uses 80% bedrock groundwater, then 80% of the projected future crop irrigation demand is assumed to use bedrock groundwater. Existing out-of-basin supplies are represented as surface water supplies in the receiving basin.

Public Water Providers

There are more than 1,600 Oklahoma water systems permitted or regulated by the Oklahoma Department of Environmental Quality (ODEQ); 785 systems were analyzed in detail for the *2012 OCWP Update*. The public systems selected for inclusion, which collectively supply approximately 94 percent of the state's current population, consist of municipal or community water systems and rural water districts that were readily identifiable as non-profit, local governmental entities. This and other information provided in the OCWP will support provider-level planning by providing insight into future supply and infrastructure needs.

The Central Watershed Planning Region includes 119 of the 785 public supply systems analyzed for the *2012 OCWP Update*. The Public Water Providers map indicates the approximate service areas of these systems. (The map may not accurately represent existing service areas or legal boundaries. In addition, water systems often serve multiple counties and can extend into multiple planning basins and regions.)

In terms of population served (excluding provider-to-provider sales), the five largest systems in the region, in decreasing order, are Oklahoma City, Norman, Edmond PWA, Midwest City, and Moore. Together, these five systems serve more than 71 percent of the combined OCWP public water providers' population in the region.

Demands upon public water systems, which comprise the majority of the OCWP's Municipal and Industrial (M&I) water demand sector, were analyzed at both the basin and provider level. Retail demand projections detailed in the Public Water Provider Demand Forecast table were developed for each of the OCWP providers in the region. These projections include estimated system losses, defined as water lost either during water production or distribution to residential homes and businesses. Retail demands do not include wholesaled water.

OCWP provider demand forecasts are not intended to supersede water demand forecasts developed by individual providers. OCWP analyses were made using a consistent methodology based on accepted data available on a statewide basis. Where available, provider-generated forecasts were also reviewed as part of this effort.

Population and Demand Projection Data

Provider level population and demand projection data, developed specifically for OCWP analyses, focus on retail customers for whom the system provides direct service. These estimates were generated from Oklahoma Department of Commerce population projections. In addition, the 2008 OCWP Provider Survey contributed critical information on water production and population served that was used to calculate per capita water use. Population for 2010 was estimated and may not reflect actual 2010 Census values. Exceptions to this methodology are noted.

Public Water Providers/Retail Population Served (1 of 4)

Central Region

Provider	SDWIS ID[1]	County	Retail Per Capita (GPD)[2]	Population Served					
				2010	2020	2030	2040	2050	2060
ADA	OK2006201	Pontotoc	231	26,677	27,698	28,652	29,606	30,495	31,368
ALINE	OK2000206	Alfalfa	233	215	215	215	215	215	225
AMES	OK2004403	Major	101	199	199	199	199	209	209
ASHER UTIL DEV AUTH	OK3006311	Pottawatomie	133	385	411	437	462	479	505
BETHANY	OK2005519	Oklahoma	105	21,362	22,392	23,314	24,007	24,512	25,017
BLANCHARD	OK3004710	McClain	324	3,791	4,423	5,009	5,595	6,204	6,824
BOWLEGS/LIMA WATER	OK2006701	Seminole	88	3,048	3,128	3,209	3,289	3,369	3,449
BRISTOW MUN AUTH	OK2001910	Creek	155	4,620	4,940	5,190	5,430	5,660	5,920
BROOKSVILLE	OK2006363	Pottawatomie	88	96	96	105	115	115	124
CALUMET	OK2000904	Canadian	174	552	608	655	692	730	758
CALVIN	OK2003201	Hughes	100	312	342	383	423	463	503
CANADIAN CO RWD #1	OK2000908	Canadian	108	671	737	787	832	873	913
CANADIAN CO RWD #4	OK2000930	Canadian	135	1,006	1,105	1,181	1,248	1,309	1,370
CANADIAN CO WATER AUTH	OK3000903	Canadian	82	1,620	1,780	1,902	2,009	2,107	2,206
CANTON	OK2000607	Blaine	100	662	723	784	846	907	978
CARMEN	OK2000207	Alfalfa	102	420	420	420	420	431	431
CARNEY	OK2004104	Lincoln	80	666	723	780	828	885	942
CASHION	OK3003703	Kingfisher	112	657	730	815	888	973	1,058
CENTRAL OKLAHOMA MCD (Wholesaler only)	None	Cleveland	0	0	0	0	0	0	0
CHANDLER	OK1020702	Lincoln	375	2,910	3,176	3,394	3,621	3,858	4,105
CHOCTAW	OK2005510	Oklahoma	102	3,892	4,079	4,247	4,372	4,466	4,556
CIMARRON CITY	OK2004253	Logan	380	52	56	60	65	73	77
CLEO SPRINGS	OK2004402	Major	153	326	326	326	326	336	336
COLE	OK3004708	McClain	163	494	574	653	732	812	891
CRESCENT	OK2004204	Logan	126	1,454	1,633	1,792	1,952	2,111	2,280
DACOMA PWA	OK3007607	Woods	92	130	130	130	130	130	139
DAVENPORT UTIL AUTH	OK3004104	Lincoln	72	904	989	1,056	1,123	1,199	1,275
DEER CREEK RURAL WATER CORP	OK2005504	Oklahoma	188	4,576	4,799	4,996	5,145	5,252	5,362
DEL CITY	OK1020805	Oklahoma	100	22,507	23,599	24,566	25,294	25,831	26,357
DEPEW	OK2001903	Creek	73	576	615	647	676	706	738
DIBBLE	OK3004709	McClain	86	332	390	439	488	546	595
DOVER PUBLIC WORKS TRUST AUTH	OK2003705	Kingfisher	92	412	464	515	567	619	670
DRUMMOND	OK3002401	Garfield	60	425	446	456	466	477	487

Public Water Providers/Retail Population Served (2 of 4)
Central Region

Provider	SDWIS ID[1]	County	Retail Per Capita (GPD)[2]	Population Served					
				2010	2020	2030	2040	2050	2060
EDMOND PWA	OK1020723	Oklahoma	125	68,800	81,993	95,337	108,830	122,474	136,267
EL RENO	OK2000902	Canadian	197	18,886	20,723	22,161	23,400	24,544	25,709
FAIRVIEW	OK2004404	Major	78	2,709	2,749	2,749	2,790	2,820	2,860
FRANCIS	OK2006205	Pontotoc	244	168	178	183	188	193	203
GEARY	OK2000608	Blaine	158	1,278	1,398	1,518	1,638	1,758	1,900
GOLDSBY WATER AUTH TRUST	OK2004707	McClain	107	1,764	2,061	2,332	2,603	2,887	3,183
GOLTRY	OK2000203	Alfalfa	105	268	268	268	268	268	278
GREENFIELD PWA	OK3000606	Blaine	78	92	99	106	113	120	134
GUTHRIE	OK1020903	Logan	232	10,307	11,591	12,729	13,877	14,997	16,190
HARRAH	OK2005506	Oklahoma	73	4,831	5,062	5,275	5,429	5,545	5,660
HEASTON RW CORP	OK3000901	Canadian	204	568	624	666	704	738	773
HELENA	OK2000210	Alfalfa	125	437	437	437	437	447	447
HENNESSEY	OK2003704	Kingfisher	100	2,126	2,380	2,624	2,878	3,123	3,405
HITCHCOCK DEV	OK2000610	Blaine	125	208	222	250	264	292	306
HOLDENVILLE	OK1020803	Hughes	110	4,962	5,529	6,096	6,692	7,363	8,024
HUGHES CO RWD #4	OK3003203	Hughes	72	828	924	1,019	1,119	1,230	1,340
JONES	OK2005507	Oklahoma	88	1,693	1,775	1,851	1,908	1,946	1,984
KENDRICK MUN AUTH	OK3004109	Lincoln	163	359	383	407	431	455	503
KINGFISHER	OK2003702	Kingfisher	168	4,707	5,265	5,813	6,370	6,918	7,535
KINGFISHER CO RWD #3	OK2003722	Kingfisher	209	138	154	171	187	204	221
KINGFISHER CO RWD #4	OK3003704	Kingfisher	72	67	75	83	91	99	107
KONAWA PWA	OK2006704	Seminole	74	1,481	1,520	1,570	1,609	1,659	1,708
LAHOMA PWA	OK2002417	Garfield	87	583	603	613	622	632	652
LEXINGTON	OK2001409	Cleveland	175	2,059	2,209	2,334	2,431	2,502	2,573
LINCOLN CO RWD #1	OK1020703	Lincoln	80	410	447	477	509	542	578
LINCOLN CO RWD #2	OK3004102	Lincoln	216	410	447	477	509	542	578
LINCOLN CO RWD #3	OK3004107	Lincoln	50	589	642	686	732	779	830
LINCOLN CO RW & SD #4	OK2004105	Lincoln	109	2,577	2,808	3,000	3,201	3,408	3,631
LOGAN CO RWD #1	OK2004207	Logan	152	4,726	5,305	5,820	6,344	6,855	7,404
LOGAN CO RWD #2	OK2004206	Logan	133	1,190	1,336	1,466	1,598	1,726	1,865
LONGDALE	OK2000611	Blaine	153	255	270	301	324	347	378
LOYAL	OK2003701	Kingfisher	114	94	105	115	126	136	147

Public Water Providers/Retail Population Served (3 of 4)
Central Region

Provider	SDWIS ID[1]	County	Retail Per Capita (GPD)[2]	Population Served					
				2010	2020	2030	2040	2050	2060
LUTHER	OK2005503	Oklahoma	126	637	666	696	715	735	745
MAJOR COUNTY RWD #1	OK2004407	Major	145	937	950	950	963	976	989
MAUD	OK2006302	Pottawatomie	83	1,162	1,248	1,320	1,391	1,463	1,535
MCLOUD	OK2006301	Pottawatomie	96	2,561	2,736	2,898	3,054	3,209	3,371
MEEKER PWA	OK3004108	Lincoln	66	1,044	1,132	1,211	1,290	1,378	1,467
MENO	OK2004401	Major	95	201	201	201	201	212	212
MERIDIAN	OK2004254	Logan	65	54	63	72	81	81	90
MIDWEST CITY	OK1020806	Oklahoma	78	56,099	58,823	61,236	63,062	64,390	65,699
MINCO	OK2002610	Grady	63	1,706	1,830	1,935	2,030	2,126	2,221
MOORE	OK2001412	Cleveland	116	51,602	55,442	58,547	61,023	62,764	64,453
MUSTANG	OK2000922	Canadian	92	17,850	19,586	20,943	22,117	23,205	24,306
NEWCASTLE	OK2004704	McClain	228	6,388	7,459	8,451	9,442	10,474	11,515
NICHOLS HILLS	OK2005501	Oklahoma	286	4,088	4,287	4,458	4,591	4,686	4,781
NOBLE	OK2001411	Cleveland	129	5,663	6,089	6,427	6,698	6,892	7,076
NORMAN5	OK1020801	Cleveland	136	112,208	128,404	140,985	146,950	151,130	155,216
NORTH BLAINE WATER	OK2000606	Blaine	450	883	961	1,043	1,127	1,212	1,301
OKARCHE	OK2003703	Kingfisher	146	1,146	1,289	1,420	1,552	1,695	1,838
OKARCHE RWD	OK2003715	Kingfisher	120	557	627	691	755	825	894
OKEENE	OK2000612	Blaine	240	1,263	1,380	1,497	1,613	1,739	1,866
OKEMAH UTIL AUTH	OK1020706	Okfuskee	136	6,086	6,245	6,384	6,543	6,682	6,901
OKFUSKEE CO RWD #1 (BOLEY)	OK2005402	Okfuskee	43	412	423	434	445	456	471
OKFUSKEE CO RWD #2	OK3005402	Okfuskee	180	2,209	2,265	2,321	2,377	2,433	2,508
OKFUSKEE CO RWD #3	OK3005401	Okfuskee	79	1,817	1,864	1,910	1,956	2,002	2,063
OKLAHOMA CITY	OK1020902	Oklahoma	166	564,969	595,620	622,117	642,572	657,876	673,025
OKMULGEE CO RWD #7 (NUYAKA)	OK3005608	Okmulgee	202	1,000	1,073	1,138	1,204	1,273	1,342
PADEN	OK2005401	Okfuskee	78	625	639	653	667	681	708
PIEDMONT	OK2000909	Canadian	100	6,399	7,031	7,505	7,932	8,311	8,706
PONTOTOC CO RWD #1 (HOMER)	OK3006205	Pontotoc	211	446	463	479	495	510	525
PONTOTOC CO RWD #8	OK2006215	Pontotoc	76	3,521	3,657	3,783	3,908	4,024	4,141
POTTAWATOMIE CO DEV AUTH	OK3006303	Pottawatomie	108	1,224	1,308	1,387	1,462	1,536	1,613
POTTAWATOMIE CO RWD #2 (TRI COUNTY)	OK2006362	Pottawatomie	76	3,570	3,815	4,045	4,264	4,479	4,703
POTTAWATOMIE CO RWD #3	OK1020807	Pottawatomie	130	571	610	647	682	717	753

Public Water Providers/Retail Population Served (4 of 4)
Central Region

Provider	SDWIS ID[1]	County	Retail Per Capita (GPD)[2]	Population Served					
				2010	2020	2030	2040	2050	2060
PRAGUE	OK2004101	Lincoln	120	2,201	2,402	2,564	2,735	2,916	3,107
PURCELL	OK2004701	McClain	82	8,456	9,863	11,181	12,486	13,855	15,236
RINGWOOD	OK2004405	Major	133	500	500	500	512	512	524
ROCK CREEK	OK2004205	Logan	196	145	163	179	195	211	228
SASAKWA PWA	OK2006705	Seminole	168	150	160	160	160	170	170
SASAKWA RWD	OK2006708	Seminole	170	288	307	307	307	326	326
SEMINOLE CO RW & SWMD #3	OK3006703	Seminole	109	339	350	360	369	380	391
SHAWNEE	OK1020504	Pottawatomie	117	30,589	32,695	34,661	36,537	38,373	40,299
SLICK	OK3001921	Creek	113	154	163	173	183	192	202
SPENCER	OK2005509	Oklahoma	152	3,152	3,303	3,437	3,540	3,612	3,691
ST LOUIS RWD	OK2006304	Pottawatomie	73	206	224	234	243	262	271
STRATFORD	OK2002503	Garvin	145	1,478	1,518	1,537	1,567	1,597	1,627
STROUD PWA	OK1020705	Lincoln	131	2,826	3,082	3,291	3,509	3,737	3,983
TECUMSEH UTIL AUTH	OK1020506	Pottawatomie	99	6,218	6,648	7,049	7,431	7,804	8,196
TUTTLE	OK2002608	Grady	91	5,062	5,425	5,745	6,020	6,306	6,592
UNION CITY	OK3000909	Canadian	55	774	845	906	956	1,002	1,053
WANETTE	OK3006310	Pottawatomie	62	408	436	465	493	512	540
WASHINGTON	OK2004703	McClain	95	546	635	723	811	899	987
WATONGA	OK2000602	Blaine	195	4,788	5,208	5,667	6,127	6,576	7,074
WELLSTON	OK1020724	Lincoln	92	842	918	984	1,050	1,116	1,192
WETUMKA	OK1020508	Hughes	237	1,501	1,669	1,846	2,024	2,229	2,434
YUKON	OK2000910	Canadian	145	21,713	23,833	25,478	26,910	28,222	29,561

1 SDWIS - Safe Drinking Water Information System

2 RED ENTRY indicates data were taken from 2007 OWRB Water Rights Database. GPD=gallons per day

3 Retail per capita and 2010 population taken from Bristow Water System and Supply Study, 2008

4 Population estimates taken from Edmond 50-Year Water Supply Plan, 2009

5 Population estimates for 2010-2030 taken from 2025 Norman Land Use Plan

Public Water Provider Demand Forecast (1 of 4)
Central Region

Provider	SDWIS ID[1]	County	Demand (AFY)					
			2010	2020	2030	2040	2050	2060
ADA	OK2006201	Pontotoc	6,900	7,164	7,411	7,658	7,887	8,113
ALINE	OK2000206	Alfalfa	56	56	56	56	56	59
AMES	OK2004403	Major	22	22	22	22	24	24
ASHER UTIL DEV AUTH	OK3006311	Pottawatomie	58	61	65	69	72	75
BETHANY	OK2005519	Oklahoma	2,507	2,628	2,736	2,817	2,876	2,936
BLANCHARD	OK3004710	McClain	1,376	1,605	1,817	2,030	2,251	2,476
BOWLEGS/LIMA WATER	OK2006701	Seminole	300	308	316	324	332	340
BRISTOW MUN AUTH	OK2001910	Creek	804	860	903	945	985	1,030
BROOKSVILLE	OK2006363	Pottawatomie	9	9	10	11	11	12
CALUMET	OK2000904	Canadian	107	118	127	135	142	148
CALVIN	OK2003201	Hughes	35	38	43	47	52	56
CANADIAN CO RWD #1	OK2000908	Canadian	82	90	96	101	106	111
CANADIAN CO RWD #4	OK2000930	Canadian	153	168	179	189	198	208
CANADIAN CO WATER AUTH	OK3000903	Canadian	148	163	174	183	192	201
CANTON	OK2000607	Blaine	74	81	88	95	102	110
CARMEN	OK2000207	Alfalfa	48	48	48	48	49	49
CARNEY	OK2004104	Lincoln	60	65	70	74	79	84
CASHION	OK3003703	Kingfisher	83	92	102	112	122	133
CENTRAL OKLAHOMA MCD (Wholesaler only)	None	Cleveland	0	0	0	0	0	0
CHANDLER	OK1020702	Lincoln	1,222	1,334	1,426	1,521	1,621	1,724
CHOCTAW	OK2005510	Oklahoma	446	468	487	501	512	523
CIMARRON CITY	OK2004253	Logan	22	24	26	27	31	33
CLEO SPRINGS	OK2004402	Major	56	56	56	56	58	58
COLE	OK3004708	McClain	90	104	119	133	148	162
CRESCENT	OK2004204	Logan	206	231	254	276	299	323
DACOMA PWA	OK3007607	Woods	13	13	13	13	13	14
DAVENPORT UTIL AUTH	OK3004104	Lincoln	72	79	85	90	96	102
DEER CREEK RURAL WATER CORP	OK2005504	Oklahoma	964	1,011	1,052	1,084	1,106	1,129
DEL CITY	OK1020805	Oklahoma	2,516	2,638	2,746	2,827	2,887	2,946
DEPEW	OK2001903	Creek	47	50	53	55	57	60
DIBBLE	OK3004709	McClain	32	38	42	47	53	57
DOVER PUBLIC WORKS TRUST AUTH	OK2003705	Kingfisher	42	48	53	58	64	69
DRUMMOND	OK3002401	Garfield	29	30	31	31	32	33

Projections of Retail Water Demands

Each public water supply system has a "retail" demand, defined as the amount of water used by residential and non-residential customers within that provider's service area. Public-supplied residential demands include water provided to households for domestic uses both inside and outside the home. Non-residential demands include customer uses at office buildings, shopping centers, industrial parks, schools, churches, hotels, and related locations served by a public water supply system. Retail demands do not include wholesale water to other providers.

Municipal and Industrial (M&I) demand is driven by projected population growth and specific customer characteristics. Demand forecasts for each public system are estimated from average water use (in gallons per capita per day) multiplied by projected population. Oklahoma Department of Commerce 2002 population projections (unpublished special tabulation for the OWRB) were calibrated to 2007 Census estimates and used to establish population growth rates for cities, towns, and rural areas through 2060. Population growth rates were applied to 2007 population-served values for each provider to project future years' service area (retail) populations.

The main source of data for per capita water use for each provider was the 2008 OCWP Provider Survey conducted by the OWRB in cooperation with the Oklahoma Rural Water Association and Oklahoma Municipal League. For each responding provider, data from the survey included population served, annual average daily demand, total water produced, wholesale purchases and sales between providers, and estimated system losses.

For missing or incomplete data, the weighted average per capita demand was used for the provider's county. In some cases, provider survey data were supplemented with data from the OWRB water rights database. Per capita supplier demands can vary over time due to precipitation and service area characteristics, such as commercial and industrial activity, tourism, or conservation measures. For the baseline demand projections described here, the per capita demand was held constant through each of the future planning year scenarios. OCWP estimates of potential reductions in demand from conservation measures are analyzed on a basin and regional level, but not for individual provider systems.

Public Water Provider Demand Forecast (2 of 4)
Central Region

Provider	SDWIS ID[1]	County	Demand (AFY)					
			2010	2020	2030	2040	2050	2060
EDMOND PWA	OK1020723	Oklahoma	9,653	11,504	13,376	15,269	17,183	19,119
EL RENO	OK2000902	Canadian	4,162	4,566	4,883	5,156	5,408	5,665
FAIRVIEW	OK2004404	Major	237	240	240	244	246	250
FRANCIS	OK2006205	Pontotoc	46	49	50	51	53	55
GEARY	OK2000608	Blaine	226	248	269	290	312	337
GOLDSBY WATER AUTH TRUST	OK2004707	McClain	211	247	279	312	346	381
GOLTRY	OK2000203	Alfalfa	32	32	32	32	32	33
GREENFIELD PWA	OK3000606	Blaine	8	9	9	10	11	12
GUTHRIE	OK1020903	Logan	2,676	3,009	3,304	3,602	3,893	4,202
HARRAH	OK2005506	Oklahoma	395	414	432	444	454	463
HEASTON RW CORP	OK3000901	Canadian	130	142	152	161	169	177
HELENA	OK2000210	Alfalfa	61	61	61	61	63	63
HENNESSEY	OK2003704	Kingfisher	238	267	294	322	350	381
HITCHCOCK DEV	OK2000610	Blaine	29	31	35	37	41	43
HOLDENVILLE	OK1020803	Hughes	611	681	751	825	907	989
HUGHES CO RWD #4	OK3003203	Hughes	67	75	82	91	100	108
JONES	OK2005507	Oklahoma	166	174	182	187	191	195
KENDRICK MUN AUTH	OK3004109	Lincoln	66	70	74	79	83	92
KINGFISHER	OK2003702	Kingfisher	884	989	1,092	1,197	1,300	1,416
KINGFISHER CO RWD #3	OK2003722	Kingfisher	32	36	40	44	48	52
KINGFISHER CO RWD #4	OK3003704	Kingfisher	5	6	7	7	8	9
KONAWA PWA	OK2006704	Seminole	123	126	130	134	138	142
LAHOMA PWA	OK2002417	Garfield	57	59	59	60	61	63
LEXINGTON	OK2001409	Cleveland	404	433	457	477	490	504
LINCOLN CO RWD #1	OK1020703	Lincoln	37	40	43	46	49	52
LINCOLN CO RWD #2	OK3004102	Lincoln	99	108	115	123	131	140
LINCOLN CO RWD #3	OK3004107	Lincoln	33	36	39	41	44	47
LINCOLN CO RW & SD #4	OK2004105	Lincoln	313	341	365	389	414	442
LOGAN CO RWD #1	OK2004207	Logan	803	901	989	1,078	1,164	1,258
LOGAN CO RWD #2	OK2004206	Logan	177	199	218	237	257	277
LONGDALE	OK2000611	Blaine	44	46	52	56	60	65
LOYAL	OK2003701	Kingfisher	12	13	15	16	17	19

Public Water Provider Demand Forecast (3 of 4)
Central Region

Provider	SDWIS ID[1]	County	Demand (AFY)					
			2010	2020	2030	2040	2050	2060
LUTHER	OK2005503	Oklahoma	90	94	98	101	104	105
MAJOR COUNTY RWD #1	OK2004407	Major	152	154	154	156	159	161
MAUD	OK2006302	Pottawatomie	108	116	123	129	136	143
MCLOUD	OK2006301	Pottawatomie	274	293	310	327	343	361
MEEKER PWA	OK3004108	Lincoln	77	83	89	95	101	108
MENO	OK2004401	Major	21	21	21	21	22	22
MERIDIAN	OK2004254	Logan	4	5	5	6	6	7
MIDWEST CITY	OK1020806	Oklahoma	4,898	5,136	5,347	5,507	5,623	5,737
MINCO	OK2002610	Grady	120	129	136	143	150	156
MOORE	OK2001412	Cleveland	6,689	7,187	7,590	7,911	8,136	8,355
MUSTANG	OK2000922	Canadian	1,838	2,016	2,156	2,277	2,389	2,502
NEWCASTLE	OK2004704	McClain	1,633	1,907	2,161	2,414	2,678	2,944
NICHOLS HILLS	OK2005501	Oklahoma	1,310	1,374	1,428	1,471	1,501	1,532
NOBLE	OK2001411	Cleveland	815	877	925	964	992	1,019
NORMAN	OK1020801	Cleveland	17,139	19,613	21,535	22,446	23,085	23,709
NORTH BLAINE WATER	OK2000606	Blaine	446	485	526	569	611	656
OKARCHE	OK2003703	Kingfisher	187	211	232	254	277	300
OKARCHE RWD	OK2003715	Kingfisher	75	85	93	102	111	121
OKEENE	OK2000612	Blaine	340	371	403	434	468	502
OKEMAH UTIL AUTH	OK1020706	Okfuskee	924	948	969	993	1,015	1,048
OKFUSKEE CO RWD #1 (BOLEY)	OK2005402	Okfuskee	20	20	21	21	22	23
OKFUSKEE CO RWD #2	OK3005402	Okfuskee	445	457	468	479	491	506
OKFUSKEE CO RWD #3	OK3005401	Okfuskee	160	164	168	172	176	182
OKLAHOMA CITY	OK1020902	Oklahoma	105,062	110,762	115,689	119,493	122,339	125,156
OKMULGEE CO RWD #7 (NUYAKA)	OK3005608	Okmulgee	226	243	257	272	288	304
PADEN	OK2005401	Okfuskee	55	56	57	58	60	62
PIEDMONT	OK2000909	Canadian	714	785	838	886	928	972
PONTOTOC CO RWD #1 (HOMER)	OK3006205	Pontotoc	105	109	113	117	120	124
PONTOTOC CO RWD #8	OK2006215	Pontotoc	301	312	323	334	343	353
POTTAWATOMIE CO DEV AUTH	OK3006303	Pottawatomie	149	159	168	177	186	196
POTTAWATOMIE CO RWD #2 (TRI COUNTY)	OK2006362	Pottawatomie	304	325	344	363	381	400
POTTAWATOMIE CO RWD #3	OK1020807	Pottawatomie	83	89	94	99	104	110

Public Water Provider Demand Forecast (4 of 4)
Central Region

Provider	SDWIS ID[1]	County	Demand (AFY)					
			2010	2020	2030	2040	2050	2060
PRAGUE	OK2004101	Lincoln	295	322	343	366	390	416
PURCELL	OK2004701	McClain	776	905	1,026	1,146	1,271	1,398
RINGWOOD	OK2004405	Major	75	75	75	76	76	78
ROCK CREEK	OK2004205	Logan	32	36	39	43	46	50
SASAKWA PWA	OK2006705	Seminole	28	30	30	30	32	32
SASAKWA RWD	OK2006708	Seminole	55	58	58	58	62	62
SEMINOLE CO RW & SWMD #3	OK3006703	Seminole	41	43	44	45	46	48
SHAWNEE	OK1020504	Pottawatomie	3,999	4,274	4,531	4,776	5,016	5,268
SLICK	OK3001921	Creek	19	21	22	23	24	26
SPENCER	OK2005509	Oklahoma	538	564	587	605	617	630
ST LOUIS RWD	OK2006304	Pottawatomie	17	18	19	20	21	22
STRATFORD	OK2002503	Garvin	241	247	250	255	260	265
STROUD PWA	OK1020705	Lincoln	415	452	483	515	548	585
TECUMSEH UTIL AUTH	OK1020506	Pottawatomie	687	734	779	821	862	905
TUTTLE	OK2002608	Grady	517	554	586	614	643	673
UNION CITY	OK3000909	Canadian	48	52	56	59	62	65
WANETTE	OK3006310	Pottawatomie	28	30	32	34	36	38
WASHINGTON	OK2004703	McClain	58	67	77	86	95	105
WATONGA	OK2000602	Blaine	1,045	1,137	1,237	1,337	1,436	1,544
WELLSTON	OK1020724	Lincoln	87	95	102	108	115	123
WETUMKA	OK1020508	Hughes	399	443	490	537	592	646
YUKON	OK2000910	Canadian	3,537	3,882	4,150	4,383	4,597	4,815

1 SDWIS - Safe Drinking Water Information System

The OWRB provider demand forecasts are not intended to supersede demand forecasts developed by individual water providers. However, the OCWP analyses sought to use a consistent methodology based on accepted data that are available on a statewide basis. When made available, provider-generated forecasts were also reviewed as part of this effort.

Wholesale Water Transfers (1 of 3)
Central Region

Provider	SDWIS ID[1]	Sales			Purchases		
		Sells to	Emergency or Ongoing	Treated or Raw or Both	Purchases from	Emergency or Ongoing	Treated or Raw or Both
ADA	OK2006201	Pontotoc Co RWD #7 Pontotoc Co RWD #6 (FITTSTOWN) Pontotoc Co RWD #9 Pontotoc Co RWD #1 (HOMER)	O O O O	T R T T			
ASHER UTIL DEV AUTH	OK3006311				Pottawatomie County RWD #3	O	T
BETHANY	OK2005519				Oklahoma City	O	T
BLANCHARD	OK3004710	Dibble	O	T	Oklahoma City	O	T
BRISTOW MUN AUTH	OK2001910	Slick	O	T			
CANADIAN CO WATER AUTH	OK3000903				Oklahoma City	O	T
CASHION	OK3003703				Logan Co RWD #2	O	T
CENTRAL OKLAHOMA MCD (Wholesaler only)	None	Del City Midwest City Norman	O O O	R R R			
CHANDLER	OK1020702	Davenport Utility Auth Lincoln Co RW & Sewer Dist #4 Lincoln Co RWD #2 Lincoln Co RWD #3	O O	B T T T			
DACOMA PWA	OK3007607				Alva	O	T
DAVENPORT UTIL AUTH	OK3004104				Chandler	O	B
DEER CREEK RURAL WATER CORP	OK2005504				Oklahoma City	O	T
DEL CITY	OK1020805				Central Oklahoma Master Conservancy	O	R
DIBBLE	OK3004709				Blanchard	O	T
DRUMMOND	OK3002401				Enid Garfield Co RWD #5	O E	T T
EDMOND PWA	OK1020723				Oklahoma City	E	T
EL RENO	OK2000902	Heaston RW Corp Minco Union City	O E O	T T T	Oklahoma City	O	T
FAIRVIEW	OK2004404	Major County RWD #1	O	T			
GEARY	OK2000608	Greenfield PWA	O	T			
GOLDSBY WATER AUTH TRUST	OK2004707				Newcastle	O	T

Wholesale Water Transfers

Some providers sell water on a "wholesale" basis to other providers, effectively increasing the amount of water that the selling provider must deliver and reducing the amount that the purchasing provider diverts from surface and groundwater sources. Wholesale water transfers between public water providers are fairly common and can provide an economical way to meet demands. Wholesale quantities typically vary from year to year depending upon growth, precipitation, emergency conditions, and agreements between systems.

Water transfers between providers can help alleviate costs associated with developing or maintaining infrastructure, such as a reservoir or pipeline; allow access to higher quality or more reliable sources; or provide additional supplies only when required, such as in cases of supply emergencies. Utilizing the 2008 OCWP Provider Survey and OWRB water rights data, the Wholesale Water Transfers table presents a summary of known wholesale arrangements for providers in the region. Transfers can consist of treated or raw water and can occur on a regular basis or only during emergencies. Providers commonly sell to and purchase from multiple water providers.

Wholesale Water Transfers (2 of 3)

Central Region

Provider	SDWIS ID[1]	Sales			Purchases		
		Sells to	Emergency or Ongoing	Treated or Raw or Both	Purchases from	Emergency or Ongoing	Treated or Raw or Both
GOLTRY	OK2000203				Jet	O	
GREENFIELD PWA	OK3000606				Geary	O	T
HEASTON RW CORP	OK3000901				El Reno	O	T
HITCHCOCK DEV	OK2000610	North Blaine Water		T	North Blaine Water	E	T
HOLDENVILLE	OK1020803	Hughes Co RWD #4 (EufaulaRegion) Hughes Co RWD #5 (EufaulaRegion) Hughes Co RWD #3 (EufaulaRegion)	E O O	T T T			
HUGHES CO RWD #4	OK3003203				Hughes Co RWD #6	O	T
KENDRICK MUN AUTH	OK3004109				Stroud Public Works Authority	O	T
KINGFISHER	OK2003702	Kingfisher Co RWD #4	O	T			
KINGFISHER CO RWD #4	OK3003704	(Eufaula Region)			Kingfisher	O	T
LAHOMA PWA	OK2002417				Enid	E	R
LEXINGTON	OK2001409				Purcell	E	T
LINCOLN CO RWD #2	OK3004102				Chandler		T
LINCOLN CO RWD #3	OK3004107				Chandler		T
LINCOLN CO RW & SD #4	OK2004105				Lone Chimney Water Association Chandler Cushing	O O E	T T T
LOGAN CO RWD #2	OK2004206	Cashion	O	T			
LOYAL	OK2003701				North Blaine Water	E	T
MAJOR COUNTY RWD #1	OK2004407				Fairview	O	T
MEEKER PWA	OK3004108				Shawnee	O	T
MIDWEST CITY	OK1020806				Central Oklahoma Master Conservancy Oklahoma City	O E	R T
MINCO	OK2002610				El Reno Union City	E E	T T
MOORE	OK2001412				Oklahoma City	O	T
MUSTANG	OK2000922				Oklahoma City	O	T
NEWCASTLE	OK2004704	Tuttle Goldsby Water Auth Trust	O O	T T	Oklahoma City	O	T
NICHOLS HILLS	OK2005501				Oklahoma City	E	T
NORMAN	OK1020801				Oklahoma City Central Oklahoma Master Conservancy	E O	T R
NORTH BLAINE WATER	OK2000606	Okeene Hitchcock Dev Loyal	O O E	T T T	Hitchcock Dev		T

Wholesale Water Transfers (3 of 3)
Central Region

Provider	SDWIS ID[1]	Sales: Sells to	Sales: Emergency or Ongoing	Sales: Treated or Raw or Both	Purchases: Purchases from	Purchases: Emergency or Ongoing	Purchases: Treated or Raw or Both
OKEENE	OK2000612				North Blaine Water	O	T
OKEMAH UTIL AUTH	OK1020706	Okfuskee Co RWD #2 Okfuskee Co RWD #3	O O	T T			
OKFUSKEE CO RWD #2	OK3005402	Seminole Co RW & SWMD #3 Hughes Co RWD # 1	O O	T T	Okemah Utilities Authority	O	T
OKFUSKEE CO RWD #3	OK3005401				Okemah Utilities Authority	O	T
OKMULGEE CO RWD #7 (NUYAKA)	OK3005608				Okmulgee Okmulgee Co RWD #6	O E	T T
OKLAHOMA CITY	OK1020902	Moore Yukon Blanchard Newcastle Norman Edmond PWA - Arcadia Mustang Canadian Co Water Authority Bethany El Reno Midwest City Nichols Hills Deer Creek Rural Water Corp Piedmont	O O O O E E O O O O E E O O	T T T T T T T T T T T T T T			
PIEDMONT	OK2000909				Oklahoma City	O	T
PONTOTOC CO RWD # 1 (HOMER)	OK3006205				Ada	O	T
POTTAWATOMIE CO DEV AUTH	OK3006303	Tecumseh Utility Authority	E	T	Shawnee	O	T
POTTAWATOMIE CO RWD #3	OK1020807	Asher Util Dev Auth Wanette	O O	T	Oklahoma City	O	R
PURCELL	OK2004701	Lexington	E	T			
SEMINOLE CO RW & SWMD #3	OK3006703				Okfuskee Co RWD # 2	O	T
SHAWNEE	OK1020504	Pottawatomie Co Development Auth Meeker Public Works Authority	O O	T T			
SLICK	OK3001921				Bristow Mun Auth	O	T
STROUD PWA	OK1020705	Kendrick Municipal Authority	O	T			
TECUMSEH UTIL AUTH	OK1020506				Pottawatomie Co Development Auth	E	T
TUTTLE	OK2002608	Grady Co RWD #6	O	T			
UNION CITY	OK3000909	Minco	E	T	El Reno	O	T
WANETTE	OK3006310				Pottawatomie County RWD #3	O	
WETUMKA	OK1020508	Hughes County RWD #1	O	T			
YUKON	OK2000910				Oklahoma City	O	T

1 SDWIS - Safe Drinking Water Information System

Provider Water Rights

Public water providers using surface water or groundwater obtain water rights from the OWRB. Water providers purchasing water from other suppliers or sources are not required to obtain water rights as long as the furnishing entity has the appropriate water right or other source of authority. Each public water provider's current water right(s) and source of supply have been summarized in this report. The percentage of each provider's total 2007 water rights from surface water, alluvial groundwater, and bedrock groundwater supplies was also calculated, indicating the relative proportions of sources available to each provider.

A comparison of existing water rights to projected demands can show when additional water rights or other sources and in what amounts might be needed. Forecasts of conditions for the year 2060 indicate where additional water rights may be needed to satisfy demands by that time. However, in most cases, wholesale water transfers to other providers must also be addressed by the selling provider's water rights. Thus, the amount of water rights required will exceed the retail demand for a selling provider and will be less than the retail demand for a purchasing provider.

In preparing to meet long-term needs, public water providers should consider strategic factors appropriate to their sources of water. For example, public water providers who use surface water can seek and obtain a "schedule of use" as part of their stream water right, which addresses projected growth and consequent increases in stream water use. Such schedules of use can be employed to address increases that are anticipated to occur over many years or even decades, as an alternative to the usual requirement to use the full authorized amount of stream water in a seven-year period. On the other hand, public water providers that utilize groundwater should consider the prospect that it may be necessary to purchase or lease additional land in order to increase their groundwater rights.

Public Water Provider Water Rights and Withdrawals - 2010 (1 of 4)

Central Region

Provider	SDWIS ID[1]	County	Permitted Quantity	Source		
				Permitted Surface Water	Permitted Alluvial Groundwater	Permitted Bedrock Groundwater
			AFY	Percent		
ADA	OK2006201	Pontotoc	17,941	48%	0%	52%
ALINE	OK2000206	Alfalfa	---	---	---	---
AMES	OK2004403	Major	42	0%	100%	0%
ASHER UTIL DEV AUTH	OK3006311	Pottawatomie	153	0%	0%	100%
BETHANY	OK2005519	Oklahoma	7,932	0%	100%	0%
BLANCHARD	OK3004710	McClain	1,650	---	---	100%
BOWLEGS/LIMA WATER	OK2006701	Seminole	250	0%	0%	100%
BRISTOW MUN AUTH	OK2001910	Creek	1,406	0%	0%	100%
BROOKSVILLE	OK2006363	Pottawatomie	57	0%	5%	95%
CALUMET	OK2000904	Canadian	256	0%	100%	0%
CALVIN	OK2003201	Hughes	793	---	100%	---
CANADIAN CO RWD #1	OK2000908	Canadian	---	---	---	---
CANADIAN CO RWD #4	OK2000930	Canadian	---	---	---	---
CANADIAN CO WATER AUTH	OK3000903	Canadian	---	---	---	---
CANTON	OK2000607	Blaine	157	0%	0%	100%
CARMEN	OK2000207	Alfalfa	402	0%	100%	0%
CARNEY	OK2004104	Lincoln	59	0%	0%	100%
CASHION	OK3003703	Kingfisher	63	0%	0%	100%
CENTRAL OKLAHOMA MCD (Wholesaler Only)	None	Cleveland	21,600	100%	0%	0%
CHANDLER	OK1020702	Lincoln	5,062	99%	0%	1%
CHOCTAW	OK2005510	Oklahoma	3,401	0%	64%	36%
CIMARRON CITY	OK2004253	Logan	28	0%	100%	0%
CLEO SPRINGS	OK2004402	Major	286	0%	100%	0%
COLE	OK3004708	McClain	---	---	---	---
CRESCENT	OK2004204	Logan	575	0%	100%	0%
DACOMA PWA	OK3007607	Woods	---	---	---	---
DAVENPORT UTIL AUTH	OK3004104	Lincoln	183	100%	0%	0%
DEER CREEK RURAL WATER CORP	OK2005504	Oklahoma	2,543	0%	0%	100%
DEL CITY	OK1020805	Oklahoma	22,688	0%	1%	99%
DEPEW	OK2001903	Creek	440	0%	0%	100%
DIBBLE	OK3004709	McClain	18	0%	0%	100%
DOVER PUBLIC WORKS TRUST AUTH	OK2003705	Kingfisher	361	0%	100%	0%

Public Water Provider Water Rights and Withdrawals - 2010 (2 of 4)

Central Region

Provider	SDWIS ID[1]	County	Permitted Quantity	Source: Permitted Surface Water	Source: Permitted Alluvial Groundwater	Source: Permitted Bedrock Groundwater
			AFY	Percent		
DRUMMOND	OK3002401	Garfield	---	---	---	---
EDMOND PWA	OK1020723	Oklahoma	44,450	28%	0%	72%
EL RENO	OK2000902	Canadian	3,890	0%	100%	0%
FAIRVIEW	OK2004404	Major	2,559	0%	0%	0%
FRANCIS	OK2006205	Pontotoc	78	0%	10%	90%
GEARY	OK2000608	Blaine	745	0%	100%	0%
GOLDSBY WATER AUTH TRUST	OK2004707	McClain	1,676	0%	100%	0%
GOLTRY	OK2000203	Alfalfa	129	0%	0%	100%
GREENFIELD PWA	OK3000606	Blaine	17	0%	100%	0%
GUTHRIE	OK1020903	Logan	6,681	75%	0%	24%
HARRAH	OK2005506	Oklahoma	1,861	0%	8%	92%
HEASTON RW CORP	OK3000901	Canadian	---	---	---	---
HELENA	OK2000210	Alfalfa	748	0%	0%	100%
HENNESSEY	OK2003704	Kingfisher	464	0%	100%	0%
HITCHCOCK DEV	OK2000610	Blaine	12	0%	100%	0%
HOLDENVILLE	OK1020803	Hughes	4,650	100%	0%	0%
HUGHES CO RWD #4	OK3003203	Hughes	---	---	---	---
JONES	OK2005507	Oklahoma	422	0%	0%	100%
KENDRICK MUN AUTH	OK3004109	Lincoln	---	---	---	---
KINGFISHER	OK2003702	Kingfisher	3,492	0%	100%	0%
KINGFISHER CO RWD #3	OK2003722	Kingfisher	296	---	100%	---
KINGFISHER CO RWD #4	OK3003704	Kingfisher	---	---	---	---
KONAWA PWA	OK2006704	Seminole	302	0%	74%	26%
LAHOMA PWA	OK2002417	Garfield	370	0%	14%	86%
LEXINGTON	OK2001409	Cleveland	734	0%	100%	0%
LINCOLN CO RWD #1	OK1020703	Lincoln	36	100%	0%	0%
LINCOLN CO RWD #2	OK3004102	Lincoln	---	---	---	---
LINCOLN CO RWD #3	OK3004107	Lincoln	---	---	---	---
LINCOLN CO RW & SD #4	OK2004105	Lincoln	352	0%	0%	100%
LOGAN CO RWD #1	OK2004207	Logan	2,059	0%	0%	100%
LOGAN CO RWD #2	OK2004206	Logan	464	0%	100%	0%
LONGDALE	OK2000611	Blaine	61	0%	100%	0%

Public Water Provider Water Rights and Withdrawals - 2010 (3 of 4)

Central Region

Provider	SDWIS ID[1]	County	Permitted Quantity	Source		
				Permitted Surface Water	Permitted Alluvial Groundwater	Permitted Bedrock Groundwater
			AFY	Percent		
LOYAL	OK2003701	Kingfisher	---	---	---	---
LUTHER	OK2005503	Oklahoma	210	0%	0%	100%
MAJOR COUNTY RWD #1	OK2004407	Major	753	0%	100%	0%
MAUD	OK2006302	Pottawatomie	410	0%	0%	100%
MCLOUD	OK2006301	Pottawatomie	712	0%	100%	0%
MEEKER PWA	OK3004108	Lincoln	407	100%	0%	0%
MENO	OK2004401	Major	238	0%	100%	0%
MERIDIAN	OK2004254	Logan	170	---	---	100%
MIDWEST CITY	OK1020806	Oklahoma	28,212	0%	0%	100%
MINCO	OK2002610	Grady	479	0%	100%	0%
MOORE	OK2001412	Cleveland	9,513	0%	0%	100%
MUSTANG	OK2000922	Canadian	3,809	0%	97%	3%
NEWCASTLE	OK2004704	McClain	1,649	0%	100%	0%
NICHOLS HILLS	OK2005501	Oklahoma	5,511	0%	0%	100%
NOBLE	OK2001411	Cleveland	1,644	0%	0%	100%
NORMAN	OK1020801	Cleveland	37,089	0%	8%	92%
NORTH BLAINE WATER	OK2000606	Blaine	518	0%	85%	15%
OKARCHE	OK2003703	Kingfisher	124	0%	100%	0%
OKARCHE RWD	OK2003715	Kingfisher	---	---	---	---
OKEENE	OK2000612	Blaine	745	0%	100%	0%
OKEMAH UTIL AUTH	OK1020706	Okfuskee	1,779	100%	0%	0%
OKFUSKEE CO RWD #1 (BOLEY)	OK2005402	Okfuskee	300	---	---	100%
OKFUSKEE CO RWD #2	OK3005402	Okfuskee	---	---	---	---
OKFUSKEE CO RWD #3	OK3005401	Okfuskee	---	---	---	---
OKLAHOMA CITY	OK1020902	Oklahoma	214,065	99%	0%	1%
OKMULGEE CO RWD #7 (NUYAKA)	OK3005608	Okmulgee	---	---	---	---
PADEN	OK2005401	Okfuskee	960	---	---	100%
PIEDMONT	OK2000909	Canadian	---	---	---	---
PONTOTOC CO RWD #1 (HOMER)	OK3006205	Pontotoc	---	---	---	---
PONTOTOC CO RWD #8	OK2006215	Pontotoc	---	---	---	---
POTTAWATOMIE CO DEV AUTH	OK3006303	Pottawatomie	5,000	100%	0%	0%
POTTAWATOMIE CO RWD #2 (TRI COUNTY)	OK2006362	Pottawatomie	101	0%	100%	0%
POTTAWATOMIE CO RWD #3	OK1020807	Pottawatomie	---	---	---	---

Public Water Provider Water Rights and Withdrawals - 2010 (4 of 4)

Central Region

Provider	SDWIS ID[1]	County	Permitted Quantity	Source		
				Permitted Surface Water	Permitted Alluvial Groundwater	Permitted Bedrock Groundwater
			AFY	Percent		
PRAGUE	OK2004101	Lincoln	1,672	0%	17%	83%
PURCELL	OK2004701	McClain	5,472	0%	19%	81%
RINGWOOD	OK2004405	Major	30	0%	100%	0%
ROCK CREEK	OK2004205	Logan	---	---	---	---
SASAKWA PWA	OK2006705	Seminole	453	0%	0%	100%
SASAKWA RWD	OK2006708	Seminole	---	---	---	---
SEMINOLE CO RW & SWMD #3	OK3006703	Seminole	---	---	---	---
SHAWNEE	OK1020504	Pottawatomie	30,736	85%	0%	15%
SLICK	OK3001921	Creek	100	---	100%	---
SPENCER	OK2005509	Oklahoma	2,274	0%	0%	100%
ST LOUIS RWD	OK2006304	Pottawatomie	213	0%	0%	100%
STRATFORD	OK2002503	Garvin	392	0%	100%	0%
STROUD PWA	OK1020705	Lincoln	1,322	83%	0%	17%
TECUMSEH UTIL AUTH	OK1020506	Pottawatomie	418	100%	0%	0%
TUTTLE	OK2002608	Grady	283	0%	14%	86%
UNION CITY	OK3000909	Canadian	74	0%	100%	0%
WANETTE	OK3006310	Pottawatomie	---	---	---	---
WASHINGTON	OK2004703	McClain	86	0%	100%	0%
WATONGA	OK2000602	Blaine	4,237	0%	100%	0%
WELLSTON	OK1020724	Lincoln	318	---	25%	75%
WETUMKA	OK1020508	Hughes	750	100%	0%	0%
YUKON	OK2000910	Canadian	6,253	0%	79%	21%

1 SDWIS - Safe Drinking Water Information System

Provider Supply Plans

In 2008, a survey was sent to 785 municipal and rural water providers throughout Oklahoma to collect vital background water supply and system information. Additional detail for each of these providers was solicited in 2010 as part of follow-up interviews conducted by the ODEQ. The 2010 interviews sought to confirm key details of the earlier survey and document additional details regarding each provider's water supply infrastructure and plans. This included information on existing sources of supply (including surface water, groundwater, and other providers), short-term supply and infrastructure plans, and long-term supply and infrastructure plans.

In instances where no new source was identified, maintenance of the current source of supply is expected into the future. Providers may or may not have secured the necessary funding to implement their stated plans concerning infrastructure needs, commonly including additional wells or raw water conveyance, storage, and replacement/upgrade of treatment and distribution systems.

Additional support for individual water providers wishing to pursue enhanced planning efforts is documented in the Public Water Supply Planning Guide. This guide details how information contained in the OCWP *Watershed Planning Region Reports* and related planning documents can be used to formulate provider-level plans to meet present and future needs of individual water systems.

City of Ada (Pontotoc County)
Current Source of Supply
Primary source: Spring, Byrds Mill Spring
Short-Term Needs
Infrastructure improvements: construction of reservoir.
Long-Term Needs
None identified.

Town of Aline (Alfalfa County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Town of Ames (Major County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: recondition existing water towers; drill additional well.
Long-Term Needs
Infrastructure improvements: drill additional wells; emergency connection to the City of Enid.

Asher Util Dev Auth (Pottawatomie County)
Current Source of Supply
Primary source: Pottawatomie RWD 3
Short-Term Needs
Infrastructure improvements: upgrade distribution lines.
Long-Term Needs
Infrastructure improvements: replace distribution system lines.

City of Bethany (Oklahoma County)
Current Source of Supply
Primary source: groundwater and Oklahoma City
Short-Term Needs
Infrastructure improvements: drill additional wells.
Long-Term Needs
Infrastructure improvements: drill additional wells.

City of Blanchard (McClain County)
Current Source of Supply
Primary source: Oklahoma City
Short-Term Needs
Infrastructure improvements: paint water tower.
Long-Term Needs
Infrastructure improvements: add storage tanks; replace distribution system lines.

Town of Bowlegs/Lima Water (Seminole County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: expand well system in Ada-Vamoosa aquifer.
Long-Term Needs
None identified.

Bristow MA (Creek County)
Current Source of Supply
Primary source: groundwater.
Short-Term Needs
Infrastructure improvements: (in progress) install additional lines and fire hydrants, construct new water tower, and secure water rights to drill additional wells to serve estimated 350 new rural residents; increase sizes of main lines for additional capacity and fire flow.
Long-Term Needs
Infrastructure improvements: drill additional wells; replace distribution system.

Town of Brooksville (Pottawatomie County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: recondition storage tank.
Long-Term Needs
None identified.

Town of Calumet (Canadian County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: drill additional wells.
Long-Term Needs
Infrastructure improvements: drill additional wells.

Town of Calvin (Hughes County)
Current Source of Supply
Primary source: groundwater.
Short-Term Needs
Infrastructure improvements: drill additional wells.
Long-Term Needs
None identified.

Canadian County RWD 1
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: drill additional wells.
Long-Term Needs
Infrastructure improvements: drill additional wells.

Canadian County RWD 4
Current Source of Supply
Primary source: groundwater
Emergency supply source: City of El Reno
Short-Term Needs
Infrastructure improvements: drill additional wells.
Long-Term Needs
Infrastructure improvements: drill additional wells; expand distribution lines.

Canadian County Water Authority
Current Source of Supply
Primary source: City of Oklahoma City
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Town of Canton (Blaine County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Town of Carmen (Alfalfa County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Town of Carney (Lincoln County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: water tower maintenance.
Long-Term Needs
Infrastructure improvements: expand distribution system.

Town of Cashion (Kingfisher County)
Current Source of Supply
Primary source: Logan County RWD 2
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Central Oklahoma MCD (Wholesale)
Current Source of Supply
Primary source: Lake Thunderbird
Short-Term Needs
Infrastructure improvements: rehabilitation of several tanks.
Long-Term Needs
Infrastructure improvements: replace transmission line to Del City; new transmission facilities to import water.

City of Chandler (Lincoln County)
Current Source of Supply
Primary source: Bell Cow Lake
Emergency supply source: Chandler Lake
Short-Term Needs
New supply source: Chandler Lake
Long-Term Needs
Infrastructure improvements: replace water line to Davenport.

City of Choctaw (Oklahoma County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: build additional storage; replace outdated distribution lines; add new lines.
Long-Term Needs
Infrastructure improvements: replace 5 wells; replace distribution system; add storage.

Cimarron City (Logan County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Town of Cleo Springs (Major County)
Current Source of Supply
Primary source: City of Wynnewood
Short-Term Needs
Infrastructure improvements: drill new well.
Long-Term Needs
Infrastructure improvements: drill new well.

Town of Cole (McClain County)
Current Source of Supply
Primary source: City of Blanchard
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: add distribution system lines; add water tower.

City of Crescent (Logan County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: drill additional wells.
Long-Term Needs
Infrastructure improvements: drill additional wells.

Dacoma PWA (Woods County)
Current Source of Supply
Primary source: City of Alva
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Davenport UA (Lincoln County)
Current Source of Supply
Primary source: City of Chandler
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: add storage structure.

OCWP Provider Survey
Central Region

Deer Creek Rural Water Corp. (Oklahoma County)
Current Source of Supply
Primary source: groundwater, City of Oklahoma City
Short-Term Needs
Infrastructure improvements: drill 4 new wells; add water main lines to loop existing mains.
Long-Term Needs
Infrastructure improvements: drill 4 new wells; add meters, storage tower and water main piping.

City of Del City (Oklahoma County)
Current Source of Supply
Primary source: groundwater, Lake Thunderbird (COMCD)
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Town of Depew (Creek County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: add water tower.
Long-Term Needs
Infrastructure improvements: drill additional wells.

Town of Dibble (McClain County)
Current Source of Supply
Primary source: City of Blanchard
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: add water tower; add pump station; add fire hydrants.

Dover PWTA (Kingfisher County)
Current Source of Supply
Primary source: Cimarron Alluvial Terrace Aquifer
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Town of Drummond (Garfield County)
Current Source of Supply
Primary source: City of Enid
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Edmond PWA (Oklahoma County)
Current Source of Supply
Primary source: Arcadia lake
Short-Term Needs
Infrastructure improvement: replace 6 booster pumps; replace distribution lines >40 years; maintenance on storage tanks.
Long-Term Needs
New supply source: obtaining additional water rights from Arcadia and Sardis Lakes.

City of El Reno (Canadian County)
Current Source of Supply
Primary source: groundwater and City of Oklahoma City
Short-Term Needs
Infrastructure improvements: drill additional wells.
Long-Term Needs
Infrastructure improvement: drill additional wells.

City of Fairview (Major County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvement: add pumps; add storage; replace transmission lines.
Long-Term Needs
None identified.

Town of Francis (Pontotoc County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvement: add water lines.
Long-Term Needs
Infrastructure improvement: add generators and water lines.

City of Geary (Blaine County)
Current Source of Supply
Primary source: groundwater (Ogallala)
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvement: add water lines.

Goldsby Water Authority Trust (McClain County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvement: drill new well.
Long-Term Needs
Infrastructure improvement: add water tower; upgrade and add distribution system lines.

Town of Goltry (Alfalfa County)
Current Source of Supply
Primary source: Town of Jet
Short-Term Needs
Infrastructure improvement: refurbish existing wells.
Long-Term Needs
None identified.

Greenfield PWA (Blaine County)
Current Source of Supply
Primary source: City of Geary
Short-Term Needs
None identified.
Long-Term Needs
None identified.

City of Guthrie (Logan County)
Current Source of Supply
Primary source: Lake Guthrie, Liberty Lake
Short-Term Needs
None identified.
Long-Term Needs
None identified.

City of Harrah (Oklahoma County)
Current Source of Supply
Primary source: Garber-Wellington
Short-Term Needs
Infrastructure improvement: refurbish well 3.
Long-Term Needs
Infrastructure improvement: drill additional wells; add water towers.

Heaston RW Corp. (Canadian County)
Current Source of Supply
Primary source: City of El Reno
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: Upgrade distribution system lines.

Town of Helena (Alfalfa County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
New supply source: connect to Jet and Goltry; drill new wells.
Long-Term Needs
New supply source: connect to Jet and Goltry; drill new wells.

Town of Hennessey (Kingfisher County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
New supply source: purchase additional water rights.
Long-Term Needs
Infrastructure improvements: add storage.

Hitchcock Dev (Blaine County)
Current Source of Supply
Primary source: None identified
Short-Term Needs
None identified.
Long-Term Needs
None identified.

City of Holdenville (Hughes County)
Current Source of Supply
Primary source: Lake Holdenville
Short-Term Needs
New supply source: expand Lake Holdenville by connection to another lake.
Long-Term Needs
New supply source: expand Lake Holdenville by connection to another lake.

Hughes County RWD 4
Current Source of Supply
Primary source: Hughes County 6
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Town of Jones (Oklahoma County)
Current Source of Supply
Primary source: Garber-Wellington
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Kendrick Municipal Auth. (Lincoln County)
Current Source of Supply
Primary source: Stroud Lake
Short-Term Needs
Infrastructure improvements: add distribution lines.
Long-Term Needs
Infrastructure improvements: add water tower.

City of Kingfisher (Kingfisher County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: drill additional wells; add new storage.
Long-Term Needs
Infrastructure improvements: drill additional wells.

Kingfisher County RWD 3
Current Source of Supply
Primary source: groundwater
Emergency source: City of Kingfisher
Short-Term Needs
None identified.
Long-Term Needs
New supply source: City of Kingfisher

Kingfisher County RWD 4
Current Source of Supply
Primary source: City of Kingfisher
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Konawa PWA (Seminole County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: drill additional wells; refurbish underground storage tank; install above ground storage; replace distribution lines.
Long-Term Needs
Infrastructure improvements: drill additional wells; replace distribution lines.

Lahoma PWA (Garfield County)
Current Source of Supply
Primary source: City of Enid
Short-Term Needs
None identified.
Long-Term Needs
None identified.

City of Lexington (Cleveland County)
Current Source of Supply
Primary source: groundwater
Emergency source: City of Purcell
Short-Term Needs
New supply source: purchase additional water from Cleveland County RWD 1.
Infrastructure improvements: refurbish storage tank.
Long-Term Needs
Infrastructure improvements: Expand distribution system pipe and add storage.

Lincoln County RW & SD 4
Current Source of Supply
Primary source: groundwater, City of Chandler, Lone Chimney Assoc.
Emergency source: City of Cushing
Short-Term Needs
Infrastructure improvements: drill additional well; refurbish existing wells; add water tower.
Long-Term Needs
Infrastructure improvements: add storage, add line meters.

Lincoln County RWD 1
Current Source of Supply
Primary source: Sparks Lake
Short-Term Needs
Infrastructure improvements: add storage; add raw water pump.
Long-Term Needs
Infrastructure improvements: upsize distribution system lines; add pumps and motors to distribution lines.

Lincoln County RWD 2
Current Source of Supply
Primary source: City of Chandler
Short-Term Needs
Infrastructure improvements: refurbish storage tanks.
Long-Term Needs
Infrastructure improvements: upsize main distribution lines; add looping lines.

Lincoln County RWD 3
Current Source of Supply
Primary source: City of Chandler
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: replace portion of distribution lines; refurbish water tower.

Logan County RWD 1
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: drill additional wells.
Long-Term Needs
New supply source: possibly purchase from Guthrie or Edmond.

Logan County RWD 2
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: drill additional wells.

Town of Longdale (Blaine County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
New supply source: possibly connect with North Blaine County Water.
Long-Term Needs
Infrastructure improvements: drill additional wells.

Town of Loyal (Kingfisher County)
Current Source of Supply
Primary source: groundwater
Emergency source: North Blaine Rural Water
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: drill additional wells.

Town of Luther (Oklahoma County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: install strainer on water tower; refurbish existing wells.
Long-Term Needs
Infrastructure improvements: drill additional wells.

Major County RWD 1
Current Source of Supply
Primary source: groundwater: N. Canadian R. and Cimarron Alluvial Terrace
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: add distribution lines.

City of Maud (Pottawatomie County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: drill additional wells.

Town of McLoud (Pottawatomie County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
New supply source: interconnect with Citizen Pottawatomie Nation RWD 3.

City of Meeker PWA (Lincoln County)
Current Source of Supply
Primary source: City of Shawnee
Short-Term Needs
Infrastructure improvements: install strainer on water tower; refurbish existing wells.
Long-Term Needs
Infrastructure improvements: replace distribution lines; refurbish existing wells.

Town of Meno (Major County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: drill additional well.
Long-Term Needs
Infrastructure improvements: drill additional wells.

Town of Meridian (Logan County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
New supply source: evaluating potential connection to Langston.
Long-Term Needs
None identified.

Midwest City (Oklahoma County)
Current Source of Supply
Primary source: groundwater; Lake Thunderbird COMCD)
Short-Term Needs
New supply source: increase pumping from wells.
Long-Term Needs
New supply source: additional use of Lake Thunderbird allotment.

Town of Minco (Grady County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
None identified.

City of Moore (Cleveland County)
Current Source of Supply
Primary source: groundwater; City of Oklahoma City
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: replace distribution lines; add storage.

City of Mustang (Canadian County)
Current Source of Supply
Primary source: groundwater; City of Oklahoma City
Short-Term Needs
None identified.
Long-Term Needs
New supply source: increase City of Oklahoma City supply.
Infrastructure improvements: drill additional wells.

City of Newcastle (McClain County)
Current Source of Supply
Primary source: groundwater: S. Canadian River Alluvial and Terrace
Short-Term Needs
New supply source: City of Oklahoma City
Infrastructure improvements: add distribution lines.
Long-Term Needs
None identified.

City of Nichols Hills (Oklahoma County)
Current Source of Supply
Primary source: groundwater: Garber-Wellington
Short-Term Needs
Infrastructure improvements: drill additional wells; add storage and booster station.
Long-Term Needs
Infrastructure improvements: drill additional wells; add storage.

OCWP Provider Survey
Central Region

City of Noble (Cleveland County)
Current Source of Supply
Primary source: groundwater: terrace deposit and Garber-Wellington
Short-Term Needs
Infrastructure improvements: drill additional wells; add distribution lines; refurbish existing water towers.
Long-Term Needs
New supply source: drill additional wells; purchase from Oklahoma City.

City of Norman (Cleveland County)
Current Source of Supply
Primary source: groundwater, Lake Thunderbird (COMCD)
Short-Term Needs
Infrastructure improvements: in the process of constructing ten additional wells.
Long-Term Needs
Infrastructure improvements: evaluating options such as additional water rights and/or wells; additional treatment facilities; augmenting Lake Thunderbird with out-of-basin sources; and/or purchasing from Oklahoma City.

North Blaine Water (Blaine County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: drill additional wells.
Long-Term Needs
Infrastructure improvements: drill additional wells.

City of Okarche (Kingfisher County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: drill additional well.
Long-Term Needs
Infrastructure improvements: drill additional wells.

Okarche RWD (Kingfisher County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Town of Okeene (Blaine County)
Current Source of Supply
Primary source: groundwater: Cimarron River Terrace; North Blaine Water Corporation.
Short-Term Needs
New supply source: groundwater: N. Canadian River Terrace and alluvial aquifer.
Infrastructure improvements: drill additional wells.
Long-Term Needs
Infrastructure improvements: drill additional wells.

Okemah Utilities Authority (Okfuskee County)
Current Source of Supply
Primary source: Okemah Lake
Short-Term Needs
Infrastructure improvements: replace raw water pump and distribution pumps; refurbish existing water towers.
Long-Term Needs
Infrastructure improvements: new WTP.

Okfuskee County RWD 1 (Boley)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: drill additional wells; replace portion of existing distribution lines.
Long-Term Needs
Infrastructure improvements: drill additional wells.

Okfuskee County RWD 2
Current Source of Supply
Primary source: Okemah Utilities Authority
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Okfuskee County RWD 3
Current Source of Supply
Primary source: City of Okemah
Short-Term Needs
Infrastructure improvements: Replace existing standpipe.
Long-Term Needs
New supply source: Evaluating coop with the City of Okemah and Okfuskee Co. RWD 2.
Infrastructure improvements: upgrade water main lines.

Oklahoma City (Oklahoma County)
Current Source of Supply
Primary source: Lakes Atoka, Canton, Draper & Hefner
Short-Term Needs
New supply sources: Lake Atoka Dam is currently under engineering investigation.
Long-Term Needs
None identified.

Okmulgee County RWD 7 (Nuyaka)
Current Source of Supply
Primary source: City of Okmulgee, Okmulgee Co. RWD 6
Short-Term Needs
Infrastructure improvements: add water tower; add distribution system lines.
Long-Term Needs
Infrastructure improvements: add distribution system lines.

Town of Paden (Okfuskee County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: add storage; replace transmission and distribution lines; replace valves.
Long-Term Needs
Infrastructure improvements: drill additional well; replace distribution lines.

City of Piedmont (Canadian County)
Current Source of Supply
Primary source: groundwater; City of Oklahoma City
Short-Term Needs
New supply source: purchase additional from Oklahoma City.
Long-Term Needs
New supply source: purchase additional from Oklahoma City.
Infrastructure improvements: construct larger interceptor to Oklahoma City.

Pontotoc County RWD 1 (Homer)
Current Source of Supply
Primary source: City of Ada
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: replace distribution lines.

Pontotoc County RWD 8
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: upgrade replace distribution lines.
Long-Term Needs
Infrastructure improvements: drill additional wells; add distribution lines; add storage tanks.

Pottawatomie County RWD 2
Current Source of Supply
Primary source: groundwater
Short-Term Needs
New supply source: connect to Seminole water.
Long-Term Needs
New supply source: develop water agreements with neighbors such as Tecumseh and Shawnee.

Pottawatomie County Development Auth.
Current Source of Supply
Primary source: City of Shawnee
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Pottawatomie County RWD 3
Current Source of Supply
Primary source: raw water from Atoka pipeline (Oklahoma City)
Short-Term Needs
New supply source: planning for connections to Tecumseh and Citizen Pottawatomie Nation.
Long-Term Needs
New supply source: possible get water from Wes Watkins Reservoir.

City of Prague (Lincoln County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: drill additional well.
Long-Term Needs
New supply source: Prague Lake
Infrastructure improvements: water lines to Prague Lake. Main lines will be extended throughout the Prague area to loop the system and connect to these outside areas.

City of Purcell (McClain County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: drill additional wells; replace well pumps with variable frequency drives.
Long-Term Needs
None identified.

City of Ringwood (Major County)
Current Source of Supply
Primary source: City of Chandler
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: Drill additional wells to meet demand; add distribution lines.

Rock Creek (Logan County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Sasakwa PWA (Seminole County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Town of Sasakwa (Seminole County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: drill additional wells.
Long-Term Needs
Infrastructure improvements: drill additional wells; add storage.

Seminole County RW & SWMD 3
Current Source of Supply
Primary source: Okfuskee County RWD 2
Short-Term Needs
Infrastructure improvements: upgrade existing water tower; add water tower.
Long-Term Needs
Infrastructure improvements: drill additional wells.

City of Shawnee (Pottawatomie County)
Current Source of Supply
Primary source: Shawnee Twin Lakes, Wes Watkins Reservoir
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: install 30in raw water line from Twin Lakes to WTP; replace pumps and controls at WTP.

Town of Slick (Creek county)
Current Source of Supply
Primary source: groundwater: N. Canadian R. and Cimarron Alluvial Terrace
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: replace distribution lines.

City of Spencer (Oklahoma County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: refurbish existing wells; add computer drive system, well meters and blending tank; replace storage tanks.
Long-Term Needs
Infrastructure improvements: refurbish existing wells; add computer drive system, well meters and blending tank; replace storage tanks.

St. Louis RWD (Pottawatomie County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Town of Stratford (Garvin County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
Infrastructure improvements: replace distribution lines.

Stroud PWA (Lincoln County)
Current Source of Supply
Primary source: Stroud Municipal Lake
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Tecumseh Utility Authority (Pottawatomie County)
Current Source of Supply
Primary source: Lake Tecumseh, groundwater
Short-Term Needs
New supply source: Wes Watkins Reservoir and connect with Pottawatomie RWD 3.
Infrastructure improvements: new line from Wes Watkins Reservoir to Tecumseh Lake; construct interconnect with Pottawatomie RWD #3 as back up source.
Long-Term Needs
None identified.

City of Tuttle (Grady County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: add additional wells; extend infrastructure to new development.
Long-Term Needs
Infrastructure improvements: loop system for better service and pressure.

Town of Union City (Canadian County)
Current Source of Supply
Primary source: City of El Reno
Short-Term Needs
None identified.
Long-Term Needs
None identified.

Town of Wanette (Pottawatomie County)
Current Source of Supply
Primary source: Pottawatomie County RWD 3
Short-Term Needs
Infrastructure improvements: replace distribution lines.
Long-Term Needs
None identified.

Town of Washington (McClain County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
Infrastructure improvements: replace distribution lines.
Long-Term Needs
Infrastructure improvements: add storage; replace and upgrade distribution lines.

City of Watonga (Blaine County)
Current Source of Supply
Primary source: groundwater
Short-Term Needs
None identified.
Long-Term Needs
None identified.

City of Wellston (Lincoln County)
Current Source of Supply
Primary source: Bell Cow Lake
Short-Term Needs
None identified.
Long-Term Needs
New supply source: contract for Bell Cow will expire: may need new source.
Infrastructure improvements: replace distribution system lines; add water tower; new WTP.

City of Wetumka (Hughes County)
Current Source of Supply
Primary source: Wetumka Lake
Short-Term Needs
Infrastructure improvements: replace some distribution lines.
Long-Term Needs
Infrastructure improvements: replace water main lines.

City of Yukon (Canadian County)
Current Source of Supply
Primary source: groundwater; City of Oklahoma City
Short-Term Needs
None identified.
Long-Term Needs
New supply source: purchase additional water from Oklahoma City.

Infrastructure Cost Summary

Central Region

Provider System Category[1]	Infrastructure Need (millions of 2007 dollars)			
	Present - 2020	2021 - 2040	2041 - 2060	Total Period
Small	$668	$71	$5,720	$6,458
Medium	$839	$447	$1,134	$2,420
Large	$1,161	$417	$1,162	$2,740
Reservoir[2]	$31	$51	$115	$196
Total	$2,699	$985	$8,129	$11,814

1 Large providers are defined as those serving more than 100,000 people, medium systems as those serving between 3,301 and 100,000 people, and small systems as those serving 3,300 or fewer people.

2 The "reservoir" category refers specifically to rehabilitation projects.

- Approximately $11.8 billion is needed to meet the projected drinking water infrastructure needs of the Central Region over the next 50 years. The largest infrastructure costs are expected to occur after 2040.
- Distribution and transmission projects account for more than 90 percent of the providers' estimated infrastructure costs, followed distantly by water treatment projects.
- Small providers have the largest overall drinking water infrastructure costs.
- Projects involving rehabilitation of existing reservoirs comprise approximately two percent of the total costs.

Drinking Water Infrastructure Cost Summary

As part of the public water provider analysis, regional cost estimates to meet system drinking water infrastructure needs over the next 50 years were prepared. While it is difficult to account for changes that may occur within this extended time frame, it is beneficial to evaluate, at least on the order-of-magnitude level, the long-range costs of providing potable water.

Project cost estimates were developed for a selection of existing water providers, and then weighted to determine total regional costs. The OCWP method is similar to that utilized by the EPA to determine national drinking water infrastructure costs in 2007. However, the OCWP uses a 50-year planning horizon while the EPA uses a 20-year period. Also, the OCWP includes a broader spectrum of project types rather than limiting projects to those eligible for the Drinking Water State Revolving Fund program. While estimated costs for new reservoirs are not included, rehabilitation project costs for existing major reservoirs were applied at the regional level.

More information on the methodology and cost estimates is available in the OCWP *Drinking Water Infrastructure Needs Assessment by Region* report.

Water Supply Options

Limitations Analysis

For each of the state's 82 OCWP basins, an analysis of water supply and demand was followed by an analysis of limitations for surface water, bedrock groundwater, and alluvial groundwater use. Physical availability limitations for surface water were referred to as gaps. Availability limitations for alluvial and bedrock groundwater were referred to as depletions.

For surface water, the most pertinent limiting characteristics considered were (1) physical availability of water, (2) permit availability, and (3) water quality. For alluvial and bedrock groundwater, permit availability was not a limiting factor through 2060, and existing data were insufficient to conduct meaningful groundwater quality analyses. Therefore, limitations for major alluvial and bedrock aquifers were related to physical availability of water and included an analysis of both the amount of any forecasted depletion relative to the amount of water in storage and rate at which the depletion was predicted to occur.

Methodologies were developed to assess limitations and assign appropriate scores for each supply source in each basin. For surface water, scores were calculated weighting the characteristics as follows: 50% for physical availability, 30% for permit availability, and 20% for water quality. For alluvial and bedrock groundwater scores, the magnitude of depletion relative to amount of water in storage and rate of depletion were each weighted 50%.

The resulting supply limitation scores were used to rank all 82 basins for surface water, major alluvial groundwater, and major bedrock groundwater sources (see Water Supply Limitations map in the regional summary). For each source, basins ranking the highest were considered to be "significantly limited" in the ability of that source to meet forecasted demands reliably. Basins with intermediate rankings were considered to be "potentially limited" for that source. For bedrock and alluvial groundwater rankings, "potentially limited" was also the baseline default given to basins lacking major aquifers due to typically lower yields and insufficient data. Basins with the lowest rankings were considered to be "minimally limited" for that source and not projected to have any gaps or depletions.

Based on an analysis of all three sources of water, the basins with the most significant limitations ranking were identified as "Hot Spots." A discussion of the methodologies used in identifying Hot Spots, results, and recommendations can be found in the *OCWP Executive Report*.

Primary Options

To provide a range of potential solutions for mitigation of water supply shortages in each of the 82 OCWP basins, five primary options were evaluated for potential effectiveness: (1) demand management, (2) use of out-of-basin supplies, (3) reservoir use, (4) increasing reliance on surface water, and (5) increasing reliance on groundwater. For each basin, the potential effectiveness of each primary option was assigned one of three ratings: (1) typically effective, (2) potentially effective, and (3) likely ineffective (see Water Supply Option Effectiveness map in the regional summary). For basins where shortages are not projected, no options are necessary and thus none were evaluated.

Demand Management

"Demand management" refers to the potential to reduce water demands and alleviate gaps or depletions by implementing conservation or drought management measures. Demand management is a vitally important tool that can be implemented either temporarily or permanently to decrease demand and increase available supply. "Conservation measures" refer to long-term activities that result in consistent water savings throughout the year, while "drought management" refers to short-term measures, such as temporary restrictions on outdoor watering. Municipal and industrial conservation techniques can include modifying customer behaviors, using more efficient plumbing fixtures, or eliminating water leaks. Agricultural conservation techniques can include reducing water demand through more efficient irrigation systems and production of crops with decreased water requirements.

Two specific scenarios for conservation were analyzed for the OCWP—moderate and substantial—to assess the relative effectiveness in reducing statewide water demand in the two largest demand sectors, Municipal/Industrial and Crop Irrigation. For the Watershed Planning Region reports, only moderately expanded conservation activities were considered when assessing the overall effectiveness of the demand management option for each basin. A broader analysis of moderate and substantial conservation measures statewide is discussed below and summarized in the "Expanded Options" section of the *OCWP Executive Report*.

Demand management was considered to be "typically effective" in basins where it would likely eliminate both gaps and storage depletions and "potentially effective" in basins where it would likely either reduce gaps and depletions or eliminate either gaps or depletions (but not both). There were no basins where demand management could not reduce gaps and/or storage depletions to at least some extent; therefore this option was not rated "likely ineffective" for any basin.

Out-of-Basin Supplies

Use of "out-of-basin supplies" refers to the option of transferring water through pipelines from a source in one basin to another basin. This option was considered a "potentially effective" solution in all basins due to its general potential in eliminating gaps and depletions. The option was not rated "typically effective" because complexity and cost make it only practical as a long-term solution. The effectiveness of this option for a basin was also assessed with the consideration of potential new reservoir sites within the respective region as identified in the Expanded Options section below and the OCWP *Reservoir Viability Study*.

Reservoir Use

"Reservoir Use" refers to the development of additional in-basin reservoir storage. Reservoir storage can be provided through increased use of existing facilities, such as reallocation of existing purposes at major federal reservoir sites or rehabilitation of smaller NRCS projects to include municipal and/or industrial water supply, or the construction of new reservoirs.

The effectiveness rating of reservoir use for a basin was based on a hypothetical reservoir located at the furthest downstream basin outlet. Water transmission and legal or water quality constraints were not considered; however, potential constraints in permit availability were noted. A site located further upstream could potentially provide adequate yield to meet demand, but would likely require greater storage than a site located at the basin outlet. The effectiveness rating was also largely contingent upon the existence of previously studied reservoir sites (see the Expanded Options section below) and/or the ability of new streamflow diversions with storage to meet basin water demands.

Reservoir use was considered "typically effective" in basins containing one or more potentially viable reservoir sites unless the basin was fully allocated for surface water and had no permit availability. For basins with no permit availability, reservoir use was considered "potentially effective," since diversions would be limited to existing permits. Reservoir use was also considered "potentially effective" in basins that generate sufficient reservoir yield to meet future demand. Statewide, the reservoir use option was considered "likely ineffective" in only three basins (Basins 18, 55, and 66), where it was determined that insufficient streamflow would be available to provide an adequate reservoir yield to meet basin demand.

Increasing Reliance on Surface Water

"Increasing reliance on surface water" refers to changing the surface water-groundwater use ratio to meet future demands by increasing surface water use. For baseline analysis, the proportion of future demand supplied by surface water and groundwater for each sector is assumed equal to current proportions. Increasing the use of surface water through direct diversions without reservoir storage or releases upstream from storage provides a reliable supply option in limited areas of the state and has potential to mitigate bedrock groundwater depletions and/or alluvial groundwater depletions. However, this option largely depends upon local conditions concerning the specific location, amount, and timing of the diversion.

Due to this uncertainty, the pronounced periods of low streamflow in many river systems across the state, and the potential to create or augment surface water gaps, this option was considered "typically ineffective" for all basins. The preferred alternative statewide is reservoir use, which provides the most reliable surface water supply source.

Increasing Reliance on Groundwater

"Increasing reliance on groundwater" refers to changing the surface water-groundwater use ratio to meet future demands by increasing groundwater use. Supplies from major aquifers are particularly reliable because they generally exhibit higher well yields and contain large amounts of water in storage. Minor aquifers can also contain large amounts of water in storage, but well yields are typically lower and may be insufficient to meet the needs of high volume water users. Site-specific information on the suitability of minor aquifers for supply should be considered prior to large-scale use. Additional groundwater supplies may also be developed through artificial recharge (groundwater storage and recovery), which is summarized in the "Expanded Options" section of the *OWRB Executive Report*.

Increased reliance on groundwater supplies was considered "typically effective" in basins where both gaps and depletions could be mitigated in a measured fashion that did not lead to additional groundwater depletions. This option was considered "potentially effective" in basins where surface water gaps could be mitigated by increased groundwater use, but would likely result in increased depletions in either alluvial or bedrock groundwater storage. Increased reliance on groundwater supplies was considered "typically ineffective" in basins where there were no major aquifers.

Expanded Options

In addition to the standard analysis of primary options for each basin, specific OCWP studies were conducted statewide on several more advanced though less conventional options that have potential to reduce basin gaps and depletions. More detailed summaries of these options are available in the *OWRB Executive Report*. Full reports are available on the OWRB website.

Expanded Conservation Measures

Water conservation was considered an essential component of the "demand management" option in basin-level analysis of options for reducing or eliminating gaps and storage depletions. At the basin level, moderately expanded conservation measures were used as the basis for analyzing effectiveness. In a broader OCWP study, summarized in the *OCWP Executive Report* and documented in the OCWP *Water Demand Forecast Report Addendum: Conservation and Climate Change*, both moderately and substantially expanded conservation activities were analyzed at a statewide level for the state's two largest demand sectors: Municipal/Industrial (M&I) and Crop Irrigation. For each sector, two scenarios were analyzed: (1) moderately expanded conservation activities, and (2) substantially expanded conservation activities. Water savings for the municipal and industrial and crop irrigation water use sectors were assessed, and for the M&I sector, a cost-benefit analysis was performed to quantify savings associated with reduced costs in drinking water production and decreased wastewater treatment. The energy savings and associated water savings realized as a result of these decreases were also quantified.

Artificial Aquifer Recharge

In 2008, the Oklahoma Legislature passed Senate Bill 1410 requiring the OWRB to develop and implement criteria to prioritize potential locations throughout the state where artificial recharge demonstration projects are most feasible to meet future water supply challenges. A workgroup of numerous water agencies and user groups was organized to identify suitable locations in both alluvial and bedrock aquifers. Fatal flaw and threshold screening analyses resulted in identification of six alluvial sites and nine bedrock sites. These sites were subjected to further analysis that resulted in five sites deemed by the workgroup as having the best potential for artificial recharge demonstration projects.

Where applicable, potential recharge sites are noted in the "Increasing Reliance on Groundwater" option discussion in basin data and analysis sections of the Watershed Planning Region Reports. The site selection methodology and results for the five selected sites are summarized in the *OCWP Executive Report*; more detailed information on the workgroup and study is presented in the OCWP *Artificial Aquifer Recharge Issues and Recommendations* report.

Marginal Quality Water Sources

In 2008, the Oklahoma Legislature passed Senate Bill 1627 requiring the OWRB to establish a technical workgroup to analyze the expanded use of marginal quality water (MQW) from various sources throughout the state. The group included representatives from state and federal agencies, industry, and other stakeholders. Through facilitated discussions, the group defined MQW as that which has been historically unusable due to technological or economic issues associated with diverting, treating, and/or conveying the water. Five categories of MQW were identified for further characterization and technical analysis: (1) treated wastewater effluent, (2) stormwater runoff, (3) oil and gas flowback/produced water, (4) brackish surface and groundwater, and (5) water with elevated levels of key constituents, such as nitrates, that would require advanced treatment prior to beneficial use.

A phased approach was utilized to meet the study's objectives, which included quantifying and characterizing MQW sources and their locations for use through 2060, assessing constraints to MQW use, and matching identified sources of MQW with projected water shortages across the state. Feasibility of actual use was also reviewed. Of all the general MQW uses evaluated, water reuse—beneficially using treated wastewater to meet certain demand—is perhaps the most commonly applied elsewhere in the U.S. Similarly, wastewater was determined to be one of the most viable sources of marginal quality water for short-term use in Oklahoma. Results of the workgroup's study are summarized in the *OCWP Executive Report*; more detailed information on the workgroup and study is presented in the OCWP *Marginal Quality Water Issues and Recommendations* report.

Potential Reservoir Development

Oklahoma is the location of many reservoirs that provide a dependable, vital water supply source for numerous purposes. While economic, environmental, cultural, and geographical constraints generally limit the construction of new reservoirs, significant interest persists due to their potential in meeting various future needs, particularly those associated with municipalities and regional public supply systems.

As another option to address Oklahoma's long-range water needs, the OCWP *Reservoir Viability Study* was initiated to identify potential reservoir sites throughout the state that have been analyzed to various degrees by the OWRB, Bureau of Reclamation (BOR), U.S. Army Corps of Engineers (USACE), Natural Resources Conservation Service (NRCS), and other public or private agencies. Principal elements of the study included extensive literature search; identification of criteria to determine a reservoir's viability; creation of a database to store essential information for each site; evaluation of sites; Geographic Information System (GIS) mapping of the most viable sites; aerial photograph and map reconnaissance; screening of environmental, cultural, and endangered species issues; estimates of updated construction costs; and categorical assessment of viability. The study revealed more than 100 sites statewide. Each was assigned a ranking, ranging from Category 4 (sites with at least adequate information that are viable candidates for future development) to Category 0 (sites that exist only on a historical map and for which no study data can be verified).

This analysis does not necessarily indicate an actual need or specific recommendation to build any potential project. Rather, these sites are presented to provide local and regional decision-makers with additional tools as they anticipate future water supply needs and opportunities. Study results present only a cursory examination of the many factors associated with project feasibility or implementation. Detailed investigations would be required in all cases to verify feasibility of construction and implementation. A summary of potential reservoir sites statewide is available in the *OCWP Executive Report*; more detailed information on the study is presented in the OCWP *Reservoir Viability Study*. Potential reservoir development sites for this Watershed Planning Region appear on the following table and map.

Reservoir Project Viability Categorization

Category 4: Sites with at least adequate information that are viable candidates for future development.

Category 3: Sites with sufficient data for analysis, but less than desirable for current viability.

Category 2: Sites that may contain fatal flaws or other factors that could severely impede potential development.

Category 1: Sites with limited available data and lacking essential elements of information.

Category 0: Typically sites that exist only on an historical map. Study data cannot be located or verified.

Potential Reservoir Sites (Categories 3 & 4)

Central Region

Name	Category	Stream	Basin	Purposes[1]	Total Storage	Conservation Pool: Surface Area	Conservation Pool: Storage	Conservation Pool: Dependable Yield	Primary Study: Date	Primary Study: Agency	Updated Cost Estimate[2] (2010 dollars)
					AF	Acres	AF	AFY			
Asher	4	Canadian River	56	WS, FW, R	0	20,280	550,000	400,000	1988	Bureau of Reclamation	$373,610,000
Centerpoint	3	S Deer Creek Trib	50	WS, FW, R	0	340	3,000	700	1988	Bureau of Reclamation	$8,943,000
Crescent	3	Cimarron River	64	FC, WS, R, FW	1,363,000	30,100	647,000	150,109	1970	USACE	---
Dibble	3	Walnut Creek	57	FC, WS, R, FW	0	5,400	98,000	19,044	1985	USACE	$218,741,000
Fallis	3	Bear Creek	60	FC, WS, FW, R	0	2,600	33,000	10,000	1988	Bureau of Reclamation and USACE	$95,746,000
Hennessey	4	Turkey Creek	64	FC, WS, R, FW	0	7,700	130,000	18,819	1985	USACE	$292,917,000
Purcell (Muncrief)	4	Walnut Creek	57	WS, FC, R, FW	0	6,670	112,000	20,000	1972	Bureau of Reclamation	$28,757,000
Navina	4	Cottonwood Creek Trib	64	R, FW, WS	0	6,971	111,846	34,615	1981	Bureau of Reclamation	$571,876,000
Nuyaka	4	Deep Fork	60	FC, WS, FW, R	2,100,000	53,000	1,400,000	224,044	1985	USACE	813,148,000
Sasakwa	4	Little River	61	FC, WS, FW, R	0	13,400	325,000	79,872	1985	USACE	$358,120,000
Scissortail	4	Spring Brook Creek & Canadian Sandy Creek	56	WS, R, FW	177,524	5,200	91,200	33,270	2009	Bureau of Reclamation and City of Ada	$188,354,000
Tate Mountain	4	Little River	62	WS, FW, R	0	5,940	134,600	49,800	1988	Bureau of Reclamation	---
Union	3	Canadian River	58	WS, R, FW	1,231,960	28,900	800,000	155,700	1973	Bureau of Reclamation	$1,052,041,000
Wellston	4	Captain Creek	60	WS, FC, FW, R	0	1,555	25,000	7,700	1965	USACE	$54,023,000
Welty	4	Deep Fork River	60	WS, FW, R	816,500	35,100	800,000	207,240	1985	USACE	$488,527,000
West Elm	4	West Elm Creek	62	WS, FW, R	103,600	3,300	102,800	0[3]	1985	USACE	$328,410,000

No known information is annotated as "---"

1 WS=Water Supply, R=Recreation, HP=Hydroelectric Power, IR=Irrigation, WQ=Water Quality, FW=Fish & Wildlife, FC=Flood Control, LF=Low Flow Regulation, N=Navigation, C=Conservation, CW=Cooling Water

2 The majority of cost estimates were updated using estimated costs from previous project reports combined with the U.S. Army Corps of Engineers Civil Works Construction Cost Index System (CWCCIS) annual escalation figures to scale the original cost estimates to present-day cost estimates. These estimated costs may not accurately reflect current conditions at the proposed project site and are meant to be used for general comparative purposes only.

3 Terminal storage

Expanded Water Supply Options
Central Region

Oklahoma Comprehensive Water Plan

Data & Analysis
Central Watershed Planning Region

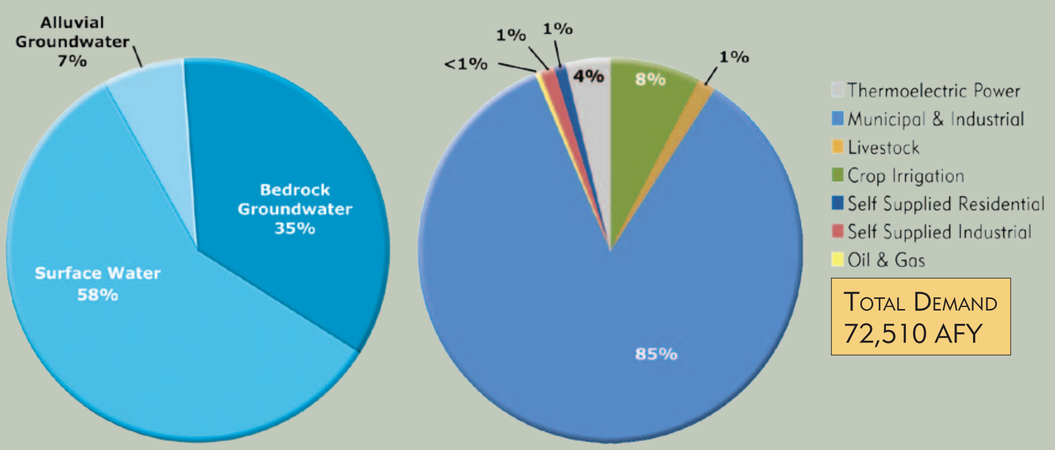
Basin 50

Basin 50 Summary

Synopsis

- Water users are expected to continue to rely primarily on surface water and bedrock groundwater, and to a lesser extent, alluvial groundwater.
- By 2020, there is a low to moderate probability of surface water gaps from increased demands on existing supplies during low flow periods.
- Alluvial groundwater storage depletions may occur by 2020 and bedrock groundwater storage depletions may occur by 2040. However, the storage depletions will be minimal in size relative to aquifer storage in the basin. Localized storage depletions may cause adverse effects for users.
- To reduce the risk of adverse impacts on water supplies, it is recommended that gaps and storage depletions be decreased where economically feasible.
- Additional conservation measures could reduce gaps and groundwater storage depletions.
- To mitigate surface water gaps, dependable groundwater supplies and/or developing new small reservoirs could be utilized as alternatives without major impacts to groundwater storage.

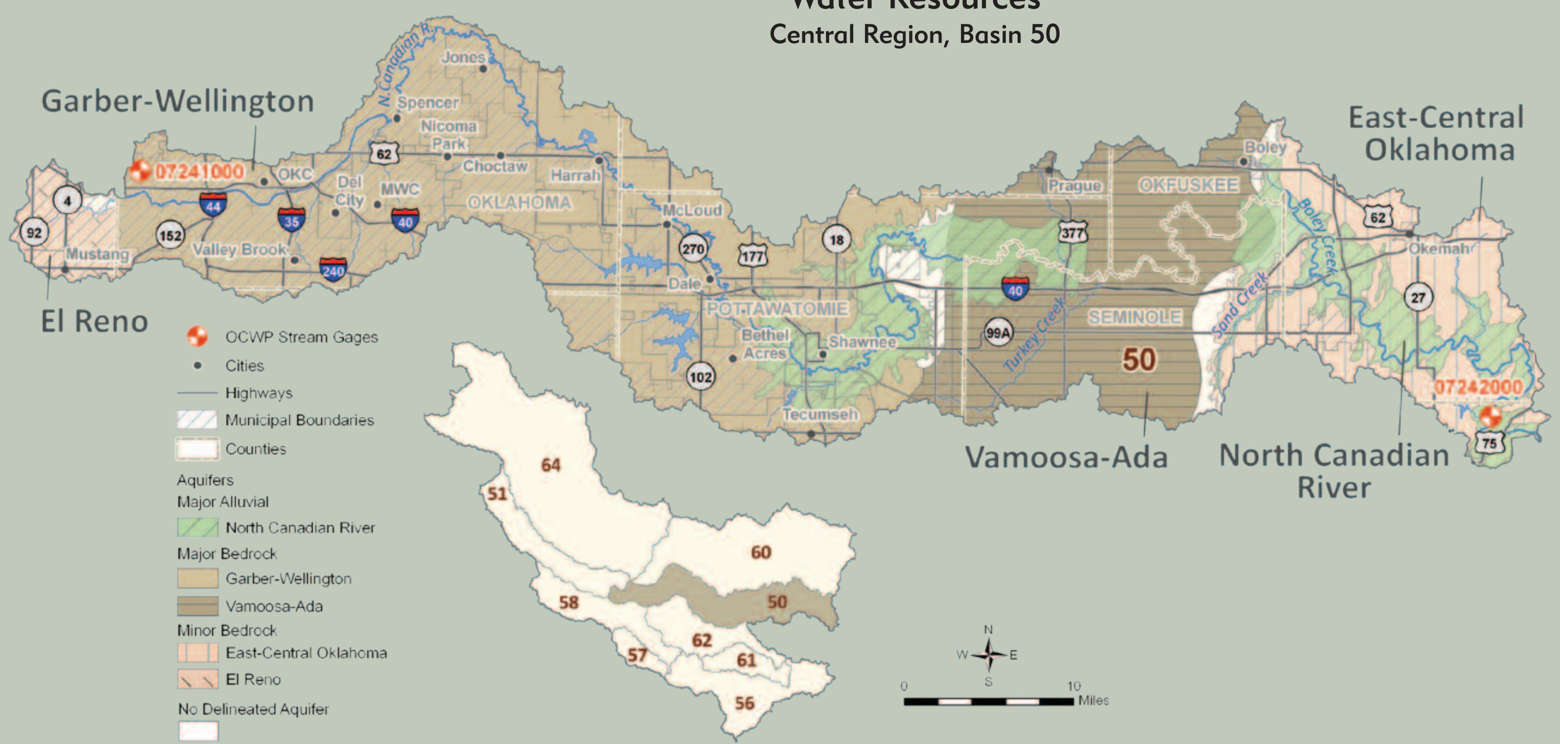
Current Demand by Source and Sector
Central Region, Basin 50



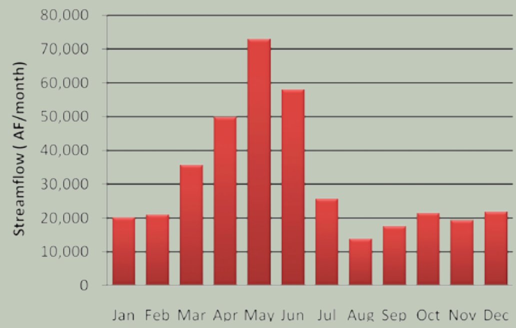
Basin 50 accounts for about 22% of the current demand in the Central Watershed Planning Region. About 85% of the basin's 2010 demand was from the Municipal and Industrial demand sector. Crop Irrigation is the second largest demand sector at 8%. Surface water satisfies about 58% of the current demand in the basin. Groundwater satisfies about 42% of the current demand (7% alluvial and 35% bedrock). The peak summer month total water demand in Basin 50 is about 2.4 times the winter monthly demand, which is similar to the overall statewide pattern.

The flow in the North Canadian River near Wetumka is typically greater than 13,800 AF/month throughout the year and greater than 35,000 AF/month in the spring and early summer. However, the river can have periods of low flow in any month of the year. The Shawnee Twin Lakes on South Deer Creek are actually two impoundments connected by a 10-foot-deep canal. Lake number one was built in 1935 and number two in 1960. The lakes provide a combined dependable yield of 4,400 AFY for the City of Shawnee and are fully allocated. Wes Watkins Reservoir, Tecumseh

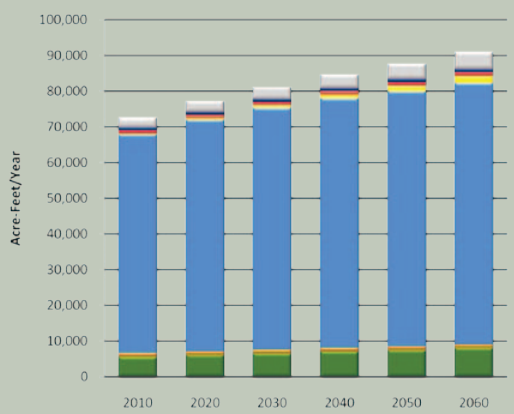
Water Resources
Central Region, Basin 50



Median Historical Streamflow at the Basin Outlet
Central Region, Basin 50



Projected Water Demand
Central Region, Basin 50



Lake, and Lake Wetumka are also important municipal reservoirs. The water supply yield of these lakes is unknown; therefore, the ability of these reservoirs to provide future water supplies could not be evaluated. The availability of permits is not expected to limit the development of surface water supplies for in-basin use through 2060. Relative to other basins in the state, the surface water quality in Basin 50 is considered fair. Campbell Creek, Turkey Creek, Sand Creek, Okemah Creek, and a small segment of the North Canadian River are impaired for Agricultural use due to high levels of chloride, sulfate, and total dissolved solids (TDS). South Deer Creek is impaired for Public and Private Water Supply due to high levels of oil and grease.

The majority of groundwater permits in Basin 50 are from the Garber-Wellington major bedrock aquifer and the North Canadian River major alluvial aquifer. The Garber-Wellington aquifer has more than 11.7 million AF of storage in Basin 50's portion of the aquifer and underlies the western half of the basin. The OWRB and USGS are currently conducting a detailed study of the Garber-Wellington to establish the equal proportionate share of the aquifer, which may change the current two AFY/acre allocated for temporary permits.

The North Canadian River aquifer has more than 1.5 million AF of storage in Basin 50 and underlies the eastern portions of the basin. There are also substantial permits in the Vamoosa-Ada major bedrock aquifer, El Reno minor bedrock aquifer, and other minor alluvial and bedrock aquifers. Basin 50 contributes about 49,000 AFY of recharge to the Garber-Wellington and Vamoosa-Ada aquifers. The use of groundwater to meet in-basin demand is not expected to be limited by the availability of permits through 2060. High concentrations of nitrate, arsenic, chromium, radionuclides, and selenium have been found locally in the Garber-Wellington aquifer and may limit its use for Municipal and Industrial and other demand sectors. The OWRB and USGS are currently conducting a detailed study to better characterize the water quality of the aquifer for all users. There are no significant groundwater quality issues in other aquifers in the basin.

The projected 2060 water demand of 91,020 AFY in Basin 50 reflects an 18,490 AFY increase (26%) over the 2010 demand. The majority of the demand and growth in demand over this period will be in the Municipal and Industrial demand sector. However, substantial growth in Crop Irrigation is also projected.

Gaps & Depletions

Based on projected demand and historical hydrology, surface water gaps and alluvial groundwater storage depletions may occur by 2020. Bedrock groundwater depletions may occur in Basin 50 by 2040. Surface water gaps will be up to 3,480 AFY and have a 22% probability of occurring in at least one month of the year by 2060. Alluvial groundwater storage depletions are expected to be up to 530 AFY and have a 22% probability of occurring in at least one month of the year by 2060. Surface water gaps and alluvial groundwater storage depletions are expected to occur in spring, summer, and fall, peaking in size in the summer. Bedrock groundwater storage depletions will occur in the summer and be 780 AFY by 2060. Projected annual alluvial and bedrock groundwater storage depletions are minimal relative to the amount of water in storage in the North Canadian River, Garber-Wellington, and Vamoosa-Ada aquifers. However, localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Water Supply Limitations
Central Region, Basin 50

Surface Water	Potential
Alluvial Groundwater	Potential
Bedrock Groundwater	Potential

Minimal · Potential · Significant

Water Supply Option Effectiveness
Central Region, Basin 50

Demand Management	Potentially Effective
Out-of-Basin Supplies	Potentially Effective
Reservoir Use	Potentially Effective
Increasing Supply from Surface Water	Likely Ineffective
Increasing Supply from Groundwater	Potentially Effective

Typically Effective · Potentially Effective · Likely Ineffective · No Option Necessary

Options

Water users are expected to continue to rely primarily on surface water supplies and bedrock groundwater, and to a lesser extent on alluvial groundwater. To reduce the risk of adverse impacts to the basin's water users, surface water gaps and groundwater storage depletions should be decreased where economically feasible.

Moderately expanded permanent conservation activities in the Municipal and Industrial, Self-Supplied Residential, and Crop Irrigation demand sectors could mitigate bedrock groundwater storage depletions, and reduce surface water gaps and alluvial groundwater storage depletions. Temporary drought management activities may not be effective for this basin, since gaps have a moderate probability of occurring and groundwater storage could continue to provide supplies during droughts.

Out-of-basin supplies could mitigate surface water gaps and groundwater storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified fifteen potential out-of-basin sites in the Central Region. However, in light of the substantial groundwater supplies and distance to reliable water supplies, out-of-basin supplies may not be cost-effective for many users in the basin.

Additional reservoir storage in Basin 50 could effectively supplement supply during dry months. The entire increase in demand from 2010 to 2060 could be supplied by a new river diversion and 7,500 AF of reservoir storage at the basin outlet. The OCWP *Reservoir Viability Study* also identified one potential site in the basin.

Increased reliance on surface water through direct diversions, without reservoir storage, will increase surface water gaps and is not recommended.

Increased reliance on the Garber-Wellington, Vamoosa-Ada, or North Canadian River aquifers could mitigate surface water gaps. Any increases in storage depletions would be minimal relative to the volume of water stored in the basin's major aquifers.

The Aquifer Recharge Workgroup identified a site near Shawnee and Seminole (site # 9) as potentially feasible for aquifer recharge and recovery. Water could potentially be withdrawn from the North Canadian River to recharge the Vamoosa-Ada aquifer.

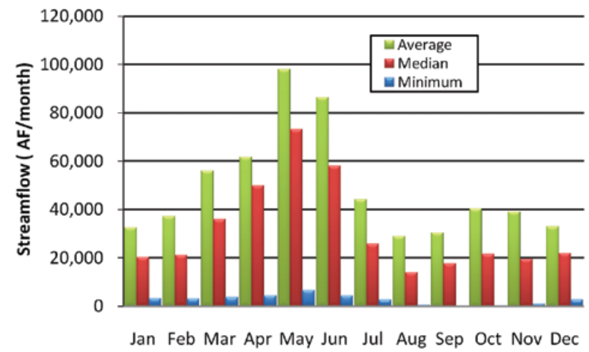
Basin 50 Data & Analysis

Surface Water Resources

- Historical streamflow from 1950 through 2007 was used to estimate the range of future surface water supplies. The North Canadian River near Wetumka had a period of below-average streamflow from the early 1960s to the early 1970s. From the mid 1980s through the late 1990s, the basin went through a prolonged period of above-average streamflow and precipitation, demonstrating the hydrologic variability in the basin.
- The median flow in the North Canadian River near Wetumka is greater than 13,800 AF/month throughout the year and greater than 35,000 AF/month in the spring and early summer. However, the river can have periods of low to very low flow in any month of the year. Relative to other basins in the state, the surface water quality in Basin 50 is considered fair.
- Shawnee Twin Lakes provide 4,400 AFY of dependable yield for the City of Shawnee and are fully allocated. Wes Watkins Reservoir, Tecumseh Lake, and Lake Wetumka are important municipal reservoirs in the basin but the water supply yields of these lakes are unknown; therefore, their ability to provide future water supplies could not be evaluated.

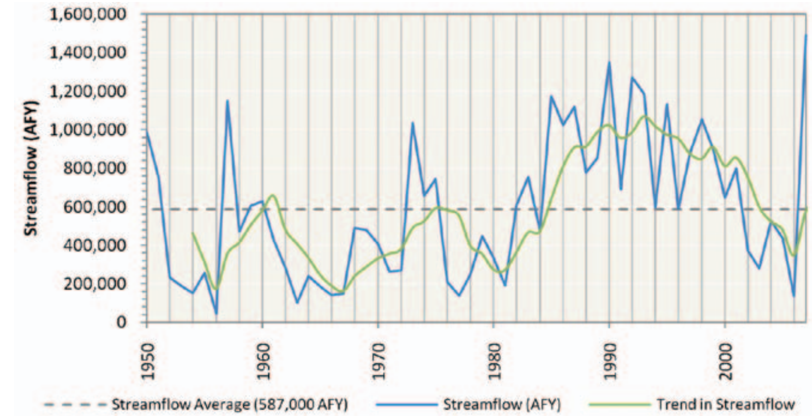
Monthly Historical Streamflow at the Basin Outlet

Central Region, Basin 50



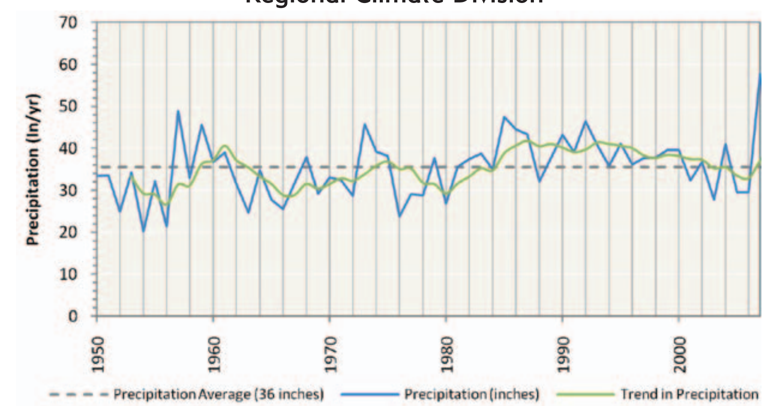
Historical Streamflow at the Basin Outlet

Central Region, Basin 50



Historical Precipitation

Regional Climate Division



Notes & Assumptions

- Precipitation data are based on regional information, while streamflow is basin-specific.
- Measured streamflow implicitly reflects the conditions that exist in the stream at the time the data were recorded (e.g., hydrology, diversions, reservoirs, and infrastructure).
- For water supply planning, the range of potential future hydrologic conditions, including droughts, is represented by 58 years of monthly surface water flows (1950 to 2007). Climate change variations to these flows are documented in a separate OCWP report.
- Surface water supplies are calculated by adjusting the historical streamflow to account for upstream demands, return flows, and out-of-basin supplies.
- The upstream state is assumed to use 60 percent of the flow at the state line based on OWRB permitting protocol.
- Historical flow is based on USGS stream gages at or near the basin outlet. Where a gage did not exist near the outlet or there were missing data in the record, an estimation of flow was determined from representative, nearby gages using statistical techniques.
- Existing surface water rights may restrict the quantity of available surface water to meet future demands. Additional permits would decrease the amount of available water.

Groundwater Resources - Aquifer Summary 2010

Central Region, Basin 50

Aquifer			Portion of Basin Overlaying Aquifer	Current Groundwater Rights	Aquifer Storage in Basin	Equal Proportionate Share	Groundwater Available for New Permits
Name	Type	Class[1]	Percent	AFY	AF	AFY/Acre	AFY
North Canadian River	Alluvial	Major	17%	17,100	1,541,000	1.0	100,500
Garber-Wellington	Bedrock	Major	52%	71,400	11,736,000	temporary 2.0	556,600
Vamoosa-Ada	Bedrock	Major	24%	2,600	2,632,000	2.0	313,500
East-Central Oklahoma	Bedrock	Minor	18%	300	1,892,000	temporary 2.0	242,700
El Reno	Bedrock	Minor	3%	6,100	100,000	temporary 2.0	36,300
Non-Delineated Groundwater Source	Bedrock	Minor	N/A	400	N/A	temporary 2.0	N/A
Non-Delineated Groundwater Source	Alluvial	Minor	N/A	400	N/A	temporary 2.0	N/A

1 Bedrock aquifers with typical yields greater than 50 gpm and alluvial aquifers with typical yields greater than 150 gpm are considered major.

Groundwater Resources

- The majority of groundwater permits in Basin 50 are from the Garber-Wellington major bedrock aquifer and the North Canadian River major alluvial aquifer. The Garber-Wellington aquifer has more than 11.7 million AF of storage in Basin 50's portion of the aquifer and underlies the western half of the basin. The OWRB and USGS are currently conducting a detailed study of the Garber-Wellington that will establish an equal proportionate share for the aquifer and may change the current EPS of 2 AFY/acre allocation under temporary permits. The North Canadian River aquifer has more than 1.5 million AF of storage in Basin 50 and underlies the eastern portion of the basin. There are also substantial permits in the Vamoosa-Ada major bedrock aquifer, El Reno minor bedrock aquifer, and other minor alluvial and bedrock aquifers. Basin 50 contributes about 49,000 AFY of recharge to the Garber-Wellington and Vamoosa-Ada aquifers.
- High concentrations of nitrate, arsenic, chromium, radionuclides, and selenium have been found locally in the Garber-Wellington aquifer and may limit its use for Municipal and Industrial and other demand sectors. The OWRB and USGS are currently conducting a detailed study to better characterize the water quality of the aquifer for all users. There are no significant groundwater quality issues in other aquifers in the basin.

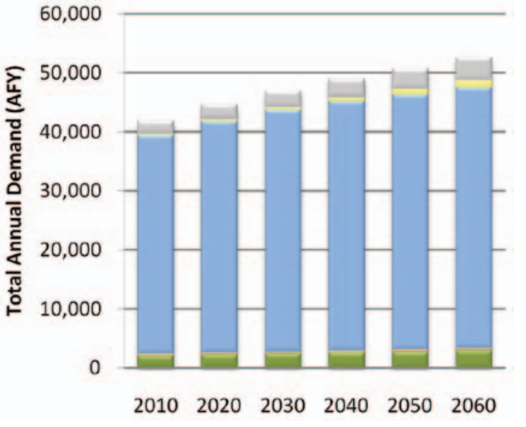
Notes & Assumptions

- Alluvial groundwater recharge is not considered separately from streamflow in physical supply availability analyses because any increases or decreases in alluvial groundwater recharge or storage would affect streamflow. Therefore, surface water flows are used to represent available alluvial groundwater recharge.
- Site-specific information on minor aquifers should be considered before large scale use. Suitability for long term supply is typically based on recharge, storage yield, capital and operational costs, and water quality.
- Groundwater permit availability is generally based on the amount of land owned or leased that overlies a specific aquifer.
- Temporary permit amounts are subject to change when the aquifer's equal proportionate share is set by the OWRB.
- Current groundwater rights represent the maximum allowable use. Actual use may be lower than the permitted amount.
- Bedrock groundwater recharge is the long-term annual average recharge to aquifers in the basin. Recharge rates on a county- or aquifer-wide level of detail were established from literature (published reports) of each aquifer. Seasonal or annual variability is not considered; therefore the modeled bedrock groundwater supply is independent of changing hydrologic conditions.

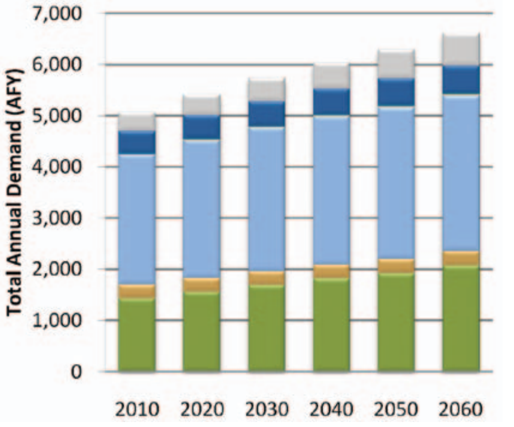
Water Demand

- Basin 50's water needs are about 22% of the demand in the Central Watershed Planning Region and will increase by 26% (18,510 AFY) from 2010 to 2060. The majority of the demand and growth in demand over this period will be in the Municipal and Industrial demand sector.
- Surface water is used to meet 58% of total demand in the basin and its use will increase by 26% (10,740 AFY) from 2010 to 2060. The majority of surface water use and growth in surface water use over this period will be in the Municipal and Industrial demand sector. Out-of-basin supplies moved from the Blue-Boggy Region via Oklahoma City's Atoka Pipeline currently helps meet a portion of the surface water demand.
- Alluvial groundwater is used to meet 7% of total demand in the basin and its use will increase by 30% (1,540 AFY) from 2010 to 2060. The majority of alluvial groundwater use and growth in alluvial groundwater use over this period will be in the Crop Irrigation and Municipal and Industrial demand sectors.
- Bedrock groundwater is used to meet 35% of total demand in the basin and its use will increase by 24% (6,210 AFY) from 2010 to 2060. The majority of bedrock groundwater use and growth in bedrock groundwater use over this period will be in the Municipal and Industrial demand sector.

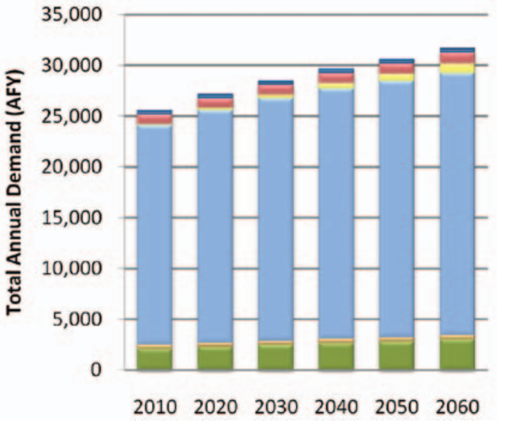
Surface Water Demand by Sector
Central Region, Basin 50



Alluvial Groundwater Demand by Sector
Central Region, Basin 50



Bedrock Groundwater Demand by Sector
Central Region, Basin 50



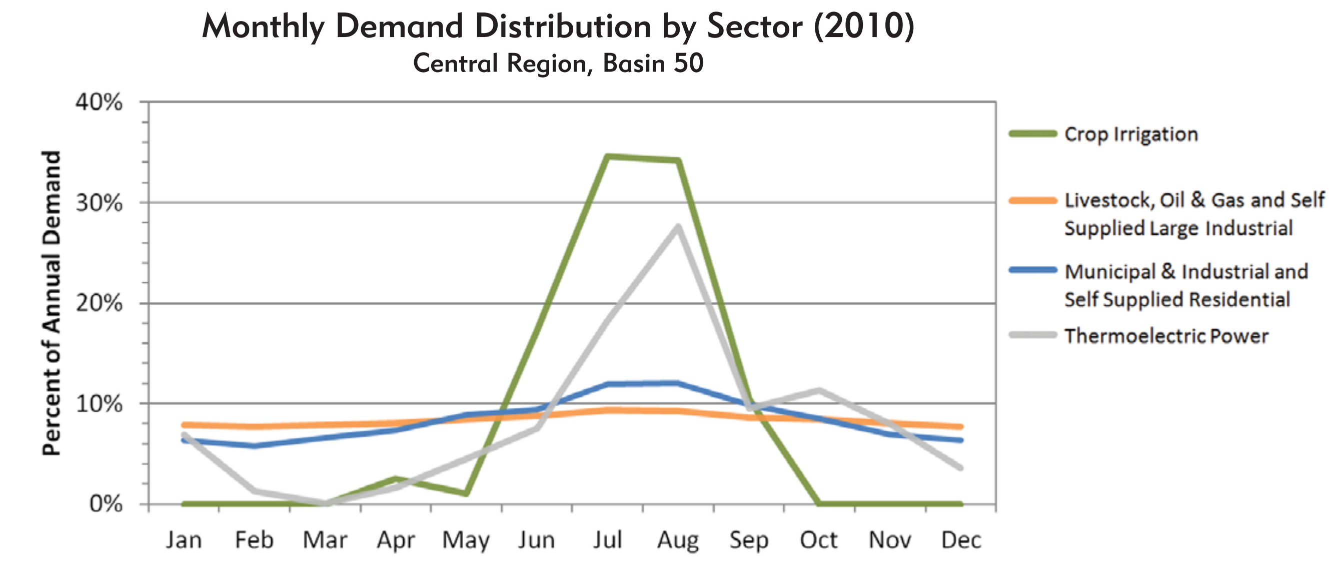
Thermoelectric Power · Self-Supplied Residential · Self-Supplied Industrial · Oil & Gas · Municipal & Industrial · Livestock · Crop Irrigation

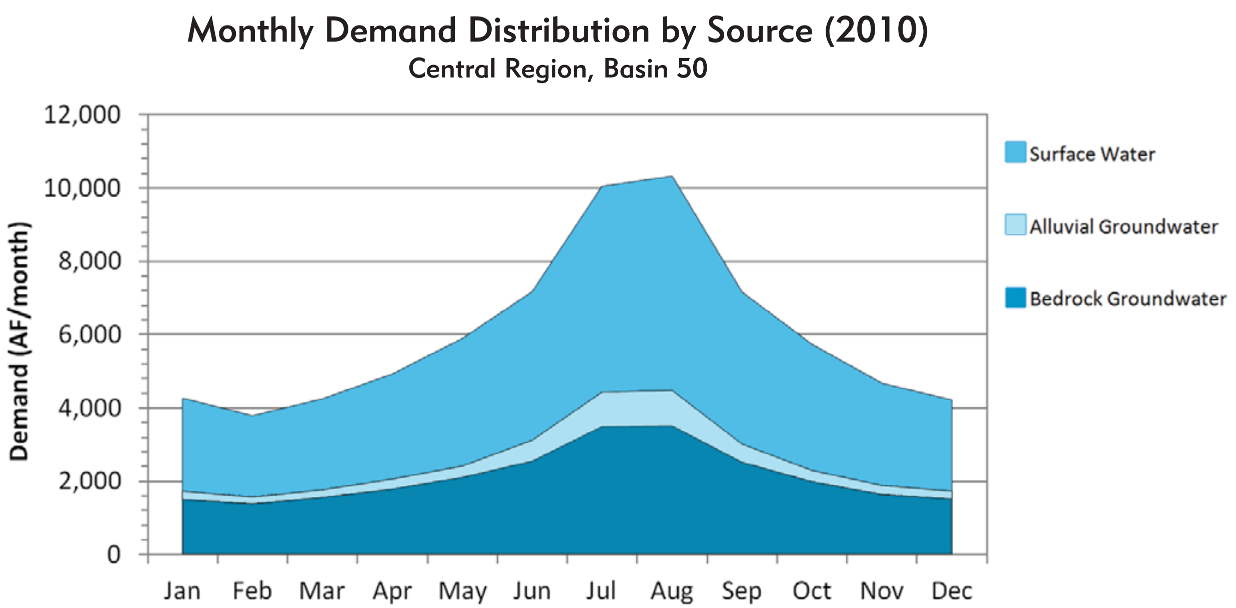
Total Demand by Sector
Central Region, Basin 50

Planning Horizon	Crop Irrigation	Livestock	Municipal & Industrial	Oil & Gas	Self-Supplied Industrial	Self-Supplied Residential	Thermoelectric Power	Total
	AFY							
2010	5,570	1,050	61,240	310	900	700	2,740	72,510
2020	6,070	1,060	64,910	560	900	740	3,060	77,300
2030	6,560	1,070	67,690	830	910	780	3,410	81,250
2040	7,060	1,080	69,860	1,170	950	810	3,810	84,740
2050	7,440	1,090	71,510	1,580	990	840	4,250	87,700
2060	8,060	1,100	73,170	2,040	1,030	880	4,740	91,020

Notes & Assumptions

- Demand values represent total demand (the amount of water pumped or diverted to meet the needs of the user).
- Values are based on the baseline demand forecast from the OCWP *Water Demand Forecast Report*.
- The effect of climate change, conservation, and non-consumptive uses, such as hydropower, are not represented in this baseline demand analysis but are documented in separate OCWP reports.
- The proportion of each supply source used to meet each water use sector's demand was assumed to be equal to the existing proportion, as represented in water rights.
- The proportions of future demands between water use sectors will vary due to differing growth rates.
- The overall proportion of supplies used to meet demand will change due to differing growth rates among the water use sectors.





Current Monthly Demand Distribution by Sector

- The Municipal and Industrial and Self-Supplied Residential demand sectors use 81% more water in summer months than in winter months. Crop Irrigation has a high demand in summer months and little or no demand in winter months. Thermoelectric Power demand peaks in August and is lowest in March. Other demand sectors have more consistent demand throughout the year.

Current Monthly Demand Distribution by Source

- The peak summer month total water demand in Basin 50 is nearly 2.4 times the monthly winter demand, which is similar to the overall statewide pattern. Surface water use in the peak summer month is about 2.3 times the monthly winter use. Monthly alluvial groundwater use peaks in the summer at about 4.1 times the monthly winter use. Monthly bedrock groundwater use peaks in the summer at about 2.3 times the monthly winter use.

Gaps and Storage Depletions

- Based on projected demand and historical hydrology, surface water gaps and alluvial groundwater storage depletions may occur by 2020. Bedrock groundwater depletions may occur in Basin 50 by 2040.
- Surface water gaps in Basin 50 may occur during the spring, summer, and fall, peaking in size in the summer. Surface water gaps in 2060 will be up to 17% (1,260 AF/month) of the surface water demand in the peak summer month, and as much as 7% (300 AF/month) of the spring monthly surface water demand. There will be a 22% probability of gaps occurring in at least one month of the year by 2060. Surface water gaps are most likely to occur during summer and fall months.
- Alluvial groundwater storage depletions in Basin 50 may occur during the spring, summer, and fall, peaking in size during the summer. Alluvial storage depletions in 2060 will be up to 16% (220 AF/month) of the alluvial groundwater demand in the peak summer month and as much as 8% (30 AF/month) of the spring monthly alluvial groundwater demand. There will be a 22% probability of alluvial storage depletions occurring in at least one month of the year by 2060. Alluvial depletions are most likely to occur during summer and fall months.
- Bedrock groundwater storage depletions in Basin 50 will occur in the summer and in 2060 will be 9% (400 AF/month) of the bedrock groundwater demand in the peak summer month.
- Projected annual groundwater storage depletions are minimal relative to the amount of water in storage in the North Canadian River, Garber-Wellington, and Vamoosa-Ada aquifers. However, localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Surface Water Gaps by Season (2060 Demand)
Central Region, Basin 50

Months (Season)	Maximum Gap [1]	Median Gap	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	0	0	0%
Mar-May (Spring)	300	300	5%
Jun-Aug (Summer)	1,260	1,100	16%
Sep-Nov (Fall)	560	470	14%

1 Amount shown represents largest amount for any one month in season indicated.

Alluvial Groundwater Storage Depletions by Season (2060 Demand)
Central Region, Basin 50

Months (Season)	Maximum Storage Depletion[1]	Median Storage Depletion	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	0	0	0%
Mar-May (Spring)	30	30	5%
Jun-Aug (Summer)	220	190	16%
Sep-Nov (Fall)	70	55	14%

1 Amount shown represents largest amount for any one month in season indicated.

Magnitude and Probability of Annual Gaps and Storage Depletions
Central Region, Basin 50

Planning Horizon	Maximum Gaps/Storage Depletions			Probability of Gaps/ Storage Depletions	
	Surface Water	Alluvial GW	Bedrock GW	Surface Water	Alluvial GW
	AFY			Percent	
2020	180	30	0	9%	9%
2030	660	110	0	17%	17%
2040	1,470	240	140	19%	19%
2050	2,280	360	430	21%	21%
2060	3,480	530	780	22%	22%

Bedrock Groundwater Storage Depletions by Season (2060 Demand)
Central Region, Basin 50

Months (Season)	Storage Depletion[1]
	AF/month
Dec-Feb (Winter)	0
Mar-May (Spring)	0
Jun-Aug (Summer)	400
Sep-Nov (Fall)	0

1 Amount shown represents largest amount for any one month in season indicated.

Notes & Assumptions

- Gaps and Storage Depletions reflect deficiencies in physically available water. Permitting, water quality, infrastructure, and nonconsumptive demand constraints are considered in separate OCWP analyses.
- Local gaps and storage depletions may vary from basin-level values due to local variations in demands and local availability of supply sources.
- For this baseline analysis, each basin's future demand is met by the basin's available supplies.
- For this baseline analysis, the proportion of future demand supplied by surface water and groundwater for each sector is assumed equal to current proportions.
- The amount of available surface water supplies used for OCWP water supply availability analysis includes changes in historical streamflow due to increased upstream demand, return flows, and increases in out-of-basin supplies from existing infrastructure.
- Analysis of bedrock groundwater supplies is based upon recharge from major aquifers.
- Groundwater storage depletions are defined as the amount that future demands exceed available recharge.
- Median gaps and storage depletions are based only on months with gaps or storage depletions.
- Annual probability is based upon the number of years that a gap or depletion occurs in at least one month of that year.

Reducing Water Needs Through Conservation

Central Region, Basin 50

Conservation Activities[1]	2060 Gap/Storage Depletion			2060 Gap/Storage Depletion Probability	
	Surface Water	Alluvial GW	Bedrock GW	Surface Water	Alluvial GW
	AFY			Percent	
Existing Conditions	3,480	530	780	22%	22%
Moderately Expanded Conservation in Crop Irrigation Water Use	3,180	490	660	22%	22%
Moderately Expanded Conservation in M&I Water Use	530	100	0	10%	10%
Moderately Expanded Conservation in Crop Irrigation and M&I Water Use	390	70	0	10%	10%
Substantially Expanded Conservation in Crop Irrigation and M&I Water Use	0	0	0	0%	0%

1 Conservation Activities are documented in the OCWP Water Demand Forecast Report.

Reliable Diversions Based on Available Streamflow and New Reservoir Storage

Central Region, Basin 50

Reservoir Storage	Diversion
AF	AFY
100	3,800
500	5,000
1,000	6,200
2,500	9,200
5,000	13,900
Required Storage to Meet Growth in Demand (AF)	7,500
Required Storage to Meet Growth in Surface Water Demand (AF)	3,200

Water Supply Options & Effectiveness

Typically Effective | Potentially Effective | Likely Ineffective | No Option Necessary

Demand Management

Moderately expanded permanent conservation activities in the Municipal and Industrial, Self-Supplied Residential, and Crop Irrigation demand sectors could mitigate bedrock groundwater storage depletions, and reduce surface water gaps and alluvial groundwater storage depletions by 89% and 87%, respectively. Temporary drought management activities may not be effective for this basin, since gaps have a moderate probability of occurring and groundwater storage could continue to provide supplies during droughts.

Out-of-Basin Supplies

Out-of-basin supplies could mitigate groundwater storage depletions and surface water gaps. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified fifteen potential out-of-basin sites in the Central Region: Asher and Scissortail in Basin 56; Dibble and Purcell in Basin 57; Union in Basin 58; Fallis, Nuyaka, Wellston and Welty in Basin 60; Sasakwa in Basin 61; Tate Mountain and West Elm Creek (terminal storage) in Basin 62; and Crescent, Hennessey and Navina in Basin 64. However, in light of the substantial groundwater supplies and distance to reliable water sources, out-of-basin supplies may not be cost-effective for many users in the basin.

Reservoir Use

Additional reservoir storage in Basin 50 could effectively supplement supply during dry months. The entire increase in demand from 2010 to 2060 could be supplied by a new river diversion and 7,500 AF of reservoir storage at the basin outlet. The use of multiple reservoirs in the basin or reservoirs upstream of the basin's outlet may increase the amount of storage necessary to mitigate future gaps and storage depletions. The OWRB *Reservoir Viability Study* identified one potential site in Basin 50 (Centerpoint).

Increasing Reliance on Surface Water

Increased reliance on surface water through direct diversions without reservoir storage will increase surface water gaps and is not recommended.

Increasing Reliance on Groundwater

Increased reliance on the Garber-Wellington, Vamoosa-Ada, or North Canadian River aquifers could mitigate surface water gaps. Any increases in storage depletions would be minimal relative to the volume of water stored in the basin's major aquifers. The Aquifer Recharge Workgroup identified a site near Shawnee and Seminole (site # 9) as potentially feasible for aquifer recharge and recovery. Water could potentially be withdrawn from the North Canadian River to recharge the Vamoosa-Ada aquifer.

Notes & Assumptions

- Water quality may limit the use of supply sources, which may require new or additional treatment before use.
- Infrastructure related to the diversion, conveyance, treatment, and distribution of water will affect the cost-effectiveness of using any new source of supply.
- The ability to reduce demands will vary based on local acceptance of additional conservation and temporary drought management activities.
- Gaps and depletions may be mitigated in individual calendar months without reductions in the annual probability (chance of having shortage during another month).
- River diversion for new or additional reservoir storage is based on a hypothetical on-channel reservoir at the basin outlet. Reported yields will vary depending upon the reservoir location; placement at the basin outlet would likely result in a higher yield.
- Aquifer storage and recovery may provide additional storage or an alternative to surface storage and should be evaluated on a case by case basis.

Data & Analysis
Central Watershed Planning Region

Basin 51

Basin 51 Summary

Synopsis

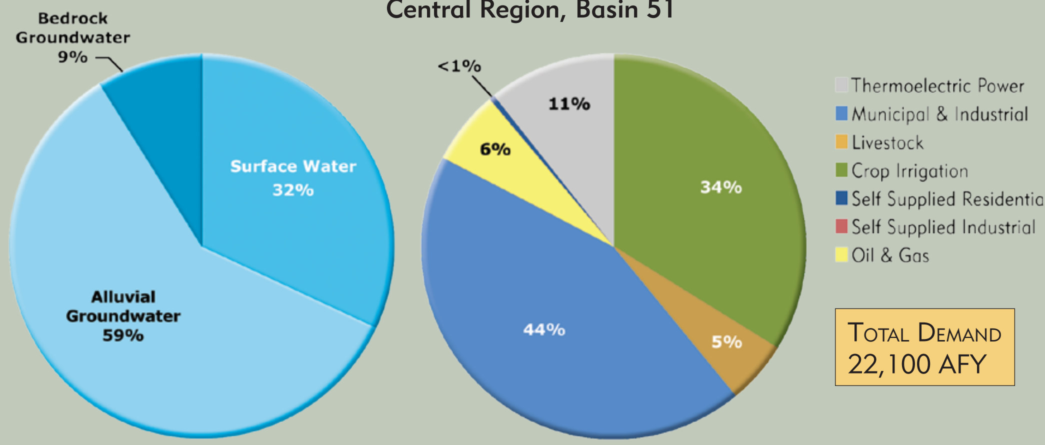
- Water users are expected to continue to rely mainly on alluvial groundwater and, to a lesser extent, surface water and bedrock groundwater.
- By 2020, there is a high probability of surface water gaps from increased demands on existing supplies during low flow periods.
- Alluvial and bedrock groundwater storage depletions may also occur by 2020. Localized storage depletions may cause adverse effects for users.
- To reduce the risk of adverse impacts on water supplies, it is recommended that gaps and storage depletions be decreased where economically feasible.
- Additional conservation measures could significantly reduce surface water gaps and groundwater storage depletions.
- Aquifer storage (recharge) and recovery could be considered to store variable surface water supplies, increase alluvial groundwater storage, and reduce adverse effects of localized storage depletions.
- To mitigate surface water gaps, alternatives such as dependable groundwater supplies, out-of-basin supplies, and/or developing new reservoirs could be used. These supply sources could be used without major impacts to groundwater storage.
- Basin 51 has been identified as a "hot spot," where more pronounced water supply availability issues are forecasted. (See "Regional and Statewide Opportunities and Solutions" in the *2012 OCWP Executive Report*.)

Basin 51 accounts for about 7% of the current demand in the Central Watershed Planning Region. About 44% of the basin's 2010 demand was from the Municipal and Industrial demand sector. Crop irrigation is the second largest demand sector at 34%. Surface water satisfies about 32% of the current demand in the basin. Groundwater satisfies about 68% of the current demand (59% alluvial and 9% bedrock). The peak summer month total water demand in Basin 51 is about 3.9 times the winter monthly demand, which is similar to the overall statewide pattern.

The flow in the North Canadian River below Lake Overholser near Oklahoma City is typically greater than 2,000 AF/month throughout the year, except in August, and greater than 5,000 AF/month in the spring and early summer. However, the river can have periods of low flow in any month of the year. Lake Overholser, one of three lakes constructed in the Central Watershed Planning Region by Oklahoma City, was built in 1919 on the North Canadian River for water supply and recreational purposes. The lake provides a dependable yield of 5,000 AFY, which is supplemented by releases from Canton Lake in the Panhandle Planning Region. The total amount permitted from Lake Overholser is 80,000 AFY, which includes water rights from the North Canadian watershed and releases from Canton Lake. Overholser is fully permitted and not expected to provide additional water supplies in the future. Lake El Reno is used by the City of El Reno for flood control and recreation, but does not provide water supplies. Surface water in the basin is fully allocated, limiting diversions from sources originating within the basins to existing permitted amounts. Relative to other basins in the state, the surface water quality in Basin 51 is considered poor. A small segment

Current Demand by Source and Sector

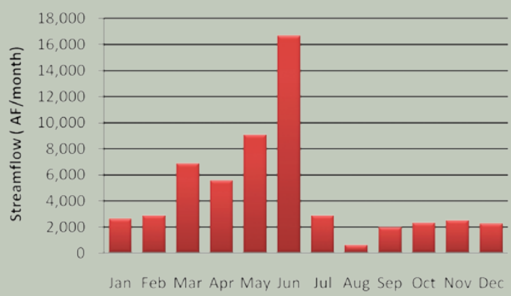
Central Region, Basin 51



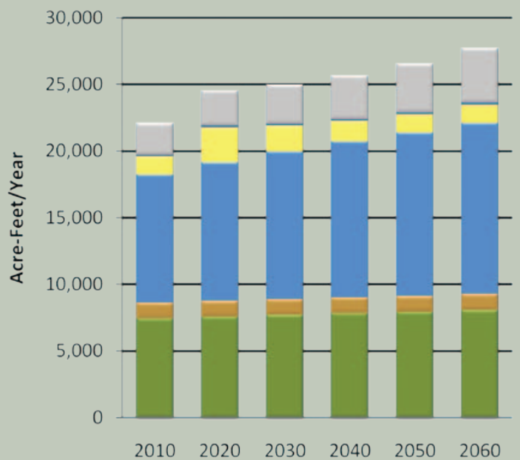
Water Resources

Central Region, Basin 51

Median Historical Streamflow at the Basin Outlet
Central Region, Basin 51



Projected Water Demand
Central Region, Basin 51



of the North Canadian River near Lake Overholser is impaired for Agricultural use due to high levels of sulfate.

The majority of groundwater permits in Basin 51 are from the North Canadian River major alluvial aquifer. The North Canadian River aquifer underlies the length of the basin along its northern edge (about 45% of the basin area) and has more than 1.2 million AF of groundwater storage in the basin. There are also permits in the Canadian River major alluvial aquifer, which only underlies a small portion of the basin, and to a lesser extent the El Reno and non-delineated minor bedrock aquifers. Site-specific information on the suitability of the minor aquifers for supply should be considered before large scale use. The Garber-Wellington aquifer underlies a small portion of the basin, but is not currently used. The use of groundwater to meet in-basin demand is not expected to be limited by the availability of permits through 2060. There are no significant groundwater quality issues in the basin.

The projected 2060 water demand of 27,750 AFY in Basin 51 reflects a 5,650 AFY increase (26%) over the 2010 demand. The largest demand and greatest growth in demand over this period will be in the Municipal and Industrial demand sector. Substantial growth in Thermoelectric Power demand is also projected.

Gaps & Depletions

Based on projected demand and historical hydrology, surface water gaps and groundwater storage depletions may occur by 2020. Surface water gaps will be up to 1,580 AFY and have an 81% probability of occurring in at least one month of the year by 2060. Alluvial groundwater storage depletions are expected to be up to 2,810 AFY and have an 81% probability of occurring in at least one month of the year by 2060. Surface water gaps and alluvial groundwater storage depletions are expected to occur throughout the year, peaking in size in the summer. Bedrock groundwater storage depletions will occur in the summer and fall and be 110 AFY by 2060. Alluvial storage groundwater depletions are minimal compared to the groundwater storage in the basin's portion of the North Canadian River and Canadian River aquifers. Future bedrock groundwater withdrawals are expected to occur from minor aquifers. Therefore, the severity of the storage depletions was not evaluated due to insufficient information. Localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Options

Surface Water users are expected to continue to rely mainly on alluvial groundwater and to a lesser extent surface water. To reduce the risk of adverse impacts to the basin's water users, surface water gaps and groundwater storage depletions should be decreased where economically feasible.

Water Supply Limitations
Central Region, Basin 51

Surface Water	Significant
Alluvial Groundwater	Significant
Bedrock Groundwater	Potential

Minimal   Potential   Significant

Water Supply Option Effectiveness
Central Region, Basin 51

Demand Management	Potentially Effective
Out-of-Basin Supplies	Potentially Effective
Reservoir Use	Potentially Effective
Increasing Supply from Surface Water	Likely Ineffective
Increasing Supply from Groundwater	Potentially Effective

Typically Effective   Potentially Effective   Likely Ineffective   No Option Necessary

Moderately expanded permanent conservation activities in the Municipal and Industrial, Self-Supplied Residential, and Crop Irrigation demand sectors could significantly reduce surface water gaps and groundwater storage depletions. Temporary drought management activities may not be effective in this basin, since gaps have a high probability of occurring and groundwater storage could continue to provide supplies during droughts.

Out-of-basin supplies could mitigate surface water gaps and groundwater storage depletions. Oklahoma City currently provides supplies to its service area in the basin, including El Reno, Yukon, and the Canadian County Water Authority. Increased regionalization of supplies could reduce future surface water gaps and groundwater storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified sixteen potential out-of-basin sites in the Central Region. However, due to the distance to reliable water supplies, out-of-basin supplies may not be cost-effective for some users in the basin.

Additional reservoir storage in Basin 51 could effectively supplement supplies during dry months. The entire increase in demand from 2010 to 2060 could be supplied by a new reservoir diversion and 19,500 AF of reservoir storage at the basin outlet. As surface water in the basin is fully allocated, substantial permit issues must be resolved in order to construct new reservoir storage.

Increasing the use of surface water supplies through direct diversions, without reservoir storage, will increase surface water gaps and is not recommended. Additionally, surface water in the basin is fully allocated, limiting diversions to existing permitted amounts.

Increased reliance on alluvial groundwater supplies could mitigate surface water gaps, but would increase the amount of groundwater storage depletions. Any increases in storage depletions would be minimal relative to the volume of water stored in the major aquifers underlying the basin. However, localized storage depletions may occur and adversely affect well yields, water quality, and/or pumping costs.

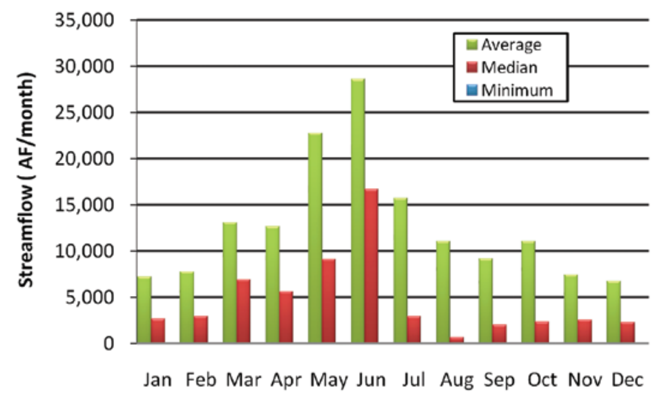
The Aquifer Recharge Workgroup identified a site near Basin 51 (site # 27) as potentially feasible for aquifer recharge and recovery. Water could potentially be withdrawn from the North Canadian River to recharge the North Canadian River aquifer.

Basin 51 Data & Analysis

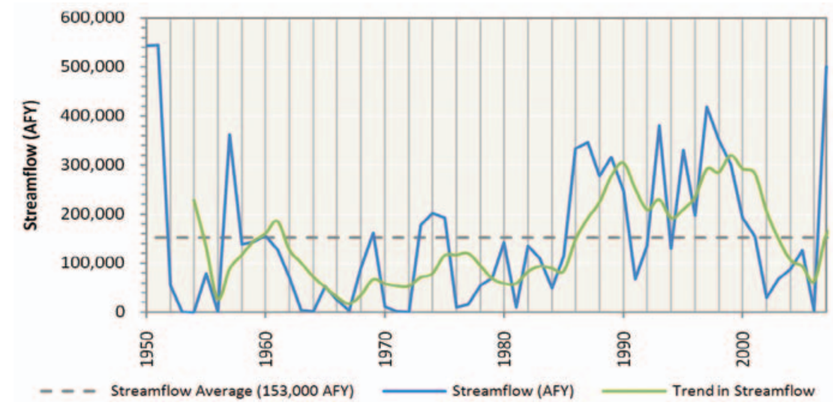
Surface Water Resources

- Historical streamflow from 1950 through 2007 was used to estimate the range of future surface water supplies. The basin had a period of below-average streamflow from the early 1960s to the early 1980s. From the mid 1980s through the late 1990s, the basin went through a prolonged period of above-average streamflow and precipitation, demonstrating the hydrologic variability in the basin.
- The median flow in the North Canadian River below Lake Overholser is greater than 2,000 AF/month throughout the year, except August, and greater than 5,000 AF/month in the spring and early summer. However, the river can have periods of low flow in any month of the year. Relative to other basins in the state, the surface water quality in Basin 51 is considered poor.
- Lake Overholser provides 5,000 AFY of dependable water supply for Oklahoma City from the North Canadian River. The yield is supplemented by releases from Canton Reservoir. Overholser is fully permitted and not expected to provide additional water supplies in the future. Lake El Reno is used by the City of El Reno for flood control and recreation, but does not provide water supplies.

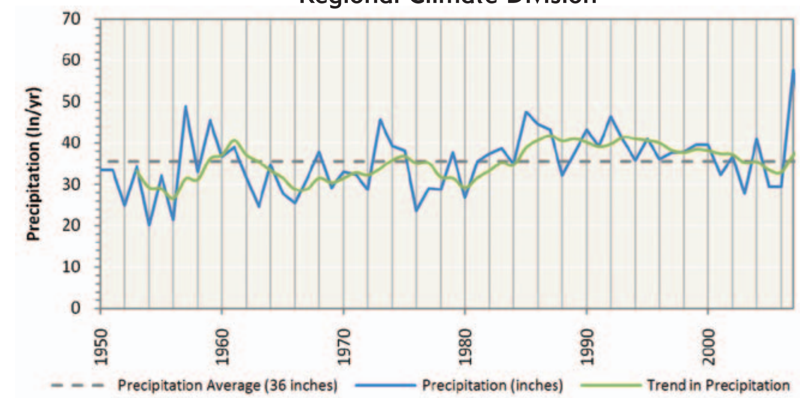
Monthly Historical Streamflow at the Basin Outlet
Central Region, Basin 51



Historical Streamflow at the Basin Outlet
Central Region, Basin 51



Historical Precipitation
Regional Climate Division



Notes & Assumptions

- Precipitation data are based on regional information, while streamflow is basin-specific.
- Measured streamflow implicitly reflects the conditions that exist in the stream at the time the data were recorded (e.g., hydrology, diversions, reservoirs, and infrastructure).
- For water supply planning, the range of potential future hydrologic conditions, including droughts, is represented by 58 years of monthly surface water flows (1950 to 2007). Climate change variations to these flows are documented in a separate OCWP report.
- Surface water supplies are calculated by adjusting the historical streamflow to account for upstream demands, return flows, and out-of-basin supplies.
- The upstream state is assumed to use 60 percent of the flow at the state line based on OWRB permitting protocol.
- Historical flow is based on USGS stream gages at or near the basin outlet. Where a gage did not exist near the outlet or there were missing data in the record, an estimation of flow was determined from representative, nearby gages using statistical techniques.
- Existing surface water rights may restrict the quantity of available surface water to meet future demands. Additional permits would decrease the amount of available water.

Groundwater Resources - Aquifer Summary (2010)

Central Region, Basin 51

Aquifer			Portion of Basin Overlaying Aquifer	Current Groundwater Rights	Aquifer Storage in Basin	Equal Proportionate Share	Groundwater Available for New Permits
Name	Type	Class[1]	Percent	AFY	AF	AFY/Acre	AFY
Canadian River	Alluvial	Major	3%	12,100	48,000	temporary 2.0	24,800
Garber-Wellington	Bedrock	Major	1%	0	226,000	temporary 2.0	12,500
North Canadian River	Alluvial	Major	45%	58,100	1,264,000	1.0	148,600
El Reno	Bedrock	Minor	71%	2,400	1,692,000	temporary 2.0	649,200
Non-Delineated Groundwater Source	Bedrock	Minor	N/A	5,000	N/A	temporary 2.0	N/A
Non-Delineated Groundwater Source	Alluvial	Minor	N/A	0	N/A	temporary 2.0	N/A

1 Bedrock aquifers with typical yields greater than 50 gpm and alluvial aquifers with typical yields greater than 150 gpm are considered major.

Groundwater Resources

- The majority of groundwater permits in Basin 51 are from the North Canadian River major alluvial aquifer. The North Canadian River aquifer underlies the length of the basin along its northern edge (about 45% of the basin area) and has more than 1.2 million AF of groundwater storage in the basin. There are also permits in the Canadian River major alluvial aquifer, which only underlies a small portion of the basin, and to a lesser extent the El Reno and non-delineated minor bedrock aquifers. Site-specific information on the suitability of the minor aquifers for supply should be considered before large scale use. The Garber-Wellington aquifer underlies a small portion of the basin but is not currently used.
- There are no significant groundwater quality issues in the basin.

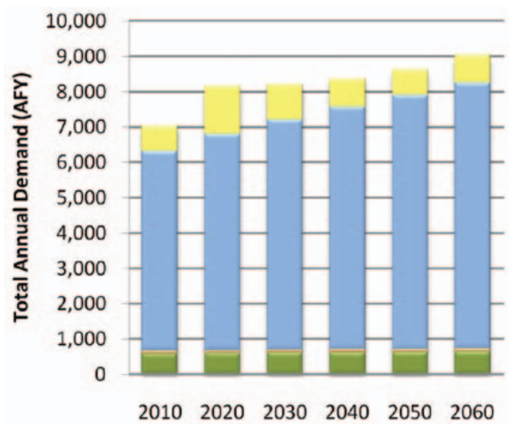
Notes & Assumptions

- Alluvial groundwater recharge is not considered separately from streamflow in physical supply availability analyses because any increases or decreases in alluvial groundwater recharge or storage would affect streamflow. Therefore, surface water flows are used to represent available alluvial groundwater recharge.
- Site-specific information on minor aquifers should be considered before large scale use. Suitability for long term supply is typically based on recharge, storage yield, capital and operational costs, and water quality.
- Groundwater permit availability is generally based on the amount of land owned or leased that overlies a specific aquifer.
- Temporary permit amounts are subject to change when the aquifer's equal proportionate share is set by the OWRB.
- Current groundwater rights represent the maximum allowable use. Actual use may be lower than the permitted amount.
- Bedrock groundwater recharge is the long-term annual average recharge to aquifers in the basin. Recharge rates on a county- or aquifer-wide level of detail were established from literature (published reports) of each aquifer. Seasonal or annual variability is not considered; therefore the modeled bedrock groundwater supply is independent of changing hydrologic conditions.

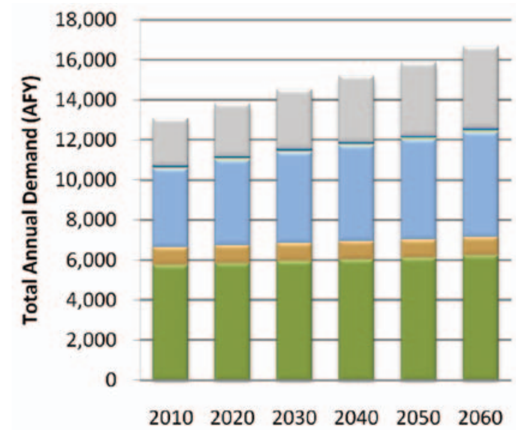
Water Demand

- Basin 51's water needs are about 7% of the demand in the Central Watershed Planning Region and will increase by 26% (5,650 AFY) from 2010 to 2060. The largest demand and greatest growth in demand over this period will be in the Municipal and Industrial demand sector. Substantial growth in Thermoelectric Power demand is also projected.
- Surface water is used to meet 32% of total demand in the basin and its use will increase by 28% (1,960 AFY) from 2010 to 2060. The majority of the surface water use and growth in surface water use over this period will be in the Municipal and Industrial demand sector.
- Alluvial groundwater is used to meet 59% of total demand in the basin and its use will increase by 27% (3,570 AFY) from 2010 to 2060. The largest alluvial groundwater use over this period will be in the Crop Irrigation demand sector. However, the greatest growth in alluvial groundwater use from 2010 to 2060 will be in the Municipal and Industrial demand sector.
- Bedrock groundwater is used to meet 9% of total demand in the basin and its use will increase 6% (120 AFY) by 2060. The majority of the bedrock groundwater use over this period will be in the Crop Irrigation demand sector. Oil and Gas demand and bedrock groundwater use will peak around 2020 because of anticipated Woodford Shale drilling activities.

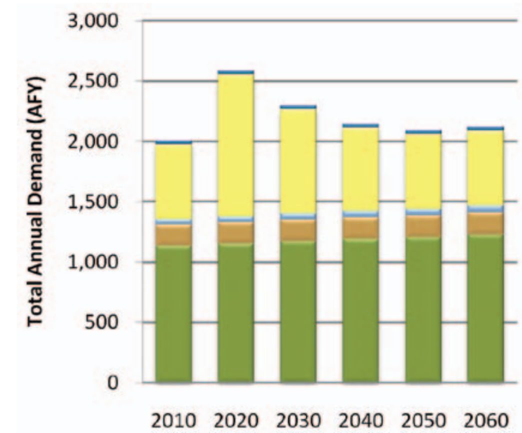
Surface Water Demand by Sector
Central Region, Basin 51



Alluvial Groundwater Demand by Sector
Central Region, Basin 51



Bedrock Groundwater Demand by Sector
Central Region, Basin 51



Thermoelectric Power | Self-Supplied Residential | Self-Supplied Industrial | Oil & Gas | Municipal & Industrial | Livestock | Crop Irrigation

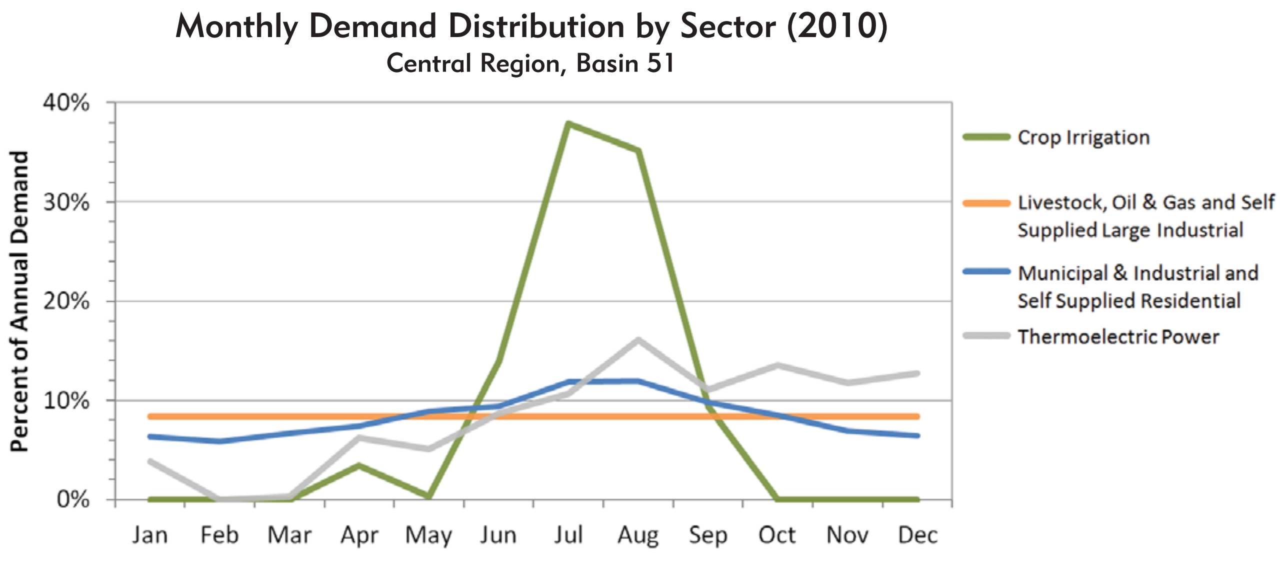
Total Demand by Sector
Central Region, Basin 51

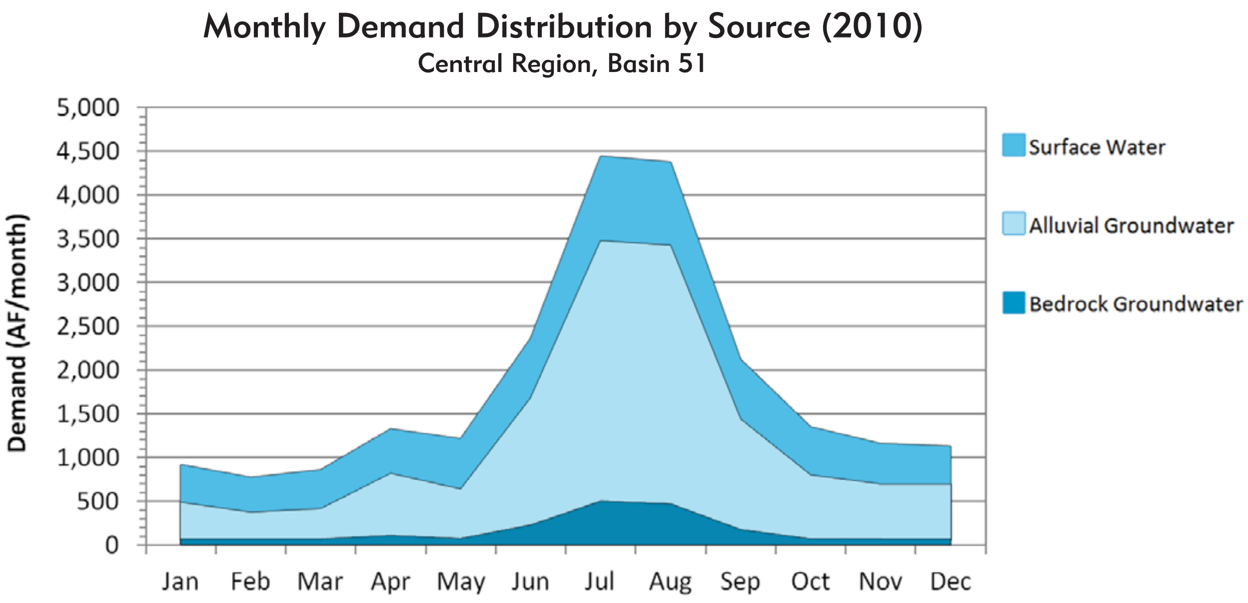
Planning Horizon	Crop Irrigation	Livestock	Municipal & Industrial	Oil & Gas[1]	Self-Supplied Industrial	Self-Supplied Residential	Thermoelectric Power	Total
	AFY							
2010	7,470	1,160	9,630	1,380	0	100	2,360	22,100
2020	7,600	1,170	10,430	2,620	0	110	2,640	24,570
2030	7,720	1,170	11,120	1,920	0	120	2,940	24,990
2040	7,850	1,180	11,730	1,530	0	130	3,280	25,700
2050	7,940	1,180	12,280	1,380	0	140	3,660	26,580
2060	8,100	1,190	12,840	1,380	0	150	4,090	27,750

1 The demand forecast developed in accordance with the O&G work group estimates that 2050 and 2060 demands in seven counties will drop below the 2010 demand level (due to Woodford Shale being played out). As a conservative approach, this assumption is not explicitly carried over into the Gap Analysis. Instead, where applicable, basin demands (in the Central Region, Basins 51 and 58) are assumed to never fall below the 2010 base year demand levels. This is reflected in the Region and Basin Total Demand by Sector tables.

Notes & Assumptions

- Demand values represent total demand (the amount of water pumped or diverted to meet the needs of the user).
- Values are based on the baseline demand forecast from the OCWP *Water Demand Forecast Report*.
- The effect of climate change, conservation, and non-consumptive uses, such as hydropower, are not represented in this baseline demand analysis but are documented in separate OCWP reports.
- The proportion of each supply source used to meet each water use sector's demand was assumed to be equal to the existing proportion, as represented in water rights.
- The proportions of future demands between water use sectors will vary due to differing growth rates.
- The overall proportion of supplies used to meet demand will change due to differing growth rates among the water use sectors.





Current Monthly Demand Distribution by Sector

- The Municipal and Industrial and Self-Supplied Residential demand sectors use 78% more water in summer months than in winter months. Crop Irrigation has a high demand in summer months and little or no demand in winter months. Thermoelectric Power has high demand from summer to early winter and the lowest demand in February and March. Other demand sectors have more consistent demand throughout the year.

Current Monthly Demand Distribution by Source

- The peak summer month total water demand in Basin 51 is about 3.9 times the monthly winter demand, which is similar to the overall statewide pattern. Surface water use in the peak summer month is about 2.2 times the monthly winter use. Monthly alluvial groundwater use peaks in the summer at about 4.7 times the monthly winter use. Monthly bedrock groundwater use peaks in the summer at about 7.2 times the monthly winter use.

Gaps and Storage Depletions

- Based on projected demand and historical hydrology, surface water gaps and groundwater storage depletions may occur by 2020.
- Surface water gaps in Basin 51 may occur throughout the year, peaking in size during the summer. Surface water gaps in 2060 will be up to 16% (190 AF/month) of the surface water demand in the peak summer month and as much as 24% (130 AF/month) of the winter monthly surface water demand. There will be an 81% probability of gaps occurring in at least one month of the year by 2040. Gaps are likely to occur in all seasons.
- Alluvial groundwater storage depletions in Basin 51 may occur throughout the year, peaking in size during the summer. Alluvial storage depletions in 2060 will be up to 15% (550 AF/month) of the alluvial groundwater demand in the peak summer month, and as much as 22% (210 AF/month) of the winter monthly alluvial groundwater demand. There will be an 81% probability of alluvial storage depletions occurring in at least one month of the year by 2040. Alluvial depletions are likely to occur during all seasons.
- Bedrock groundwater storage depletions in Basin 51 may occur during the summer and fall, peaking in size during the summer. Bedrock storage depletions in 2060 will be 7% (40 AF/month) of the bedrock groundwater demand in the peak summer month, and 5% (10 AF/month) of the fall monthly bedrock groundwater demand.
- Alluvial groundwater storage depletions are minimal compared to the groundwater storage in the basin's portion of the North Canadian River and Canadian River aquifers. Future bedrock groundwater withdrawals are expected to occur from minor aquifers. Therefore, the severity of the depletions was not evaluated due to insufficient information.

Surface Water Gaps by Season (2060 Demand)

Central Region, Basin 51

Months (Season)	Maximum Gap [1]	Median Gap	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	130	90	53%
Mar-May (Spring)	140	110	52%
Jun-Aug (Summer)	190	180	66%
Sep-Nov (Fall)	170	170	55%

1 Amount shown represents largest amount for any one month in season indicated.

Alluvial Groundwater Storage Depletions by Season (2060 Demand)

Central Region, Basin 51

Months (Season)	Maximum Storage Depletion[1]	Median Storage Depletion	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	210	100	53%
Mar-May (Spring)	160	150	53%
Jun-Aug (Summer)	550	490	66%
Sep-Nov (Fall)	300	250	55%

1 Amount shown represents largest amount for any one month in season indicated.

Magnitude and Probability of Annual Gaps and Storage Depletions

Central Region, Basin 51

Planning Horizon	Maximum Gaps/Storage Depletions			Probability of Gaps/ Storage Depletions	
	Surface Water	Alluvial GW	Bedrock GW	Surface Water	Alluvial GW
	AFY			Percent	
2020	420	670	600	76%	76%
2030	550	950	280	79%	79%
2040	840	1,490	160	81%	81%
2050	1,190	2,100	80	81%	81%
2060	1,580	2,810	110	81%	81%

Bedrock Groundwater Storage Depletions by Season (2060 Demand)

Central Region, Basin 51

Months (Season)	Average Storage Depletion[1]
	AF/month
Dec-Feb (Winter)	0
Mar-May (Spring)	0
Jun-Aug (Summer)	40
Sep-Nov (Fall)	10

1 Amount shown represents largest amount for any one month in season indicated.

Notes & Assumptions

- Gaps and Storage Depletions reflect deficiencies in physically available water. Permitting, water quality, infrastructure, and nonconsumptive demand constraints are considered in separate OCWP analyses.
- Local gaps and storage depletions may vary from basin-level values due to local variations in demands and local availability of supply sources.
- For this baseline analysis, each basin's future demand is met by the basin's available supplies.
- For this baseline analysis, the proportion of future demand supplied by surface water and groundwater for each sector is assumed equal to current proportions.
- The amount of available surface water supplies used for OCWP water supply availability analysis includes changes in historical streamflow due to increased upstream demand, return flows, and increases in out-of-basin supplies from existing infrastructure.
- Analysis of bedrock groundwater supplies is based upon recharge from major aquifers.
- Groundwater storage depletions are defined as the amount that future demands exceed available recharge.
- Median gaps and storage depletions are based only on months with gaps or storage depletions.
- Annual probability is based upon the number of years that a gap or depletion occurs in at least one month of that year.

Reducing Water Needs Through Conservation

Central Region, Basin 51

Conservation Activities[1]	2060 Gap/Storage Depletion			2060 Gap/ Storage Depletion Probability	
	Surface Water	Alluvial GW	Bedrock GW	Surface Water	Alluvial GW
	AFY			Percent	
Existing Conditions	1,580	2,810	110	81%	81%
Moderately Expanded Conservation in Crop Irrigation Water Use	1,500	2,550	30	81%	81%
Moderately Expanded Conservation in M&I Water Use	430	1,030	90	81%	81%
Moderately Expanded Conservation in Crop Irrigation and M&I Water Use	340	770	20	79%	81%
Substantially Expanded Conservation in Crop Irrigation and M&I Water Use	50	110	0	45%	45%

1 Conservation Activities are documented in the OCWP Water Demand Forecast Report

Reliable Diversions Based on Available Streamflow and New Reservoir Storage

Central Region, Basin 51

Reservoir Storage	Diversion
AF	AFY
100	900
500	1,100
1,000	1,300
2,500	1,700
5,000	2,300
Required Storage to Meet Growth in Demand (AF)	19,500
Required Storage to Meet Growth in Surface Water Demand (AF)	3,800

Water Supply Options & Effectiveness

Typically Effective | Potentially Effective | Likely Ineffective | No Option Necessary

Demand Management

Moderately expanded permanent conservation activities in the Municipal and Industrial, Self-Supplied Residential, and Crop Irrigation demand sectors could reduce surface water gaps by 78%, alluvial groundwater storage depletions by about 73%, and bedrock groundwater storage depletions by about 82%. Temporary drought management activities may not be effective in this basin since gaps have a high probability of occurring and groundwater storage could continue to provide supplies during droughts.

Out-of-Basin Supplies

Out-of-basin supplies could mitigate surface water gaps and groundwater storage depletions. Oklahoma City currently provides supply to several users in the basin, including El Reno, Yukon, and the Canadian County Water Authority. Increased regionalization of supplies could reduce future gaps and depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified sixteen potential out-of-basin sites in the Central Region: Centerpoint in Basin 50; Asher and Scissortail in Basin 56; Dibble and Purcell in Basin 57; Union in Basin 58; Fallis, Nuyaka, Wellston and Welty in Basin 60; Sasakwa in Basin 61; Tate Mountain and West Elm Creek (terminal storage) in Basin 62; and Crescent, Hennessey and Navina in Basin 64. However, due to the distance to reliable water sources, out-of-basin supplies may not be cost-effective for some users in the basin.

Reservoir Use

Additional reservoir storage in Basin 51 could supplement supplies during dry months. However, since the basin is fully allocated, substantial permit issues would have to be resolved. If allowable, the entire increase in demand from 2010 to 2060 could be supplied by a new river diversion and 19,500 AF of reservoir storage at the basin outlet. The use of multiple reservoirs in the basin or upstream of the basin's outlet may increase the amount of storage necessary to mitigate future gaps and storage depletions.

Increasing Reliance on Surface Water

Increasing the use of surface water supplies through direct diversions, without reservoir storage, will increase surface water gaps and is not recommended. Additionally, surface water in the basin is fully allocated, limiting diversions to existing permitted amounts.

Increasing Reliance on Groundwater

Increased reliance on alluvial groundwater supplies could mitigate surface water gaps but would increase the amount of groundwater storage depletions. Any increases in depletions would be minimal relative to the volume of water stored in the major aquifers underlying the basin. However, localized storage depletions may occur and adversely affect well yields, water quality, and/or pumping costs. The Aquifer Recharge Workgroup identified a site near Basin 51 (site # 27) as potentially feasible for aquifer recharge and recovery. Water could potentially be withdrawn from the North Canadian River to recharge the North Canadian River aquifer.

Notes & Assumptions

- Water quality may limit the use of supply sources, which may require new or additional treatment before use.
- Infrastructure related to the diversion, conveyance, treatment, and distribution of water will affect the cost-effectiveness of using any new source of supply.
- The ability to reduce demands will vary based on local acceptance of additional conservation and temporary drought management activities.
- Gaps and depletions may be mitigated in individual calendar months without reductions in the annual probability (chance of having shortage during another month).
- River diversion for new or additional reservoir storage is based on a hypothetical on-channel reservoir at the basin outlet. Reported yields will vary depending upon the reservoir location; placement at the basin outlet would likely result in a higher yield.
- Aquifer storage and recovery may provide additional storage or an alternative to surface storage and should be evaluated on a case by case basis.

Data & Analysis
Central Watershed Planning Region

Basin 56

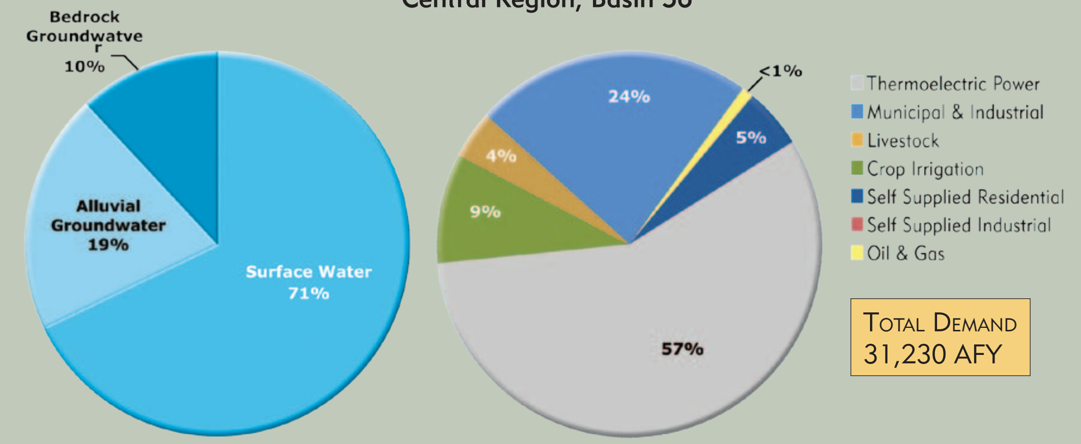
Basin 56 Summary

Synopsis

- Water users are expected to continue to rely mainly on surface water and alluvial groundwater.
- By 2020, there is a moderate probability of surface water gaps from increased demands on existing supplies during low flow periods.
- Alluvial groundwater storage depletions may occur by 2020, but will be minimal in size relative to aquifer storage in the basin. However, localized storage depletions may cause adverse effects for users.
- To reduce the risk of adverse impacts on water supplies, it is recommended that surface water gaps and groundwater depletions be decreased where economically feasible.
- Additional conservation measures could reduce surface water gaps and alluvial groundwater storage depletions.
- To mitigate surface water gaps, dependable groundwater supplies and/or new reservoirs could be developed as alternatives. These supply sources could be used without major impacts to groundwater storage.

Current Demand by Source and Sector

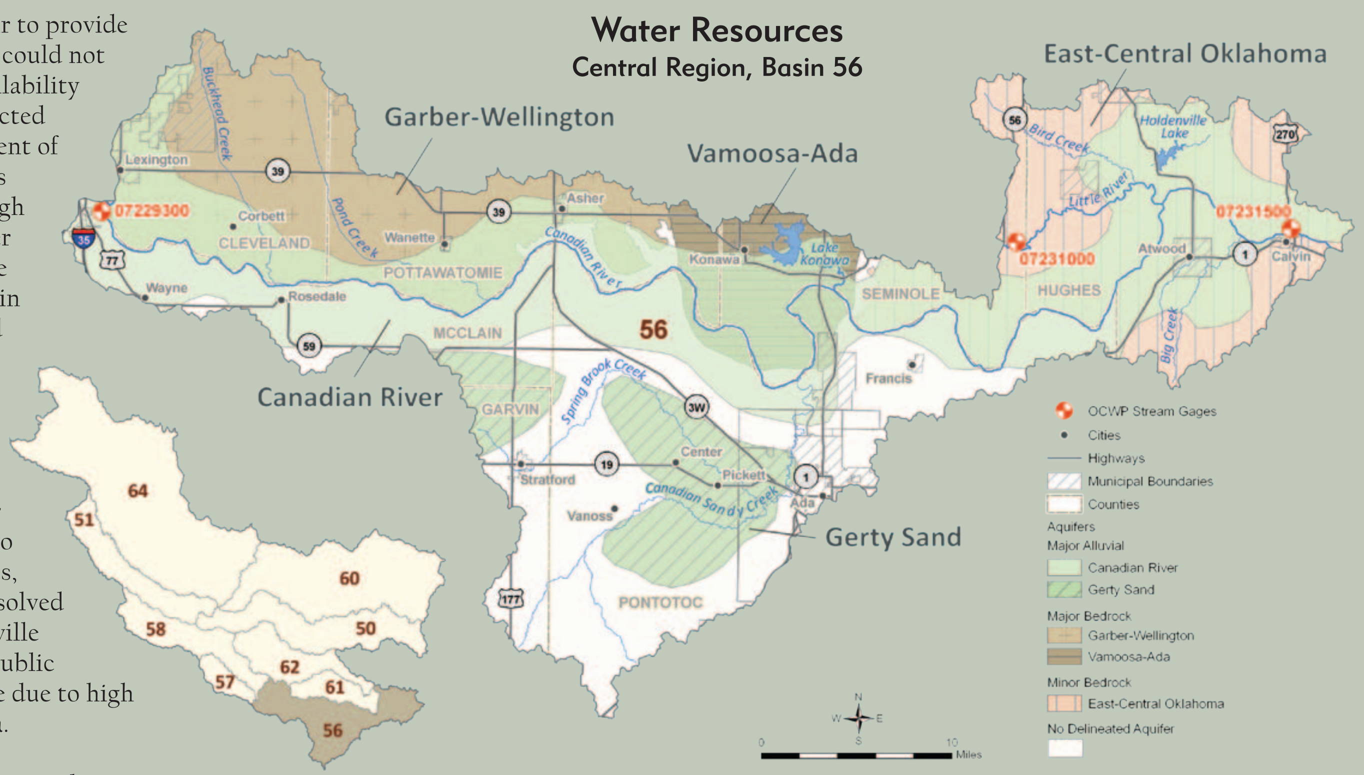
Central Region, Basin 56



Basin 56 accounts for about 9% of the current demand in the Central Watershed Planning Region. About 57% of the basin's 2010 demand was from the Thermoelectric Power demand sector. Municipal and Industrial is the second largest demand sector at 24%. Surface water satisfies about 71% of the current demand in the basin. Groundwater satisfies about 29% of the current demand (19% alluvial and 10% bedrock). The peak summer month total water demand in Basin 56 is about 1.8 times the winter monthly demand, which is less pronounced than the overall statewide pattern.

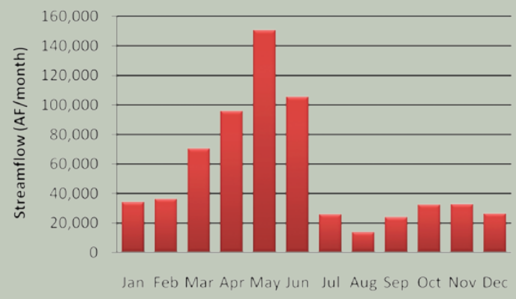
The flow in the Canadian River at Calvin is typically greater than 13,900 AF/month throughout the year and greater than 70,000 AF/month in the spring and early summer. However, the river can have periods of low flow in any month of the year. Lake Konawa provides cooling water to the Oklahoma Gas and Electric Company and is not expected to provide additional water supplies in the future. Holdenville Lake provides water supply to the City of Holdenville. The water supply yield of the lake is unknown; therefore, the ability of this reservoir to provide future water supplies could not be evaluated. The availability of permits is not expected to limit the development of surface water supplies for in-basin use through 2060. Relative to other basins in the state, the surface water quality in Basin 56 is considered fair. Segments of the Canadian River, Big Creek, and several other tributaries to the Canadian River are impaired for Agricultural use due to high levels of chlorides, sulfates, and total dissolved solids (TDS). Holdenville Lake is impaired for Public and Private Water use due to high levels of chlorophyll-a.

There are substantial groundwater permits in Basin 56 from the Canadian River major



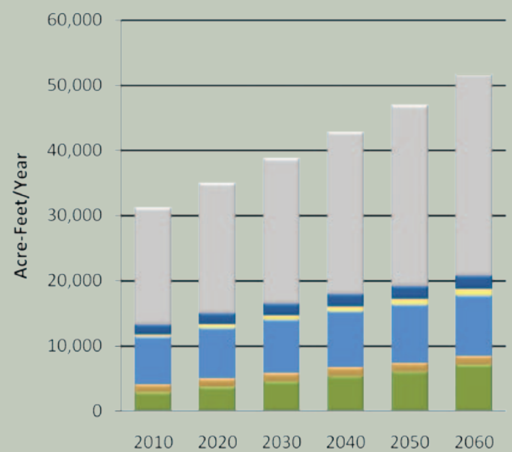
Median Historical Streamflow at the Basin Outlet

Central Region, Basin 56



Projected Water Demand

Central Region, Basin 56



alluvial aquifer, Gerty Sand major alluvial aquifer, and Garber-Wellington major bedrock aquifer. The Canadian River aquifer has more than 1 million AF of groundwater storage in Basin 56 and underlies the northern portion of the basin (about 46 % of the basin area). The Gerty Sand aquifer underlies the south-central portion of the basin and has about 161,000 AF of storage in the basin. The Garber-Wellington aquifer has more than 4.4 million AF of storage in Basin 56's portion of the aquifer and underlies the northwestern portion of the basin (about 22% of the basin area). The OWRB and USGS are currently conducting a detailed study of the Garber-Wellington aquifer that will establish the maximum annual yield and equal proportionate share for the aquifer, which may change the current 2 AFY/acre allocation for temporary permits.

There are also permits in the Vamoosa-Ada major bedrock aquifer and minor bedrock aquifers. Basin 56 contributes about 17,000 AFY of recharge to the Garber-Wellington and Vamoosa-Ada aquifers. The use of groundwater to meet in-basin demand is not expected to be limited by the availability of permits through 2060. High concentrations of nitrate, arsenic, chromium, radionuclides, and selenium have been found locally in the Garber-Wellington aquifer and may limit its use for Municipal and Industrial and other demand sectors. The OWRB and USGS are currently conducting a detailed study to better characterize the water quality of the aquifer for all users. There are no significant groundwater quality issues in other aquifers in the basin.

The projected 2060 water demand of 51,760 AFY in Basin 56 reflects a 20,530 AFY increase (66%) over the 2010 demand. The majority of the demand and growth in demand over this period will be in the Thermoelectric Power demand sector. There will also be substantial growth in demand in the Municipal and Industrial and Crop Irrigation demand sectors.

Gaps & Depletions

Based on projected demand and historical hydrology, surface water gaps and alluvial groundwater storage depletions may occur by 2020. No bedrock groundwater storage depletions are expected through 2060. Surface water gaps will be up to 8,790 AFY and have a 59% probability of occurring in at least one month of the year by 2060. Alluvial groundwater storage depletions will be up to 2,580 AFY and have a 59% probability of occurring in at least one month of the year by 2060. Surface water gaps and alluvial groundwater storage depletions in Basin 56 may occur throughout the year, peaking in size during the summer. Projected annual alluvial groundwater storage depletions are minimal relative to the amount of water in storage in the Canadian River and Gerty Sand aquifers. However, localized storage depletions may adversely affect well yields, water quality, or pumping costs.

Water Supply Limitations

Central Region, Basin 56

Surface Water	Potential
Alluvial Groundwater	Potential
Bedrock Groundwater	Minimal

Minimal · Potential · Significant

Water Supply Option Effectiveness

Central Region, Basin 56

Demand Management	Potentially Effective
Out-of-Basin Supplies	Potentially Effective
Reservoir Use	Typically Effective
Increasing Supply from Surface Water	Likely Ineffective
Increasing Supply from Groundwater	Typically Effective

Typically Effective · Potentially Effective · Likely Ineffective · No Option Necessary

Options

Water users are expected to continue to rely primarily on surface water and alluvial groundwater supplies. To reduce the risk of adverse impacts to the basin's water users, surface water gaps and alluvial groundwater storage depletions should be decreased where economically feasible.

Moderately expanded permanent conservation activities in the Municipal and Industrial, Self-Supplied Residential, and Crop Irrigation demand sectors could reduce surface water gaps and alluvial groundwater storage depletions. Temporary drought management activities may not be effective in this basin, since gaps have a high probability of occurring and groundwater storage could continue to provide supplies during droughts.

Out-of-basin supplies could mitigate alluvial groundwater depletions and surface water gaps. The City of Ada currently obtains its substantial water supplies out-of-basin from Byrds Mill Spring and the Arbuckle-Simpson major bedrock aquifer in the Blue-Boggy Region. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified fourteen potential out-of-basin sites in the Central Region. However, in light of the substantial groundwater supplies and distance to reliable water supplies, out-of-basin supplies may not be cost-effective for many users in the basin.

Additional reservoir storage in Basin 56 could effectively supplement supplies during dry months. The entire increase in demand from 2010 to 2060 could be supplied by a new reservoir diversion and 11,700 AF of reservoir storage at the basin outlet. The OCWP *Reservoir Viability Study* also identified two potential sites in Basin 56.

Increased reliance on surface water through direct diversions, without reservoir storage, will increase surface water gaps and is not recommended.

Increased reliance on the Canadian River aquifer or Garber-Wellington aquifers could mitigate surface water gaps. Any increases in storage depletions would be minimal relative to the volume of water stored in these major aquifers. However, localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

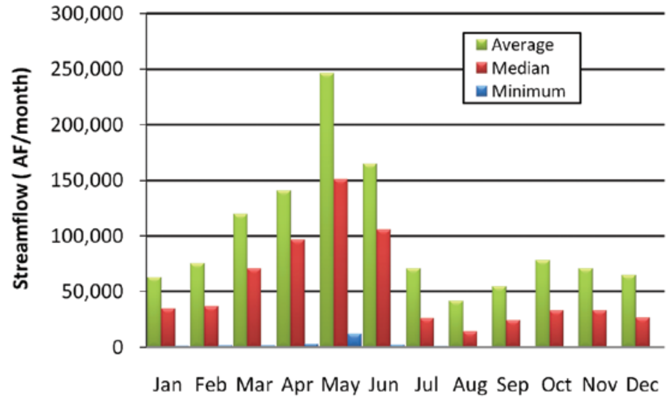
Basin 56 Data & Analysis

Surface Water Resources

- Historical streamflow from 1950 through 2007 was used to estimate the range of future surface water supplies. The Canadian River at Calvin had a period of below-average streamflow from the early 1960s to the early 1970s. From the mid 1980s through the late 1990s, the basin went through a prolonged period of above-average streamflow and precipitation, demonstrating the hydrologic variability in the basin.
- The range of historical streamflow at the basin outlet is shown by the average, median and minimum streamflow over a 58-year period of record. The median flow in the Canadian River at Calvin is greater than 13,900 AF/month throughout the year and greater than 70,000 AF/month in the spring and early summer. However, the river can have periods of low flow in any month of the year. Relative to other basins in the state, the surface water quality in Basin 56 is considered fair.
- Lake Konawa provides cooling water to the Oklahoma Gas and Electric Company and is not expected to provide additional water supplies for new users in the future. Holdenville Lake provides water supply to the City of Holdenville. The water supply yield of the lake is unknown; therefore, the ability of this reservoir to provide future water supplies could not be evaluated.

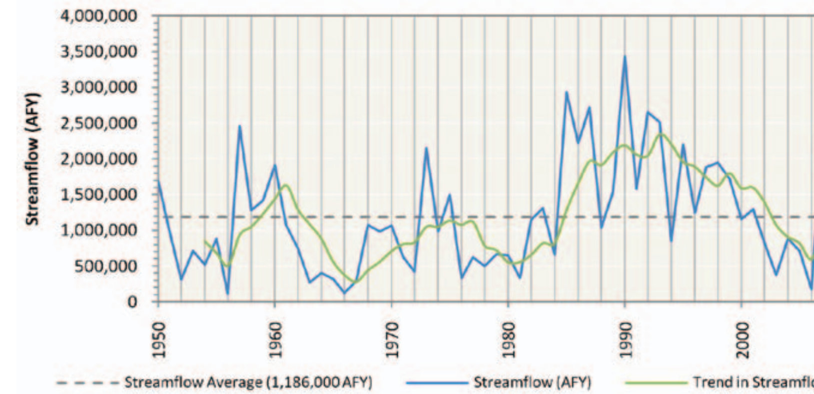
Monthly Historical Streamflow at the Basin Outlet

Central Region, Basin 56



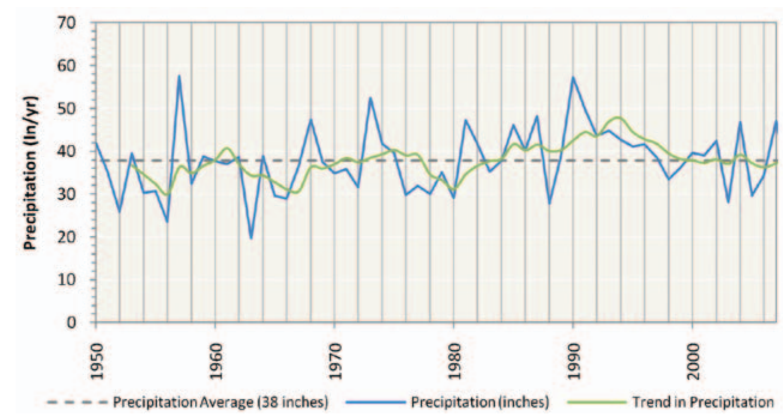
Historical Streamflow at the Basin Outlet

Central Region, Basin 56



Historical Precipitation

Regional Climate Division



Notes & Assumptions

- Precipitation data are based on regional information, while streamflow is basin-specific.
- Measured streamflow implicitly reflects the conditions that exist in the stream at the time the data were recorded (e.g., hydrology, diversions, reservoirs, and infrastructure).
- For water supply planning, the range of potential future hydrologic conditions, including droughts, is represented by 58 years of monthly surface water flows (1950 to 2007). Climate change variations to these flows are documented in a separate OCWP report.
- Surface water supplies are calculated by adjusting the historical streamflow to account for upstream demands, return flows, and out-of-basin supplies.
- The upstream state is assumed to use 60 percent of the flow at the state line based on OWRB permitting protocol.
- Historical flow is based on USGS stream gages at or near the basin outlet. Where a gage did not exist near the outlet or there were missing data in the record, an estimation of flow was determined from representative, nearby gages using statistical techniques.
- Existing surface water rights may restrict the quantity of available surface water to meet future demands. Additional permits would decrease the amount of available water.

Groundwater Resources - Aquifer Summary (2010)

Central Region, Basin 56

Aquifer			Portion of Basin Overlaying Aquifer	Current Groundwater Rights	Aquifer Storage in Basin	Equal Proportionate Share	Groundwater Available for New Permits
Name	Type	Class[1]	Percent	AFY	AF	AFY/Acre	AFY
Canadian River	Alluvial	Major	46%	15,300	1,136,000	temporary 2.0	509,000
Garber-Wellington	Bedrock	Major	22%	11,700	4,480,000	temporary 2.0	259,100
Gerty Sand	Alluvial	Major	9%	12,100	161,000	0.65	34,000
Vamoosa-Ada	Bedrock	Major	7%	1,700	676,000	2.0	80,500
East-Central Oklahoma	Bedrock	Minor	24%	2,600	2,290,000	temporary 2.0	290,700
Non-Delineated Groundwater Source	Bedrock	Minor	N/A	1,800	N/A	temporary 2.0	N/A
Non-Delineated Groundwater Source	Alluvial	Minor	N/A	0	N/A	temporary 2.0	N/A

1 Bedrock aquifers with typical yields greater than 50 gpm and alluvial aquifers with typical yields greater than 150 gpm are considered major.

Groundwater Resources

- There are substantial groundwater permits in Basin 56 from the Canadian River major alluvial aquifer, Gerty Sand major alluvial aquifer, and Garber-Wellington major bedrock aquifer. The Canadian River aquifer has more than 1 million AF of groundwater storage in Basin 56 and underlies the northern portion of the basin (about 46 % of the basin area). The Gerty Sand aquifer underlies the south-central portion of the basin and has about 160,000 AF of storage in the basin. The Garber-Wellington aquifer has more than 4.4 million AF of storage in Basin 56's portion of the aquifer and underlies the northwestern portion of the basin (about 22% of the basin area). The OWRB and USGS are currently conducting a detailed study of the Garber-Wellington that will establish an equal proportionate share for the aquifer and may change the current EPS of 2 AFY/acre allocation under temporary permits. There are also permits in the Vamoosa-Ada major bedrock aquifer and minor bedrock aquifers. Basin 56 contributes about 17,000 AFY of recharge to the Garber-Wellington and Vamoosa-Ada aquifers.
- High concentrations of nitrate, arsenic, chromium, radionuclides, and selenium have been found locally in the Garber-Wellington aquifer and may limit its use for Municipal and Industrial and other demand sectors. The OWRB and USGS are currently conducting a detailed study to better characterize the water quality of the aquifer for all users. There are no significant groundwater quality issues in other aquifers in the basin.

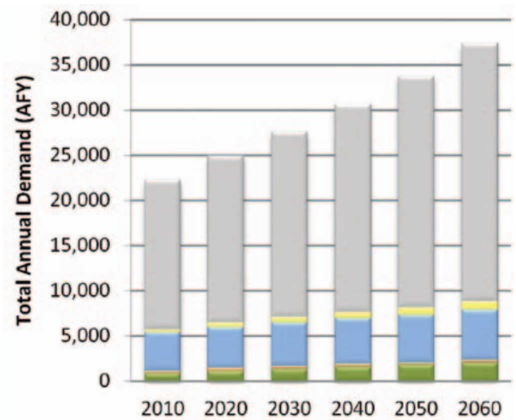
Notes & Assumptions

- Alluvial groundwater recharge is not considered separately from streamflow in physical supply availability analyses because any increases or decreases in alluvial groundwater recharge or storage would affect streamflow. Therefore, surface water flows are used to represent available alluvial groundwater recharge.
- Site-specific information on minor aquifers should be considered before large scale use. Suitability for long term supply is typically based on recharge, storage yield, capital and operational costs, and water quality.
- Groundwater permit availability is generally based on the amount of land owned or leased that overlies a specific aquifer.
- Temporary permit amounts are subject to change when the aquifer's equal proportionate share is set by the OWRB.
- Current groundwater rights represent the maximum allowable use. Actual use may be lower than the permitted amount.
- Bedrock groundwater recharge is the long-term annual average recharge to aquifers in the basin. Recharge rates on a county- or aquifer-wide level of detail were established from literature (published reports) of each aquifer. Seasonal or annual variability is not considered; therefore the modeled bedrock groundwater supply is independent of changing hydrologic conditions.

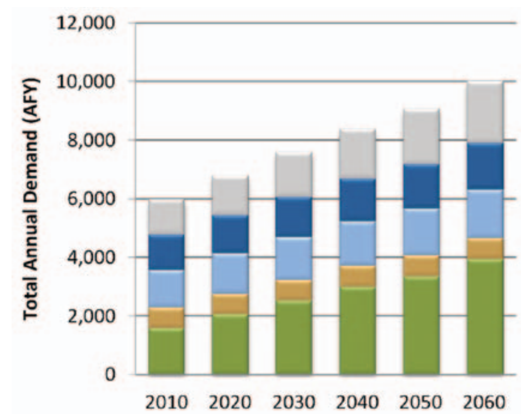
Water Demand

- Basin 56's water needs are about 9% of the demand in the Central Watershed Planning Region and will increase by 66% (20,530 AFY) from 2010 to 2060. The majority of the demand and growth in demand over this period will be in the Thermoelectric Power demand sector. There will also be substantial growth in demand in the Municipal and Industrial and Crop Irrigation demand sectors.
- Surface water and out-of-basin supplies are used to meet 68% of total demand in the basin and their use will increase by 68% (15,060 AFY) from 2010 to 2060. The majority of surface water use and growth in surface water use over this period will be in the Thermoelectric Power demand sector.
- Alluvial groundwater is used to meet 20% of total demand in the basin and its use will increase by 67% (4,000 AFY) from 2010 to 2060. The largest alluvial groundwater use and greatest growth in alluvial groundwater use over this period will be in the Crop Irrigation demand sector.
- Bedrock groundwater is used to meet 12% of total demand in the basin and its use will increase by 49% (1,470 AFY) from 2010 to 2060. The majority of bedrock groundwater use over this period will be in the Municipal and Industrial demand sector. However, the greatest growth in bedrock groundwater use will be in the Crop Irrigation demand sector.

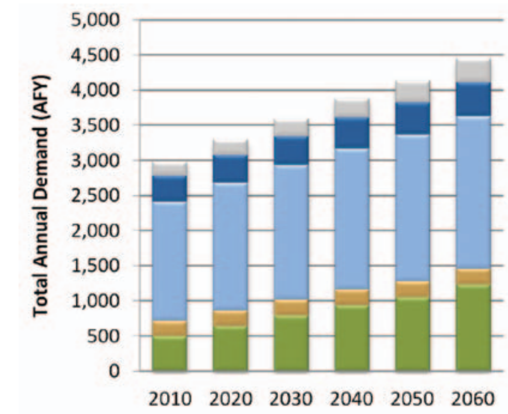
Surface Water Demand by Sector
Central Region, Basin 56



Alluvial Groundwater Demand by Sector
Central Region, Basin 56



Bedrock Groundwater Demand by Sector
Central Region, Basin 56



Thermoelectric Power | Self-Supplied Residential | Self-Supplied Industrial | Oil & Gas | Municipal & Industrial | Livestock | Crop Irrigation

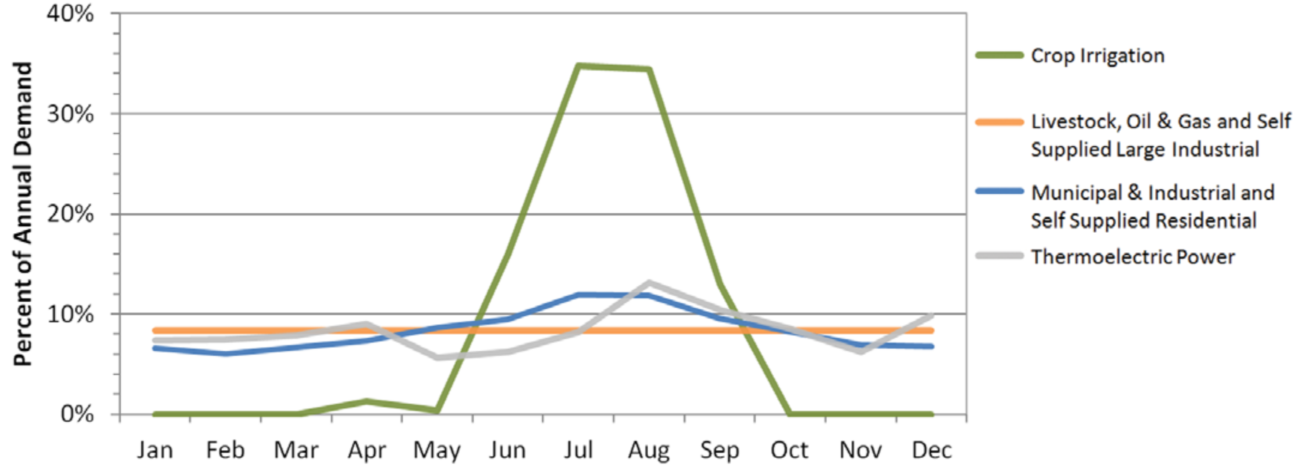
Total Demand by Sector
Central Region, Basin 56

Planning Horizon	Crop Irrigation	Livestock	Municipal & Industrial	Oil & Gas	Self-Supplied Industrial	Self-Supplied Residential	Thermoelectric Power	Total
	AFY							
2010	2,890	1,250	7,300	320	0	1,570	17,900	31,230
2020	3,740	1,270	7,800	550	0	1,690	19,970	35,020
2030	4,590	1,280	8,220	610	0	1,800	22,280	38,780
2040	5,440	1,300	8,610	720	0	1,900	24,850	42,820
2050	6,090	1,320	8,950	850	0	1,990	27,720	46,920
2060	7,130	1,340	9,300	990	0	2,070	30,930	51,760

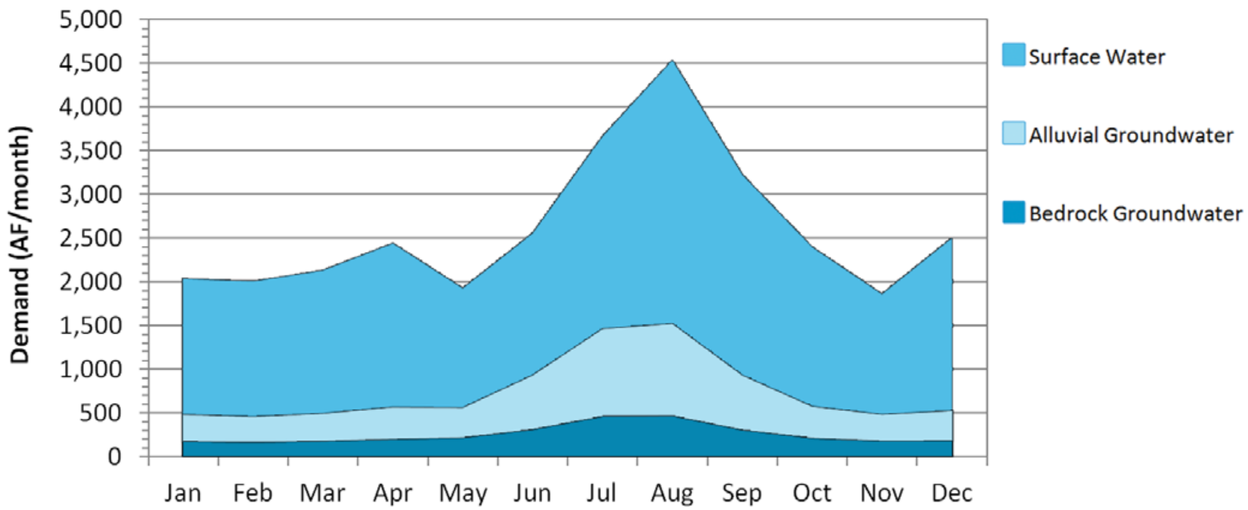
Notes & Assumptions

- Demand values represent total demand (the amount of water pumped or diverted to meet the needs of the user).
- Values are based on the baseline demand forecast from the OCWP *Water Demand Forecast Report*.
- The effect of climate change, conservation, and non-consumptive uses, such as hydropower, are not represented in this baseline demand analysis but are documented in separate OCWP reports.
- The proportion of each supply source used to meet each water use sector's demand was assumed to be equal to the existing proportion, as represented in water rights.
- The proportions of future demands between water use sectors will vary due to differing growth rates.
- The overall proportion of supplies used to meet demand will change due to differing growth rates among the water use sectors.

Monthly Demand Distribution by Sector (2010)
Central Region, Basin 56



Monthly Demand Distribution by Source (2010)
Central Region, Basin 56



Current Monthly Demand Distribution by Sector

- The Municipal and Industrial and Self-Supplied Residential demand sectors use 72% more water in summer months than in winter months. Crop Irrigation has a high demand in summer months and little or no demand in winter months. Thermoelectric Power demand peaks in August and is lowest in May. Other demand sectors have more consistent demand throughout the year.

Current Monthly Demand Distribution by Source

- The peak summer month total water demand in Basin 56 is 1.8 times the monthly winter demand, which is less pronounced than the overall statewide pattern. Surface water use in the peak summer month is about 1.5 times the monthly winter use. Monthly alluvial groundwater use peaks in the summer at about 3.1 times the monthly winter use. Monthly bedrock groundwater use peaks in the summer at about 2.6 times the monthly winter use.

Gaps and Storage Depletions

- Based on projected demand and historical hydrology, surface water gaps and alluvial groundwater storage depletions may occur by 2020. Bedrock groundwater depletions are not expected through 2060.
- Surface water gaps in Basin 56 may occur throughout the year, peaking in size during the summer. Surface water gaps in 2060 will be up to 43% (2,220 AF/month) of the surface water demand in the peak summer month, and as much as 39% (1,280 AF/month) of the winter monthly surface water demand. There will be a 59% probability of gaps occurring in at least one month of the year by 2060. Surface water gaps are most likely to occur during summer months.
- Alluvial groundwater storage depletions in Basin 56 may occur throughout the year, peaking in size during the summer. Alluvial groundwater storage depletions in 2060 will be up to 41% (840 AF/month) of the alluvial groundwater demand in the peak summer month, and as much as 39% (190 AF/month) of the winter monthly alluvial groundwater demand. There will be a 59% probability of alluvial groundwater storage depletions occurring in at least one month of the year by 2060. Alluvial groundwater storage depletions are most likely to occur during summer months.
- Projected annual alluvial groundwater storage depletions are minimal relative to the amount of water in storage in the Canadian River and Gerty Sand aquifers. However, localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Surface Water Gaps by Season (2060 Demand)
Central Region, Basin 56

Months (Season)	Maximum Gap [1]	Median Gap	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	1,280	965	16%
Mar-May (Spring)	1,030	565	3%
Jun-Aug (Summer)	2,220	1,620	47%
Sep-Nov (Fall)	1,570	1,130	26%

1 Amount shown represents largest amount for any one month in season indicated.

Alluvial Groundwater Storage Depletions by Season (2060 Demand)
Central Region, Basin 56

Months (Season)	Maximum Storage Depletion[1]	Median Storage Depletion	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	190	160	16%
Mar-May (Spring)	170	95	3%
Jun-Aug (Summer)	840	750	47%
Sep-Nov (Fall)	430	190	26%

1 Amount shown represents largest amount for any one month in season indicated.

Magnitude and Probability of Annual Gaps and Storage Depletions
Central Region, Basin 56

Planning Horizon	Maximum Gaps/Storage Depletions			Probability of Gaps/ Storage Depletions	
	Surface Water	Alluvial Groundwater	Bedrock Groundwater	Surface Water	Alluvial Groundwater
	AFY			Percent	
2020	1,290	420	0	34%	33%
2030	2,610	850	0	41%	41%
2040	4,330	1,340	0	45%	45%
2050	6,260	1,910	0	52%	52%
2060	8,790	2,580	0	59%	59%

Bedrock Groundwater Storage Depletions by Season (2060 Demand)
Central Region, Basin 56

Months (Season)	Average Storage Depletion[1]
	AF/month
Dec-Feb (Winter)	0
Mar-May (Spring)	0
Jun-Aug (Summer)	0
Sep-Nov (Fall)	0

1 Amount shown represents largest amount for any one month in season indicated.

Notes & Assumptions

- Gaps and Storage Depletions reflect deficiencies in physically available water. Permitting, water quality, infrastructure, and nonconsumptive demand constraints are considered in separate OCWP analyses.
- Local gaps and storage depletions may vary from basin-level values due to local variations in demands and local availability of supply sources.
- For this baseline analysis, each basin's future demand is met by the basin's available supplies.
- For this baseline analysis, the proportion of future demand supplied by surface water and groundwater for each sector is assumed equal to current proportions.
- The amount of available surface water supplies used for OCWP water supply availability analysis includes changes in historical streamflow due to increased upstream demand, return flows, and increases in out-of-basin supplies from existing infrastructure.
- Analysis of bedrock groundwater supplies is based upon recharge from major aquifers.
- Groundwater storage depletions are defined as the amount that future demands exceed available recharge.
- Median gaps and storage depletions are based only on months with gaps or storage depletions.
- Annual probability is based upon the number of years that a gap or depletion occurs in at least one month of that year.

Reducing Water Needs Through Conservation

Central Region, Basin 56

Conservation Activities[1]	2060 Gap/Storage Depletion			2060 Gap/Storage Depletion Probability	
	Surface Water	Alluvial GW	Bedrock GW	Surface Water	Alluvial GW
	AFY			Percent	
Existing Conditions	8,790	2,580	0	59%	59%
Moderately Expanded Conservation in Crop Irrigation Water Use	8,650	2,470	0	59%	59%
Moderately Expanded Conservation in M&I Water Use	7,760	2,270	0	55%	55%
Moderately Expanded Conservation in Crop Irrigation and M&I Water Use	7,610	2,100	0	52%	52%
Substantially Expanded Conservation in Crop Irrigation and M&I Water Use	6,520	1,760	0	47%	47%

1 Conservation Activities are documented in the OCWP Water Demand Forecast Report

Reliable Diversions Based on Available Streamflow and New Reservoir Storage

Central Region, Basin 56

Reservoir Storage	Diversion
AF	AFY
100	200
500	900
1,000	1,800
2,500	4,400
5,000	8,800
Required Storage to Meet Growth in Demand (AF)	11,700
Required Storage to Meet Growth in Surface Water Demand (AF)	7,900

Water Supply Options & Effectiveness

Typically Effective — Potentially Effective — Likely Ineffective — No Option Necessary

Demand Management

Moderately expanded permanent conservation activities in the Municipal and Industrial, Self-Supplied Residential, and Crop Irrigation demand sectors could reduce surface water gaps and alluvial groundwater storage depletions by 13% and 19%, respectively. Temporary drought management activities may not be effective in this basin, since gaps have a high probability of occurring and groundwater storage could continue to provide supplies during droughts.

Out-of-Basin Supplies

Out-of-basin supplies could mitigate surface water gaps and groundwater storage depletions. The City of Ada is expected to continue to receive out-if-basin supplies from Byrds Mill Spring and the Arbuckle-Simpson major bedrock aquifer in the Blue-Boggy Watershed Planning Region. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified fourteen potential out-of-basin sites in the Central Region: Centerpoint in Basin 50; Dibble and Purcell in Basin 57; Union in Basin 58; Fallis, Nuyaka, Wellston and Welty in Basin 60; Sasakwa in Basin 61; Tate Mountain and West Elm Creek (terminal storage) in Basin 62; and Crescent, Hennessey and Navina in Basin 64. However, in light of the substantial groundwater supplies and distance to reliable water supplies, out-of-basin supplies may not be cost-effective for many users in the basin.

Reservoir Use

Additional reservoir storage in Basin 56 could effectively supplement supplies during dry months. The entire increase in demand from 2010 to 2060 could be supplied by a new river diversion and 11,700 AF of reservoir storage at the basin outlet. The use of multiple reservoirs in the basin or reservoirs upstream of the basin's outlet may increase the amount of storage necessary to mitigate future gaps and storage depletions. The OCWP *Reservoir Viability Study* also identified two viable sites in Basin 56 (Asher Lake and Scissortail Reservoir).

Increasing Reliance on Surface Water

Increased reliance on surface water through direct diversions without reservoir storage will increase surface water gaps and is not recommended.

Increasing Reliance on Groundwater

Increased reliance on the Canadian River or Garber-Wellington aquifers could mitigate surface water gaps. Any increases in storage depletions would be minimal relative to the volume of water stored in these aquifers. However, localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Notes & Assumptions

- Water quality may limit the use of supply sources, which may require new or additional treatment before use.
- Infrastructure related to the diversion, conveyance, treatment, and distribution of water will affect the cost-effectiveness of using any new source of supply.
- The ability to reduce demands will vary based on local acceptance of additional conservation and temporary drought management activities.
- Gaps and depletions may be mitigated in individual calendar months without reductions in the annual probability (chance of having shortage during another month).
- River diversion for new or additional reservoir storage is based on a hypothetical on-channel reservoir at the basin outlet. Reported yields will vary depending upon the reservoir location; placement at the basin outlet would likely result in a higher yield.
- Aquifer storage and recovery may provide additional storage or an alternative to surface storage and should be evaluated on a case by case basis.

Oklahoma Comprehensive Water Plan

Data & Analysis
Central Watershed Planning Region

Basin 57

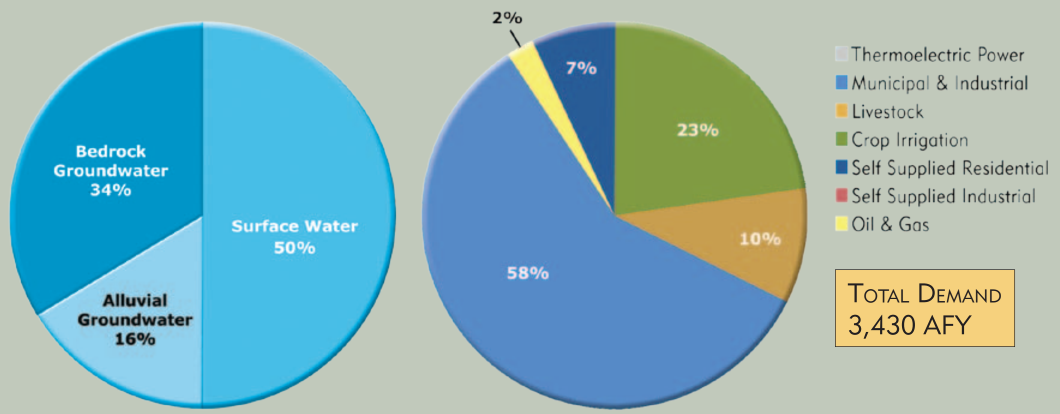
Basin 57 Summary

Synopsis

- Water users are expected to continue to rely on all supply sources: surface water, alluvial groundwater, and bedrock groundwater.
- By 2020, there is a moderate probability of surface water gaps from increased demands on existing supplies during low flow periods.
- Alluvial groundwater storage depletions may occur by 2030, but will be minimal in size relative to aquifer storage in the basin. Bedrock groundwater storage depletions will occur from a minor aquifer by 2020. The severity of the bedrock groundwater storage depletions cannot be evaluated due to insufficient information.
- To reduce the risk of adverse impacts on water supplies, it is recommended that surface water gaps and groundwater depletions be decreased where economically feasible.
- Additional conservation measures could reduce surface water gaps and groundwater storage depletions.
- To mitigate surface water gaps, dependable groundwater supplies and/or new reservoirs could be developed as alternatives. These supply sources could be used without major impacts to groundwater storage.

Current Demand by Source and Sector

Central Region, Basin 57



Basin 57 accounts for about 1% of the current demand in the Central Watershed Planning Region. About 58% of the basin's 2010 demand was from the Municipal and Industrial demand sector. Crop Irrigation is the second largest demand sector at 23%. Surface water satisfies about 50% of the current demand in the basin. Groundwater satisfies about 50% of the current demand (16% alluvial and 34% bedrock). The peak summer month demand in Basin 57 is about 3.7 times the winter monthly demand, which is similar to the overall statewide pattern.

The flow in Walnut Creek at Purcell is typically greater than 500 AF/month throughout the year and greater than 2,000 AF/month in the spring and early summer. However, the creek can have periods of low to no flow in any month of the year. Purcell Lake is available to provide water supply and recreation to the City of Purcell. The water supply yield of the lake is unknown; therefore, the ability of this reservoir to provide future water supplies could not be evaluated. The availability of permits is not expected to limit the development of surface water supplies for in-basin use through 2060. Relative to other basins in the state, the surface water quality in Basin 57 is considered fair.

The majority of groundwater rights in Basin 57 are from the El Reno minor bedrock aquifer. There are also some water rights in the Canadian River major alluvial aquifer and non-delineated minor alluvial groundwater aquifers. The Canadian River aquifer has more than 200,000 AF of groundwater storage in Basin 57 and underlies the northeastern portion of the basin (about 35% of the basin area). Site-specific information on the suitability of the minor aquifers for supply should be considered before large scale use. The use of groundwater to meet in-basin demand is not expected to be limited by the availability of permits through 2060. There are no significant groundwater quality issues in the basin.

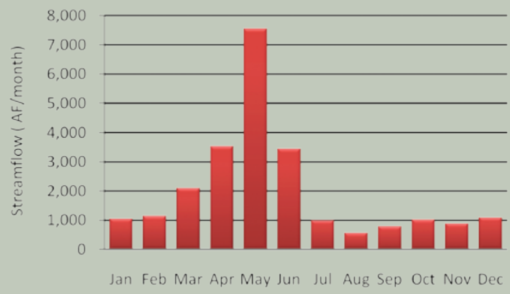
The projected 2060 water demand of 5,290 AFY in Basin 57 reflects a 1,860 AFY increase

Water Resources

Central Region, Basin 57

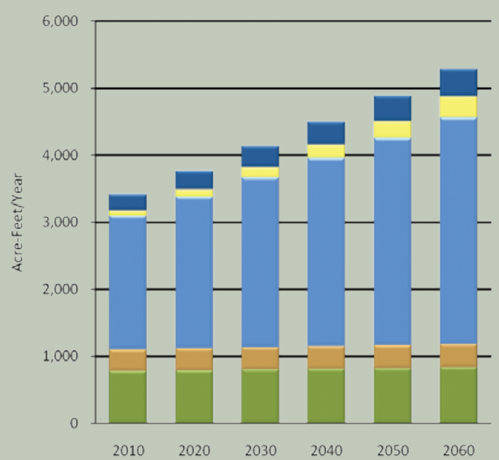
Median Historical Streamflow at the Basin Outlet

Central Region, Basin 57



Projected Water Demand

Central Region, Basin 57



(54%) over the 2010 demand. The majority of the demand and growth in demand over this period will be in the Municipal and Industrial demand sector.

Gaps & Depletions

Based on projected demand and historical hydrology, surface water gaps and bedrock groundwater storage depletions may occur by 2020, while alluvial groundwater storage depletions may occur by 2030. Surface water gaps will be up to 450 AFY and have a 55% probability of occurring in at least one month of the year by 2060. Surface water gaps in Basin 57 may occur throughout the year, peaking in size in the summer. Alluvial groundwater storage depletions will be up to 150 AFY and have a 53% probability of occurring in at least one month of the year by 2060. Projected annual alluvial groundwater storage depletions are minimal relative to the amount of water in storage in the Canadian River aquifer. Bedrock groundwater storage depletions will be up to 810 AFY by 2060. Bedrock groundwater storage depletions in Basin 57 may occur throughout the year, peaking in size during the summer. Future bedrock groundwater withdrawals are expected to occur from minor aquifers. Therefore, the severity of the storage depletions cannot be evaluated due to insufficient information. However, localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Options

Water users are expected to continue to rely on all supply sources: surface water, alluvial groundwater, and bedrock groundwater. To reduce the risk of adverse impacts to the basin's water users, surface water gaps and groundwater storage depletions should be decreased where economically feasible.

Moderately expanded permanent conservation activities in the Municipal and Industrial, Self-Supplied Residential, and Crop Irrigation demand sectors could reduce surface water gaps and groundwater storage depletions. Temporary drought management activities may not be effective in this basin, since gaps have a high probability of occurring and groundwater storage could continue to provide supplies during droughts.

Out-of-basin supplies could mitigate surface water gaps and groundwater storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified fourteen potential out-of-basin sites in the Central Region. However, in light of the distance to reliable water supplies, out-of-basin supplies may not be cost-effective for many users in the basin.

Water Supply Limitations

Central Region, Basin 57

Surface Water
Alluvial Groundwater
Bedrock Groundwater

Minimal Potential Significant

Water Supply Option Effectiveness

Central Region, Basin 57

Demand Management
Out-of-Basin Supplies
Reservoir Use
Increasing Supply from Surface Water
Increasing Supply from Groundwater

Typically Effective Potentially Effective
Likely Ineffective No Option Necessary

Additional reservoir storage in Basin 57 could effectively supplement supplies during dry months. The entire increase in demand from 2010 to 2060 could be supplied by a new reservoir diversion and 1,800 AF of reservoir storage at the basin outlet. The OCWP *Reservoir Viability Study* also identified two viable sites in Basin 57.

Increased reliance on surface water through direct diversions, without reservoir storage, will increase surface water gaps and is not recommended.

Increased reliance on the Canadian River aquifer could mitigate surface water gaps. Any increases in storage depletions would be small relative to the volume of water stored in this major aquifer. However, the aquifer only underlies the northeastern portion of the basin. Additionally, localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

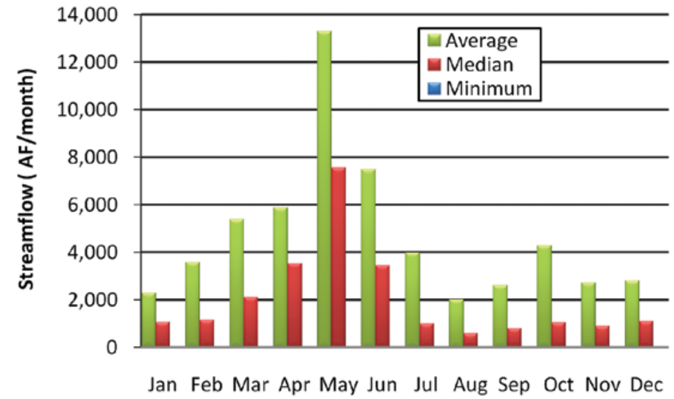
Basin 57 Data & Analysis

Surface Water Resources

- Historical streamflow from 1950 through 2007 was used to estimate the range of future surface water supplies. Walnut Creek at Purcell had a period of below-average streamflow from the early 1960s to the early 1970s. From the early 1980s through the late 1990s, the basin went through a prolonged period of above-average streamflow and precipitation, demonstrating the hydrologic variability in the basin.
- The median flow in Walnut Creek at Purcell is greater than 500 AF/month throughout the year and greater than 2,000 AF/month in the spring and early summer. However, the creek can have periods of low to no flow in any month of the year. Relative to other basins in the state, the surface water quality in Basin 57 is considered fair.
- Purcell Lake is available to provide water supply and recreation to the City of Purcell. The water supply yield of the lake is unknown; therefore, the ability of this reservoir to provide future water supplies could not be evaluated.

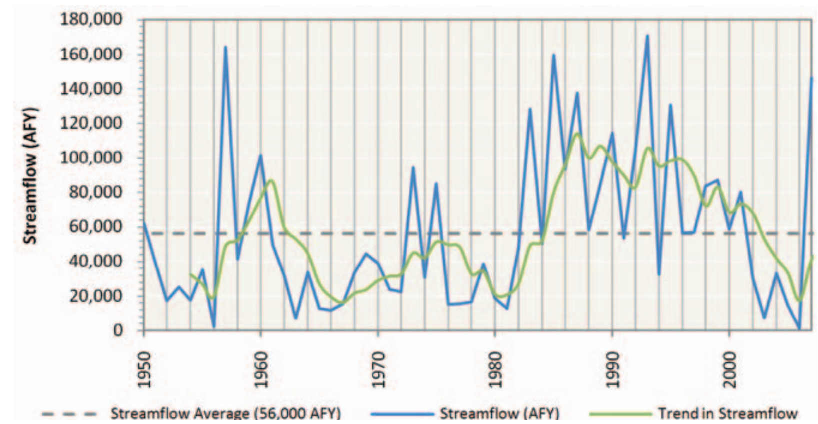
Monthly Historical Streamflow at the Basin Outlet

Central Region, Basin 57



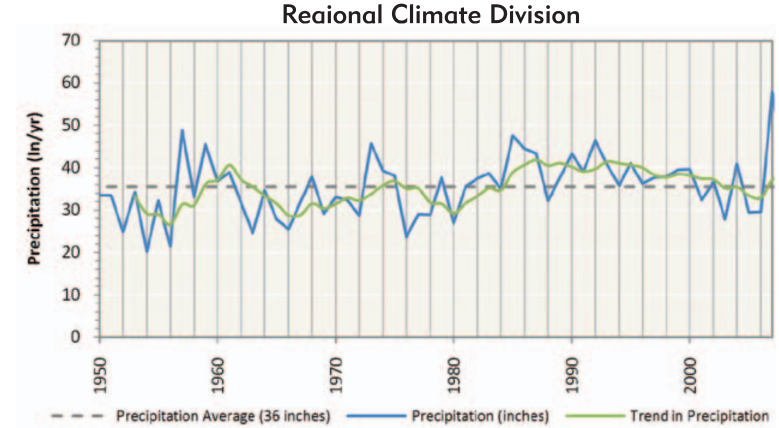
Historical Streamflow at the Basin Outlet

Central Region, Basin 57



Historical Precipitation

Regional Climate Division



Notes & Assumptions

- Precipitation data are based on regional information, while streamflow is basin-specific.
- Measured streamflow implicitly reflects the conditions that exist in the stream at the time the data were recorded (e.g., hydrology, diversions, reservoirs, and infrastructure).
- For water supply planning, the range of potential future hydrologic conditions, including droughts, is represented by 58 years of monthly surface water flows (1950 to 2007). Climate change variations to these flows are documented in a separate OCWP report.
- Surface water supplies are calculated by adjusting the historical streamflow to account for upstream demands, return flows, and out-of-basin supplies.
- The upstream state is assumed to use 60 percent of the flow at the state line based on OWRB permitting protocol.
- Historical flow is based on USGS stream gages at or near the basin outlet. Where a gage did not exist near the outlet or there were missing data in the record, an estimation of flow was determined from representative, nearby gages using statistical techniques.
- Existing surface water rights may restrict the quantity of available surface water to meet future demands. Additional permits would decrease the amount of available water.

Groundwater Resources - Aquifer Summary (2010)

Central Region, Basin 57

Aquifer			Portion of Basin Overlaying Aquifer	Current Groundwater Rights	Aquifer Storage in Basin	Equal Proportionate Share	Groundwater Available for New Permits
Name	Type	Class[1]	Percent	AFY	AF	AFY/Acre	AFY
Canadian River	Alluvial	Major	35%	100	208,000	temporary 2.0	88,900
El Reno	Bedrock	Minor	77%	2,900	531,000	temporary 2.0	196,800
Non-Delineated Groundwater Source	Bedrock	Minor	N/A	0	N/A	temporary 2.0	N/A
Non-Delineated Groundwater Source	Alluvial	Minor	N/A	900	N/A	temporary 2.0	N/A

1 Bedrock aquifers with typical yields greater than 50 gpm and alluvial aquifers with typical yields greater than 150 gpm are considered major.

Groundwater Resources

- The majority of groundwater rights in Basin 57 are from the El Reno minor bedrock aquifer. There are also water rights in the Canadian River major alluvial aquifer and non-delineated minor alluvial groundwater aquifers. The Canadian River aquifer has more than 200,000 AF of groundwater storage in Basin 57 and underlies the northeastern portion of the basin (about 35% of the basin area). Site-specific information on the suitability of the minor aquifers for supply should be considered before large scale use.
- There are no significant groundwater quality issues in the basin.

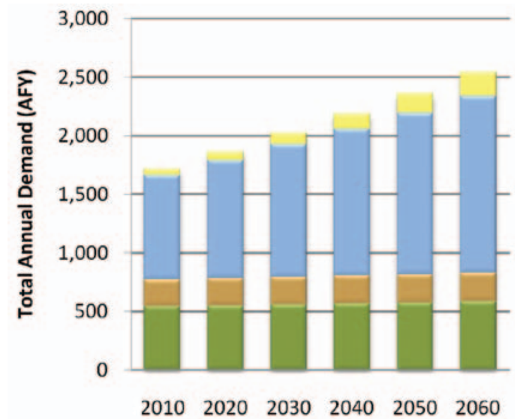
Notes & Assumptions

- Alluvial groundwater recharge is not considered separately from streamflow in physical supply availability analyses because any increases or decreases in alluvial groundwater recharge or storage would affect streamflow. Therefore, surface water flows are used to represent available alluvial groundwater recharge.
- Site-specific information on minor aquifers should be considered before large scale use. Suitability for long term supply is typically based on recharge, storage yield, capital and operational costs, and water quality.
- Groundwater permit availability is generally based on the amount of land owned or leased that overlies a specific aquifer.
- Temporary permit amounts are subject to change when the aquifer's equal proportionate share is set by the OWRB.
- Current groundwater rights represent the maximum allowable use. Actual use may be lower than the permitted amount.
- Bedrock groundwater recharge is the long-term annual average recharge to aquifers in the basin. Recharge rates on a county- or aquifer-wide level of detail were established from literature (published reports) of each aquifer. Seasonal or annual variability is not considered; therefore the modeled bedrock groundwater supply is independent of changing hydrologic conditions.

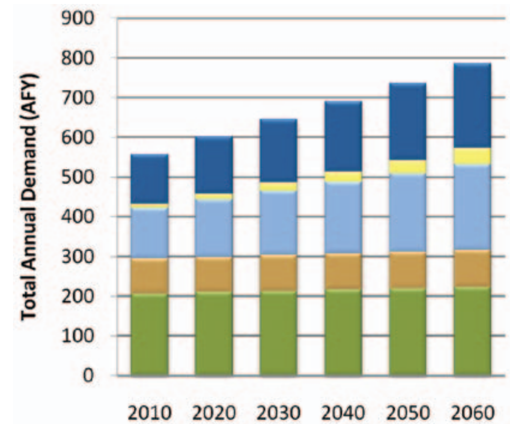
Water Demand

- Basin 57's water needs are about 1% of the demand in the Central Watershed Planning Region and will increase by 54% (1,860 AFY) from 2010 to 2060. The majority of the demand and growth in demand over this period will be in the Municipal and Industrial demand sector.
- Surface water is used to meet 50% of total demand in the basin and its use will increase by 48% (820 AFY) from 2010 to 2060. The majority of surface water use and growth in surface water use over this period will be in the Municipal and Industrial demand sector.
- Alluvial groundwater is used to meet 16% of total demand in the basin and its use will increase by 41% (230 AFY) from 2010 to 2060. The majority of alluvial groundwater use and growth in alluvial groundwater use over this period will be in the Municipal and Industrial and Self-Supplied Residential demand sectors.
- Bedrock groundwater is used to meet 34% of total demand in the basin and its use will increase by 70% (810 AFY) from 2010 to 2060. The majority of bedrock groundwater use and growth in bedrock groundwater use over this period will be in the Municipal and Industrial demand sector.

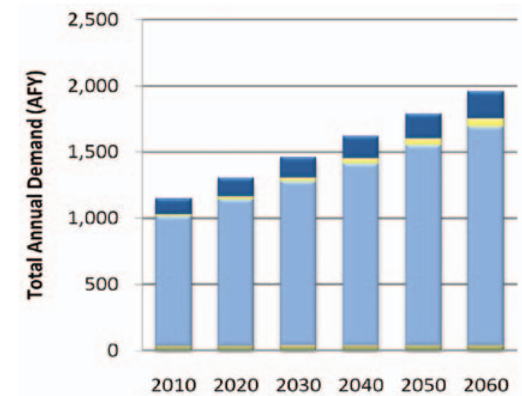
Surface Water Demand by Sector
Central Region, Basin 57



Alluvial Groundwater Demand by Sector
Central Region, Basin 57



Bedrock Groundwater Demand by Sector
Central Region, Basin 57



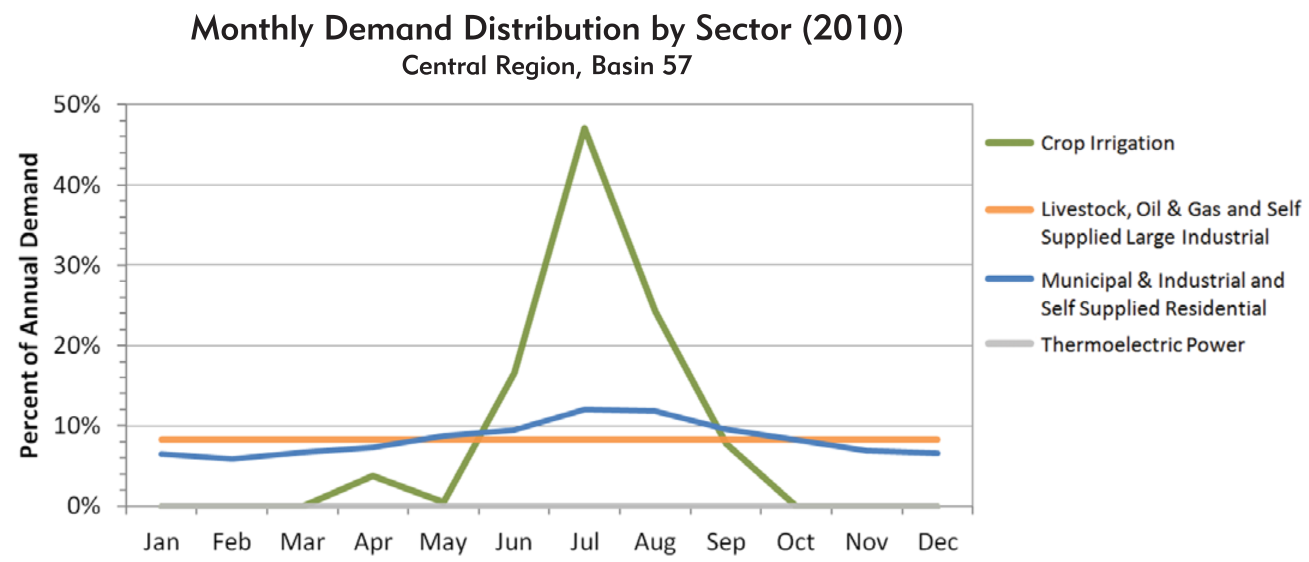
Thermoelectric Power | Self-Supplied Residential | Self-Supplied Industrial | Oil & Gas | Municipal & Industrial | Livestock | Crop Irrigation

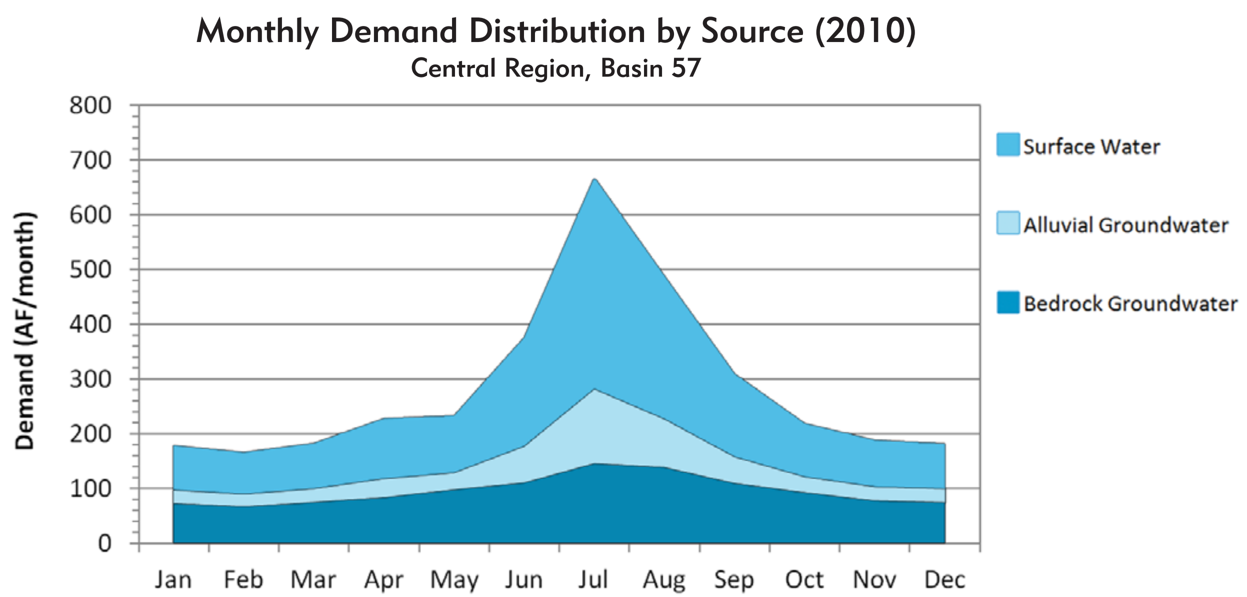
Total Demand by Sector
Central Region, Basin 57

Planning Horizon	Crop Irrigation	Livestock	Municipal & Industrial	Oil & Gas	Self-Supplied Industrial	Self-Supplied Residential	Thermoelectric Power	Total
	AFY							
2010	780	330	2,000	80	0	240	0	3,430
2020	790	330	2,260	110	0	280	0	3,770
2030	800	340	2,540	150	0	310	0	4,140
2040	810	340	2,810	200	0	340	0	4,500
2050	820	340	3,090	250	0	380	0	4,880
2060	840	350	3,380	310	0	410	0	5,290

Notes & Assumptions

- Demand values represent total demand (the amount of water pumped or diverted to meet the needs of the user).
- Values are based on the baseline demand forecast from the OCWP *Water Demand Forecast Report*.
- The effect of climate change, conservation, and non-consumptive uses, such as hydropower, are not represented in this baseline demand analysis but are documented in separate OCWP reports.
- The proportion of each supply source used to meet each water use sector's demand was assumed to be equal to the existing proportion, as represented in water rights.
- The proportions of future demands between water use sectors will vary due to differing growth rates.
- The overall proportion of supplies used to meet demand will change due to differing growth rates among the water use sectors.





Current Monthly Demand Distribution by Sector

- The Municipal and Industrial and Self-Supplied Residential demand sectors use 75% more water in summer months than in winter months. Crop Irrigation has a high demand in summer months and little or no demand in winter months. Other demand sectors have more consistent demand throughout the year.

Current Monthly Demand Distribution by Source

- The peak summer month total water demand in Basin 57 is 3.7 times the monthly winter demand, which is similar to the overall statewide pattern. Surface water use in the peak summer month is about 4.7 times the monthly winter use. Monthly alluvial groundwater use peaks in the summer at about 5.5 times the monthly winter use. Monthly bedrock groundwater use peaks in the summer at about 1.9 times the monthly winter use.

Gaps and Storage Depletions

- Based on projected demand and historical hydrology, surface water gaps and bedrock groundwater storage depletions may occur by 2020; alluvial groundwater storage depletions may occur by 2030.
- Surface water gaps in Basin 57 may occur throughout the year, peaking in size during the summer. Surface water gaps in 2060 will be up to 14% (70 AF/month) of the surface water demand in the peak summer month and as much as 24% (40 AF/month) of the spring monthly surface water demand. There is a 55% probability of gaps occurring in at least one month of the year by 2060. Surface water gaps are most likely to occur during summer and fall months.
- Alluvial storage depletions in Basin 57 may occur throughout the year. Alluvial storage depletions in 2060 will be up to 22% (20 AF/month) of the alluvial groundwater demand in the peak summer month and as much as 25% (10 AF/month) of the winter monthly alluvial groundwater demand. There will be a 53% probability of alluvial storage depletions occurring in at least one month of the year by 2060. Alluvial storage depletions are most likely to occur during summer months.
- Bedrock groundwater storage depletions in Basin 57 may occur throughout the year, peaking in size during the summer. Bedrock storage depletions in 2060 will be 42% (100 AF/month) of the bedrock groundwater demand in the peak summer month, and 38% (50 AF/month) of the winter monthly bedrock groundwater demand.
- Projected annual alluvial groundwater storage depletions are minimal relative to the amount of water in storage in the Canadian River aquifer. Future bedrock groundwater withdrawals are expected to occur from minor aquifers. Therefore, the severity of depletions cannot be evaluated. However, localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Surface Water Gaps by Season (2060 Demand)
Central Region, Basin 57

Months (Season)	Maximum Gap [1]	Median Gap	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	20	20	24%
Mar-May (Spring)	40	20	5%
Jun-Aug (Summer)	70	70	41%
Sep-Nov (Fall)	50	30	34%

1 Amount shown represents largest amount for any one month in season indicated.

Alluvial Groundwater Storage Depletions by Season (2060 Demand)
Central Region, Basin 57

Months (Season)	Maximum Storage Depletion[1]	Median Storage Depletion	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	10	10	24%
Mar-May (Spring)	10	10	5%
Jun-Aug (Summer)	20	20	38%
Sep-Nov (Fall)	10	10	34%

1 Amount shown represents largest amount for any one month in season indicated.

Magnitude and Probability of Annual Gaps and Storage Depletions
Central Region, Basin 57

Planning Horizon	Maximum Gaps/Storage Depletions			Probability of Gaps/ Storage Depletions	
	Surface Water	Alluvial Groundwater	Bedrock Groundwater	Surface Water	Alluvial Groundwater
	AFY			Percent	
2020	50	0	140	34%	0%
2030	170	30	320	47%	29%
2040	250	60	470	47%	43%
2050	360	130	630	50%	47%
2060	450	150	810	55%	53%

Bedrock Groundwater Storage Depletions by Season (2060 Demand)
Central Region, Basin 57

Months (Season)	Average Storage Depletion[1]
	AF/month
Dec-Feb (Winter)	50
Mar-May (Spring)	70
Jun-Aug (Summer)	100
Sep-Nov (Fall)	80

1 Amount shown represents largest amount for any one month in season indicated.

Notes & Assumptions

- Gaps and Storage Depletions reflect deficiencies in physically available water. Permitting, water quality, infrastructure, and nonconsumptive demand constraints are considered in separate OCWP analyses.
- Local gaps and storage depletions may vary from basin-level values due to local variations in demands and local availability of supply sources.
- For this baseline analysis, each basin's future demand is met by the basin's available supplies.
- For this baseline analysis, the proportion of future demand supplied by surface water and groundwater for each sector is assumed equal to current proportions.
- The amount of available surface water supplies used for OCWP water supply availability analysis includes changes in historical streamflow due to increased upstream demand, return flows, and increases in out-of-basin supplies from existing infrastructure.
- Analysis of bedrock groundwater supplies is based upon recharge from major aquifers.
- Groundwater storage depletions are defined as the amount that future demands exceed available recharge.
- Median gaps and storage depletions are based only on months with gaps or storage depletions.
- Annual probability is based upon the number of years that a gap or depletion occurs in at least one month of that year.

Reducing Water Needs Through Conservation

Central Region, Basin 57

Conservation Activities[1]	2060 Gap/Storage Depletion			2060 Gap/Storage Depletion Probability	
	Surface Water	Alluvial GW	Bedrock GW	Surface Water	Alluvial GW
	AFY			Percent	
Existing Conditions	450	150	810	55%	53%
Moderately Expanded Conservation in Crop Irrigation Water Use	410	140	810	53%	50%
Moderately Expanded Conservation in M&I Water Use	170	40	440	47%	38%
Moderately Expanded Conservation in Crop Irrigation and M&I Water Use	150	30	440	47%	29%
Substantially Expanded Conservation in Crop Irrigation and M&I Water Use	0	0	270	0%	0%

1 Conservation Activities are documented in the OCWP Water Demand Forecast Report

Reliable Diversions Based on Available Streamflow and New Reservoir Storage

Central Region, Basin 57

Reservoir Storage	Diversion
AF	AFY
100	500
500	900
1,000	1,300
2,500	2,300
5,000	4,100
Required Storage to Meet Growth in Demand (AF)	1,800
Required Storage to Meet Growth in Surface Water Demand (AF)	500

Water Supply Options & Effectiveness

Typically Effective | Potentially Effective | Likely Ineffective | No Option Necessary

Demand Management

[Potentially Effective] Moderately expanded permanent conservation activities in the Municipal and Industrial, Self-Supplied Residential, and Crop Irrigation demand sectors could reduce surface water gaps by 67%, alluvial groundwater storage depletions by 80%, and bedrock groundwater storage depletions by 46%. Temporary drought management activities may not be effective in this basin since gaps have a high probability of occurring and groundwater storage could continue to provide supplies during droughts.

Out-of-Basin Supplies

[Potentially Effective] Out-of-basin supplies could mitigate surface water gaps and groundwater storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified fourteen potential out-of-basin sites in the Central Region: Centerpoint in Basin 50; Asher and Scissortail in Basin 56; Union in Basin 58; Fallis, Nuyaka, Wellston and Welty in Basin 60; Sasakwa in Basin 61; Tate Mountain and West Elm Creek (terminal storage) in Basin 62; and Crescent, Hennessey and Navina in Basin 64. However, In light of the distance to reliable water supplies, out-of-basin supplies may not be cost-effective for many users in the basin.

Reservoir Use

[Typically Effective] Additional reservoir storage in Basin 57 could effectively supplement supplies during dry months. The entire increase in demand from 2010 to 2060 could be supplied by a new reservoir diversion and 1,800 AF of river storage at the basin outlet. The use of multiple reservoirs in the basin or reservoirs upstream of the basin's outlet may increase the amount of storage necessary to mitigate future gaps and storage depletions. The OCWP *Reservoir Viability Study* identified two viable sites in Basin 57 (Purcell Lake and Dibble Reservoir).

Increasing Reliance on Surface Water

[Likely Ineffective] Increased reliance on surface water through direct diversions, without reservoir storage, will increase surface water gaps and is not recommended.

Increasing Reliance on Groundwater

[Potentially Effective] Increased reliance on the Canadian River aquifer could mitigate surface water gaps. Any increases in storage depletions would be small relative to the volume of water stored in this major aquifer. However, the aquifer only underlies the northeastern portion of the basin.

Notes & Assumptions

- Water quality may limit the use of supply sources, which may require new or additional treatment before use.
- Infrastructure related to the diversion, conveyance, treatment, and distribution of water will affect the cost-effectiveness of using any new source of supply.
- The ability to reduce demands will vary based on local acceptance of additional conservation and temporary drought management activities.
- Gaps and depletions may be mitigated in individual calendar months without reductions in the annual probability (chance of having shortage during another month).
- River diversion for new or additional reservoir storage is based on a hypothetical on-channel reservoir at the basin outlet. Reported yields will vary depending upon the reservoir location; placement at the basin outlet would likely result in a higher yield.
- Aquifer storage and recovery may provide additional storage or an alternative to surface storage and should be evaluated on a case by case basis.

Oklahoma Comprehensive Water Plan

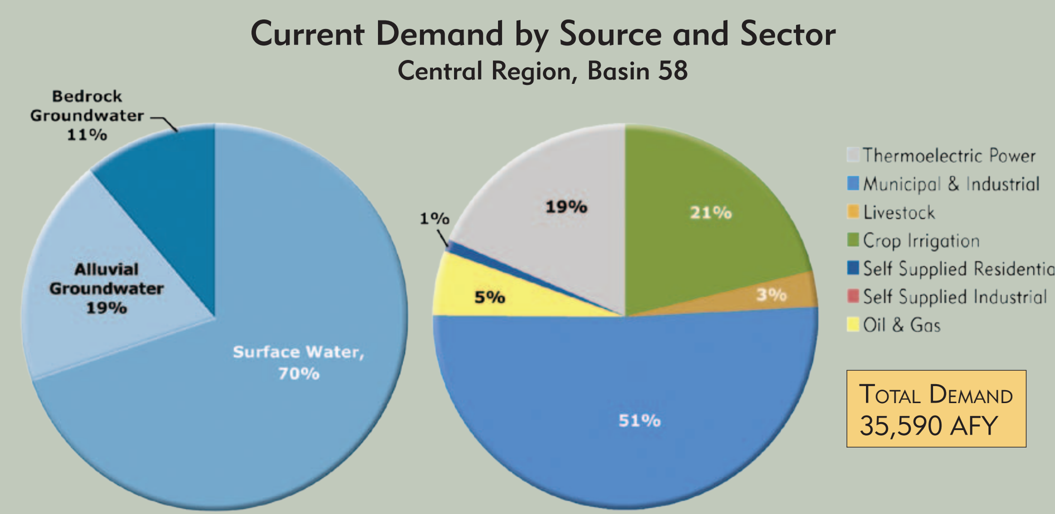
Data & Analysis
Central Watershed Planning Region

Basin 58

Basin 58 Summary

Synopsis

- Water users are expected to continue to rely primarily on surface water and to a lesser extent alluvial and bedrock groundwater.
- By 2020, there is a low to moderate probability of surface water gaps from increased demands on existing supplies during low flow periods.
- Alluvial groundwater storage depletions may occur by 2020, but will minimal in size relative to aquifer storage in the basin.
- To reduce the risk of adverse impacts on water supplies, it is recommended that surface water gaps and alluvial groundwater depletions be decreased where economically feasible.
- Additional conservation measures could reduce surface water gaps and alluvial groundwater storage depletions.
- To mitigate surface water gaps, dependable groundwater supplies and/or developing new reservoirs could be used as alternatives. These supply sources could be used without major impacts to groundwater storage.

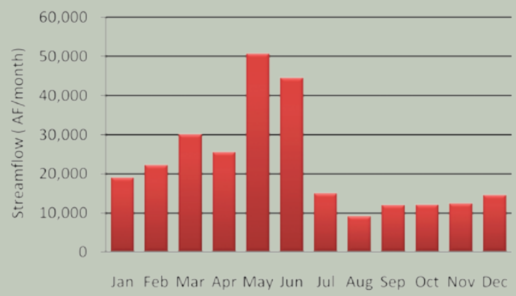


Basin 58 accounts for about 11% of the current demand in the Central Watershed Planning Region. About 51% of the basin's 2010 demand was from the Municipal and Industrial demand sector. Crop Irrigation is the second largest demand sector at 21% followed closely by Thermoelectric Power demand at 19%. Surface water satisfies about 70% of the current demand in the basin. Groundwater satisfies about 30% of the current demand (19% alluvial and 11% bedrock). The peak summer month total water demand in Basin 58 is about 3 times the monthly winter demand, which is similar to the overall statewide pattern.

The flow in the Canadian River at Purcell is typically greater than 9,000 AF/month throughout the year and greater than 25,000 AF/month in the spring and early summer. However, the river can have periods of low flow in any month of the year. There are no major reservoirs in Basin 58. The availability of permits is not expected to limit the development of surface water supplies for in-basin use through 2060. Relative to other basins in the state, the surface water quality in Basin 58 is considered poor. However, individual lakes and streams may have acceptable water quality. A small tributary to the Canadian River is impaired for Agricultural use due to high levels of chloride, sulfate, and total dissolved solids (TDS). Dry Creek is impaired for Public and Private Water Supply due to high levels of oil and grease.

The majority of groundwater rights in Basin 58 are from the Canadian River major alluvial aquifer. There are also substantial water rights in the Garber-Wellington major bedrock aquifer. The Canadian River aquifer has more than 1.1 million AF of groundwater storage in Basin 58 and underlies about 57% of the basin area. The Garber-Wellington aquifer has more than 3.3 million AF of groundwater storage in Basin 58 and underlies the southern portion of the basin (about 19% of the basin area). Basin 58 contributes 15,000 AFY of recharge to the Garber-Wellington and Rush Springs aquifers. The OWRB and USGS are currently conducting a detailed study of the Garber-Wellington that will establish the aquifer's maximum annual yield

Median Historical Streamflow at the Basin Outlet
Central Region, Basin 58



Projected Water Demand
Central Region, Basin 58

and equal proportionate share, which may change the current two AFY/acre allocated under temporary permits. There are additional rights in the Rush Springs major bedrock aquifer and in minor aquifers. Site-specific information on the suitability of the minor aquifers for supply should be considered before large scale use. The use of groundwater to meet in-basin demand is not expected to be limited by the availability of permits through 2060. High concentrations of nitrate, arsenic, chromium, radionuclides, and selenium have been found locally in the Garber-Wellington aquifer and may limit its use for Municipal and Industrial and other demand sectors. The OWRB and USGS are currently conducting a detailed study to better characterize the water quality of the aquifer for all users. There are no significant groundwater quality issues in other aquifers in the basin.

The projected 2060 water demand of 47,420 AFY in Basin 58 reflects an 11,830 AFY increase (33%) over the 2010 demand. The largest demand and greatest growth in demand over this period will be in the Municipal and Industrial demand sector. Substantial growth in demand is also projected for the Thermoelectric Power demand sector.

Gaps & Depletions

Based on projected demand and historical hydrology, surface water gaps and alluvial groundwater storage depletions may occur by 2020. Surface water gaps will be up to 2,690 AFY and have a 19% probability of occurring in at least one month of the year by 2060. Surface water gaps in Basin 58 may occur throughout the year, peaking in size in the summer. Alluvial groundwater storage depletions will be up to 590 AFY and have a 19% probability of occurring in at least one month of the year by 2060. Projected annual alluvial groundwater storage depletions are minimal relative to the amount of water in storage in the Canadian River aquifer. No bedrock groundwater storage depletions are expected through 2060. However, localized alluvial and bedrock storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Options

Water users are expected to continue to rely primarily on surface water and to a lesser extent alluvial and bedrock groundwater. To reduce the risk of adverse impacts to the basin's water users, surface water gaps and alluvial groundwater storage depletions should be decreased where economically feasible.

Moderately expanded permanent conservation activities in the Municipal and Industrial, Self-Supplied Residential, and Crop Irrigation demand sectors could reduce surface water gaps and alluvial groundwater storage depletions. Temporary drought management

Water Supply Limitations
Central Region, Basin 58

Surface Water
Alluvial Groundwater
Bedrock Groundwater

Minimal · Potential · Significant

Water Supply Option Effectiveness
Central Region, Basin 58

Demand Management
Out-of-Basin Supplies
Reservoir Use
Increasing Supply from Surface Water
Increasing Supply from Groundwater

Typically Effective · Potentially Effective · Likely Ineffective · No Option Necessary

activities may be effective for surface water supplies in this basin, since gaps have a low to moderate probability of occurring. However, temporary drought management activities may not be needed for groundwater supplies, since groundwater storage could continue to provide supplies during droughts.

Out-of-basin supplies could mitigate surface water gaps and groundwater storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified fifteen potential out-of-basin sites in the Central Region. However, in light of the distance to reliable water supplies and substantial groundwater resources, out-of-basin supplies may not be cost-effective for many users in the basin.

Additional reservoir storage in Basin 58 could effectively supplement supplies during dry months. The entire increase in demand from 2010 to 2060 could be supplied by a new river diversion and 2,800 AF of reservoir storage at the basin outlet. The OCWP *Reservoir Viability Study* identified one potential site in Basin 58.

Increased reliance on surface water through direct diversions, without reservoir storage, will increase surface water gaps and is not recommended.

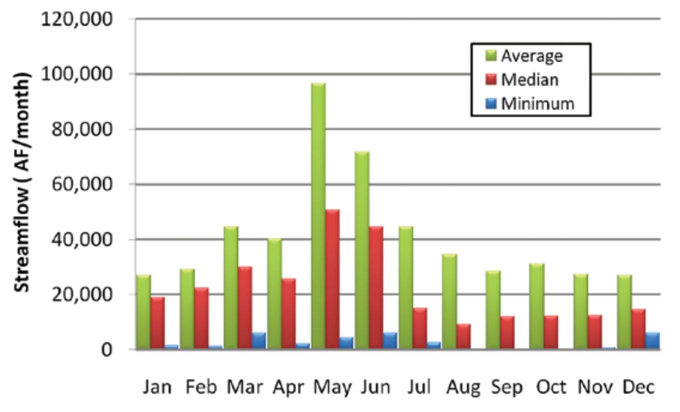
Increased reliance on the Canadian River aquifer or Garber-Wellington aquifer could mitigate surface water gaps. Any increases in storage depletions would be minimal relative to the volume of water in stored in these major aquifers. However, localized storage depletions may occur and adversely affect well yields, water quality, and/or pumping costs.

Basin 58 Data & Analysis

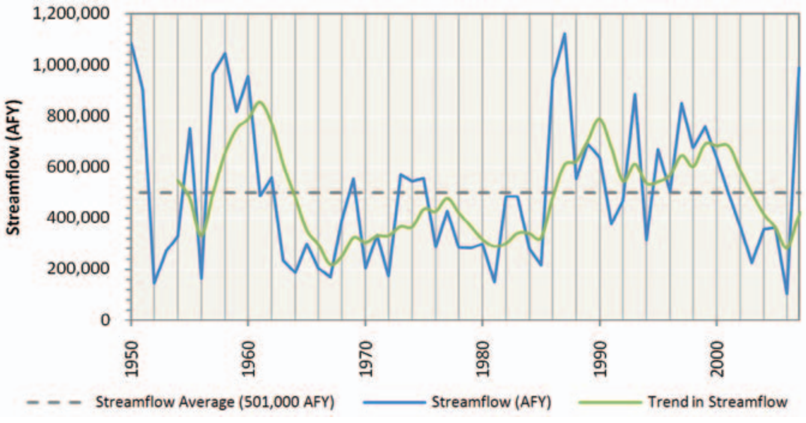
Surface Water Resources

- Historical streamflow from 1950 through 2007 was used to estimate the range of future surface water supplies. The Canadian River at Purcell had a period of below-average streamflow from the early 1960s to the mid 1980s. From the mid 1980s through the late 1990s, the basin went through a prolonged period of above-average streamflow and precipitation, demonstrating the hydrologic variability in the basin.
- The median flow in the Canadian River at Purcell is greater than 9,000 AF/month throughout the year and greater than 25,000 AF/month in the spring and early summer. However, the river can have periods of low flow in any month of the year. Relative to other basins in the state, the surface water quality in Basin 58 is considered poor. However, individual lakes and streams may have acceptable water quality.
- There are no major reservoirs in Basin 58.

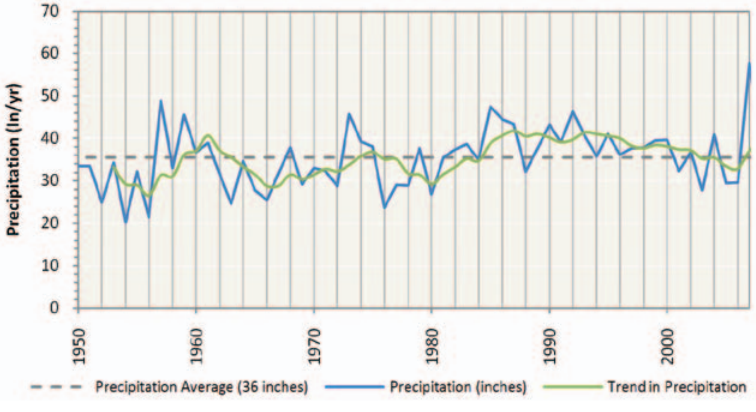
Monthly Historical Streamflow at the Basin Outlet
Central Region, Basin 58



Historical Streamflow at the Basin Outlet
Central Region, Basin 58



Historical Precipitation
Regional Climate Division



Notes & Assumptions

- Precipitation data are based on regional information, while streamflow is basin-specific.
- Measured streamflow implicitly reflects the conditions that exist in the stream at the time the data were recorded (e.g., hydrology, diversions, reservoirs, and infrastructure).
- For water supply planning, the range of potential future hydrologic conditions, including droughts, is represented by 58 years of monthly surface water flows (1950 to 2007). Climate change variations to these flows are documented in a separate OCWP report.
- Surface water supplies are calculated by adjusting the historical streamflow to account for upstream demands, return flows, and out-of-basin supplies.
- The upstream state is assumed to use 60 percent of the flow at the state line based on OWRB permitting protocol.
- Historical flow is based on USGS stream gages at or near the basin outlet. Where a gage did not exist near the outlet or there were missing data in the record, an estimation of flow was determined from representative, nearby gages using statistical techniques.
- Existing surface water rights may restrict the quantity of available surface water to meet future demands. Additional permits would decrease the amount of available water.

Groundwater Resources - Aquifer Summary (2010)

Central Region, Basin 58

Aquifer			Portion of Basin Overlaying Aquifer	Current Groundwater Rights	Aquifer Storage in Basin	Equal Proportionate Share	Groundwater Available for New Permits
Name	Type	Class[1]	Percent	AFY	AF	AFY/Acre	AFY
Canadian River	Alluvial	Major	57%	40,100	1,184,000	temporary 2.0	433,300
Garber-Wellington	Bedrock	Major	19%	19,700	3,373,000	temporary 2.0	129,000
Rush Springs	Bedrock	Major	11%	5,500	942,000	temporary 2.0	92,200
El Reno	Bedrock	Minor	44%	2,400	996,000	temporary 2.0	382,500
Non-Delineated Groundwater Source	Bedrock	Minor	N/A	200	N/A	temporary 2.0	N/A
Non-Delineated Groundwater Source	Alluvial	Minor	N/A	1,100	N/A	temporary 2.0	N/A

1 Bedrock aquifers with typical yields greater than 50 gpm and alluvial aquifers with typical yields greater than 150 gpm are considered major.

Groundwater Resources

- The majority of groundwater rights in Basin 58 are from the Canadian River major alluvial aquifer. There are also substantial water rights in the Garber-Wellington major bedrock aquifer. The OWRB and USGS are currently conducting a detailed study of the Garber-Wellington that will establish an equal proportionate share for the aquifer and may change the current EPS of 2 AFY/acre allocation under temporary permits. There are additional rights in the Rush Springs major bedrock aquifer and in minor aquifers. The Canadian River aquifer has more than 1.1 million AF of groundwater storage in Basin 58 and underlies about 57% of the basin area. The Garber-Wellington aquifer has more than 3.3 million AF of groundwater storage in Basin 58 and underlies the southern portion of the basin (about 19% of the basin area). Basin 58 contributes 15,000 AFY of recharge to the Garber-Wellington and Rush Springs aquifers. Site-specific information on the suitability of the minor aquifers for supply should be considered before large scale use.
- High concentrations of nitrate, arsenic, chromium, radionuclides, and selenium have been found locally in the Garber-Wellington aquifer and may limit its use for Municipal and Industrial and other demand sectors. The OWRB and USGS are currently conducting a detailed study to better characterize the water quality of the aquifer for all users. There are no significant groundwater quality issues in other aquifers in the basin.

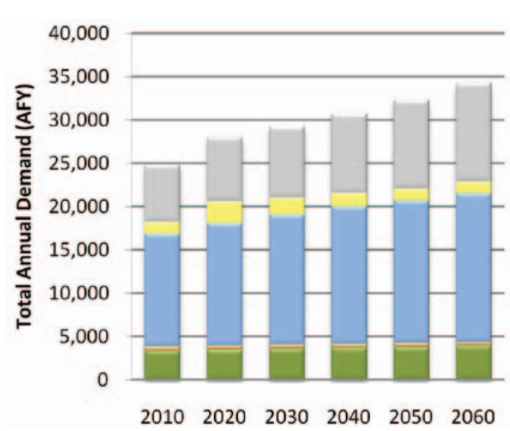
Notes & Assumptions

- Alluvial groundwater recharge is not considered separately from streamflow in physical supply availability analyses because any increases or decreases in alluvial groundwater recharge or storage would affect streamflow. Therefore, surface water flows are used to represent available alluvial groundwater recharge.
- Site-specific information on minor aquifers should be considered before large scale use. Suitability for long term supply is typically based on recharge, storage yield, capital and operational costs, and water quality.
- Groundwater permit availability is generally based on the amount of land owned or leased that overlies a specific aquifer.
- Temporary permit amounts are subject to change when the aquifer's equal proportionate share is set by the OWRB.
- Current groundwater rights represent the maximum allowable use. Actual use may be lower than the permitted amount.
- Bedrock groundwater recharge is the long-term annual average recharge to aquifers in the basin. Recharge rates on a county- or aquifer-wide level of detail were established from literature (published reports) of each aquifer. Seasonal or annual variability is not considered; therefore the modeled bedrock groundwater supply is independent of changing hydrologic conditions.

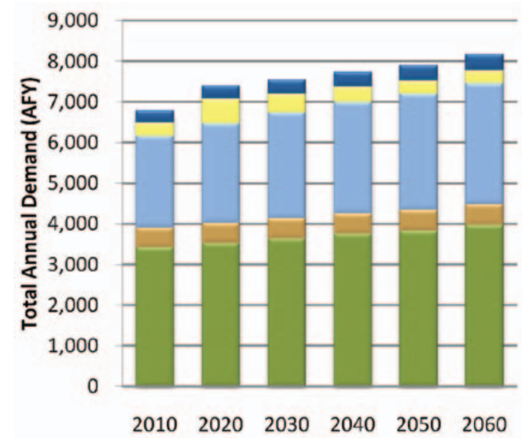
Water Demand

- Basin 58's water needs are about 11% of the demand in the Central Watershed Planning Region and will increase by 33% (11,830 AFY) from 2010 to 2060. The largest demand and greatest growth in demand over this period will be in the Municipal and Industrial demand sector. Substantial growth in demand is also projected for the Thermoelectric Power demand sector.
- Surface water is used to meet 70% of total demand in the basin and its use will increase by 38% (9,420 AFY) from 2010 to 2060. The largest surface water use over this period will be in the Municipal and Industrial demand sector. However, the greatest growth in surface water use will be in the Thermoelectric Power demand sector.
- Alluvial groundwater is used to meet 19% of total demand in the basin and its use will increase by 20% (1,390 AFY) from 2010 to 2060. The largest alluvial groundwater use over this period will be in the Crop Irrigation demand sector. However, the greatest growth in alluvial groundwater use will be in the Municipal and Industrial demand sector.
- Bedrock groundwater is used to meet 11% of total demand in the basin and its use will increase by 26% (1,020 AFY) from 2010 to 2060. The majority of bedrock groundwater use and growth in bedrock groundwater use over this period will be in the Municipal and Industrial demand sector.

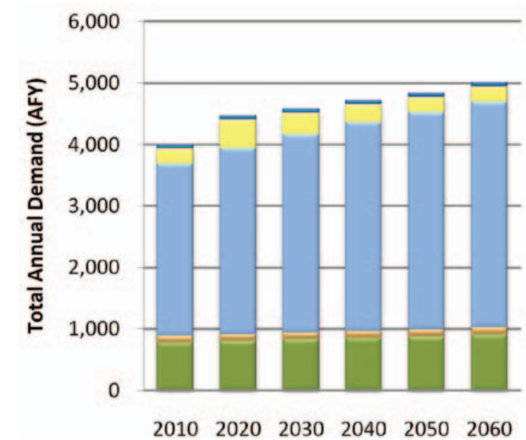
Surface Water Demand by Sector
Central Region, Basin 58



Alluvial Groundwater Demand by Sector
Central Region, Basin 58



Bedrock Groundwater Demand by Sector
Central Region, Basin 58



Thermoelectric Power | Self-Supplied Residential | Self-Supplied Industrial | Oil & Gas | Municipal & Industrial | Livestock | Crop Irrigation

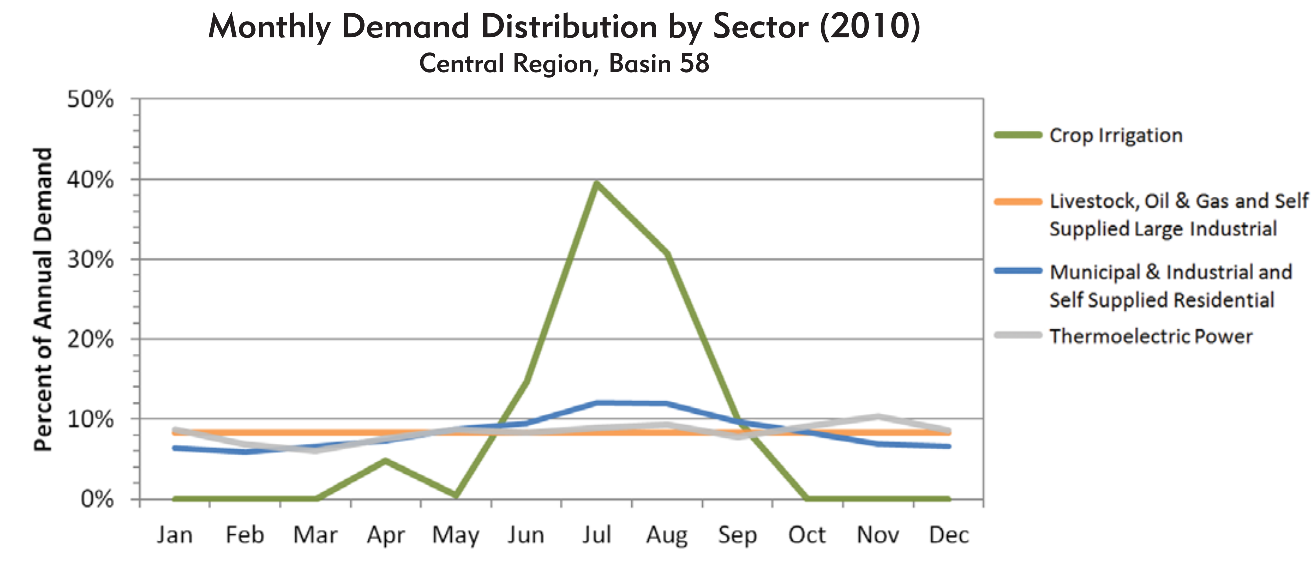
Total Demand by Sector
Central Region, Basin 58

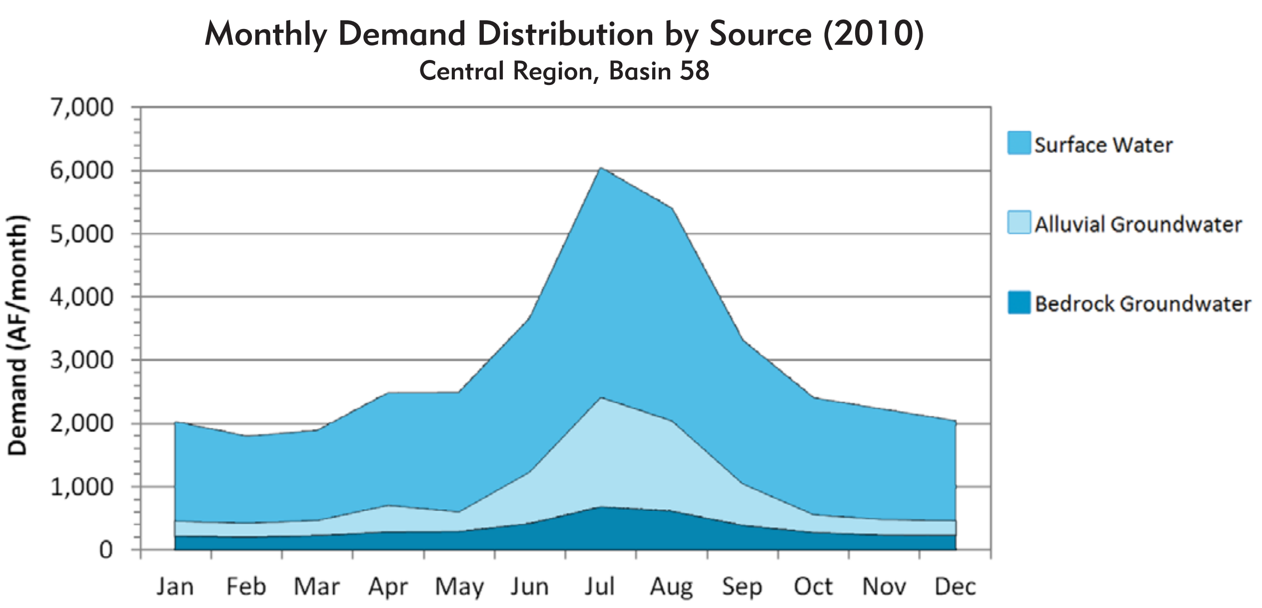
Planning Horizon	Crop Irrigation	Livestock	Municipal & Industrial	Oil & Gas[1]	Self-Supplied Industrial	Self-Supplied Residential	Thermoelectric Power	Total
	AFY							
2010	7,540	1,060	18,140	1,940	0	340	6,570	35,590
2020	7,780	1,080	19,630	3,670	0	370	7,330	39,860
2030	8,020	1,100	20,890	2,770	0	390	8,180	41,350
2040	8,260	1,110	21,970	2,280	0	410	9,130	43,160
2050	8,450	1,130	22,870	1,940	0	430	10,180	45,000
2060	8,740	1,150	23,780	1,940	0	450	11,360	47,420

1 The demand forecast developed in accordance with the O&G work group estimates that 2050 and 2060 demands in seven counties will drop below the 2010 demand level (due to Woodford Shale being played out). As a conservative approach, this assumption is not explicitly carried over into the Gap Analysis. Instead, where applicable, basin demands (in the Central Region, Basins 51 and 58) are assumed to never fall below the 2010 base year demand levels. This is reflected in the Region and Basin Total Demand by Sector tables.

Notes & Assumptions

- Demand values represent total demand (the amount of water pumped or diverted to meet the needs of the user).
- Values are based on the baseline demand forecast from the OCWP *Water Demand Forecast Report*.
- The effect of climate change, conservation, and non-consumptive uses, such as hydropower, are not represented in this baseline demand analysis but are documented in separate OCWP reports.
- The proportion of each supply source used to meet each water use sector's demand was assumed to be equal to the existing proportion, as represented in water rights.
- The proportions of future demands between water use sectors will vary due to differing growth rates.
- The overall proportion of supplies used to meet demand will change due to differing growth rates among the water use sectors.





Current Monthly Demand Distribution by Sector

- The Municipal and Industrial and Self-Supplied Residential demand sectors use 77% more water in summer months than in winter months. Crop Irrigation has a high demand in summer months and little or no demand in winter months. Thermoelectric Power has its highest demand in November and its lowest demand in March. Other demand sectors have more consistent demand throughout the year.

Current Monthly Demand Distribution by Source

- The peak summer month total water demand in Basin 58 is 3 times the monthly winter demand, which is similar to the overall statewide pattern. Surface water use in the peak summer month is about 2.3 times the monthly winter use. Monthly alluvial groundwater use peaks in the summer at about 7.3 times the monthly winter use. Monthly bedrock groundwater use peaks in the summer at about 3.1 times the monthly winter use.

Gaps and Storage Depletions

- Based on projected demand and historical hydrology, surface water gaps and alluvial groundwater storage depletions may occur by 2020. No bedrock groundwater storage depletions are expected through 2060. However, localized storage depletions may cause adverse effects for some users.
- Surface water gaps in Basin 58 may occur throughout the year, peaking in size during the summer. Surface water gaps in 2060 will be up to 15% (720 AF/month) of the surface water demand in the peak summer month, and as much as 14% (320 AF/month) of the winter monthly surface water demand.
- There will be a 19% probability of gaps occurring in at least one month of the year by 2060. Surface water gaps are most likely to occur during summer months.
- Alluvial groundwater storage depletions in Basin 58 may occur throughout the year. Alluvial groundwater storage depletions in 2060 will be up to 15% (300 AF/month) of the alluvial groundwater demand in the peak summer month, and as much as 14% (40 AF/month) of the winter monthly alluvial groundwater demand.
- There will be a 19% probability of alluvial groundwater storage depletions occurring in at least one month of the year by 2060. Alluvial groundwater storage depletions are most likely to occur during summer months.
- Projected annual alluvial groundwater storage depletions are minimal relative to the amount of water in storage in the Canadian River aquifer. However, localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Surface Water Gaps by Season (2060 Demand)

Central Region, Basin 58

Months (Season)	Maximum Gap [1]	Median Gap	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	320	270	2%
Mar-May (Spring)	420	330	5%
Jun-Aug (Summer)	720	700	14%
Sep-Nov (Fall)	460	420	7%

1 Amount shown represents largest amount for any one month in season indicated.

Alluvial Groundwater Storage Depletions by Season (2060 Demand)

Central Region, Basin 58

Months (Season)	Maximum Storage Depletion[1]	Median Storage Depletion	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	40	35	2%
Mar-May (Spring)	70	60	5%
Jun-Aug (Summer)	300	260	14%
Sep-Nov (Fall)	110	60	7%

1 Amount shown represents largest amount for any one month in season indicated.

Magnitude and Probability of Annual Gaps and Storage Depletions

Central Region, Basin 58

Planning Horizon	Maximum Gaps/Storage Depletions			Probability of Gaps/ Storage Depletions	
	Surface Water	Alluvial Groundwater	Bedrock Groundwater	Surface Water	Alluvial Groundwater
	AFY			Percent	
2020	320	90	0	12%	12%
2030	480	140	0	12%	12%
2040	1,000	250	0	12%	12%
2050	1,720	410	0	16%	16%
2060	2,690	590	0	19%	19%

Bedrock Groundwater Storage Depletions by Season (2060 Demand)

Central Region, Basin 58

Months (Season)	Average Storage Depletion[1]
	AF/month
Dec-Feb (Winter)	0
Mar-May (Spring)	0
Jun-Aug (Summer)	0
Sep-Nov (Fall)	0

1 Amount shown represents largest amount for any one month in season indicated.

Notes & Assumptions

- Gaps and Storage Depletions reflect deficiencies in physically available water. Permitting, water quality, infrastructure, and nonconsumptive demand constraints are considered in separate OCWP analyses.
- Local gaps and storage depletions may vary from basin-level values due to local variations in demands and local availability of supply sources.
- For this baseline analysis, each basin's future demand is met by the basin's available supplies.
- For this baseline analysis, the proportion of future demand supplied by surface water and groundwater for each sector is assumed equal to current proportions.
- The amount of available surface water supplies used for OCWP water supply availability analysis includes changes in historical streamflow due to increased upstream demand, return flows, and increases in out-of-basin supplies from existing infrastructure.
- Analysis of bedrock groundwater supplies is based upon recharge from major aquifers.
- Groundwater storage depletions are defined as the amount that future demands exceed available recharge.
- Median gaps and storage depletions are based only on months with gaps or storage depletions.
- Annual probability is based upon the number of years that a gap or depletion occurs in at least one month of that year.

Reducing Water Needs Through Conservation

Central Region, Basin 58

Conservation Activities[1]	2060 Gap/Storage Depletion			2060 Gap/Storage Depletion Probability	
	Surface Water	Alluvial GW	Bedrock GW	Surface Water	Alluvial GW
	AFY			Percent	
Existing Conditions	2,690	590	0	19%	19%
Moderately Expanded Conservation in Crop Irrigation Water Use	2,560	540	0	17%	17%
Moderately Expanded Conservation in M&I Water Use	870	230	0	12%	12%
Moderately Expanded Conservation in Crop Irrigation and M&I Water Use	740	170	0	12%	12%
Substantially Expanded Conservation in Crop Irrigation and M&I Water Use	30	0	0	3%	0%

1 Conservation Activities are documented in the OCWP Water Demand Forecast Report

Reliable Diversions Based on Available Streamflow and New Reservoir Storage

Central Region, Basin 58

Reservoir Storage	Diversion
AF	AFY
100	3,500
500	5,400
1,000	7,100
2,500	11,000
5,000	17,400
Required Storage to Meet Growth in Demand (AF)	2,800
Required Storage to Meet Growth in Surface Water Demand (AF)	1,900

Water Supply Options & Effectiveness

Typically Effective | Potentially Effective | Likely Ineffective | No Option Necessary

Demand Management

Moderately expanded permanent conservation activities in the Municipal and Industrial, Self-Supplied Residential, and Crop Irrigation demand sectors could reduce surface water gaps by 72% and alluvial groundwater storage depletions by 71%. Temporary drought management activities may be effective for surface water supplies in this basin, since gaps have a low to moderate probability of occurring. However, temporary drought management activities may not be needed for groundwater supplies, since groundwater storage could continue to provide supplies during droughts.

Out-of-Basin Supplies

Out-of-basin supplies could mitigate surface water gaps and groundwater storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified fifteen potential out-of-basin sites in the Central Region: Centerpoint in Basin 50; Asher and Scissortail in Basin 56; Dibble and Purcell in Basin 57; Fallis, Nuyaka, Wellston and Welty in Basin 60; Sasakwa in Basin 61; Tate Mountain and West Elm Creek (terminal storage) in Basin 62; and Crescent, Hennessey and Navina in Basin 64. However, in light of the distance to reliable water supplies and substantial groundwater supplies, out-of-basin supplies may not be cost-effective for many users in the basin.

Reservoir Use

Additional reservoir storage in Basin 58 could effectively supplement supplies during dry months. The entire increase in demand from 2010 to 2060 could be supplied by a new river diversion and 2,800 AF of reservoir storage at the basin outlet. The use of multiple reservoirs in the basin or reservoirs upstream of the basin's outlet may increase the amount of storage necessary to mitigate future gaps and storage depletions. The OCWP *Reservoir Viability Study* also identified one potential site in Basin 58 (Union Reservoir).

Increasing Reliance on Surface Water

Increased reliance on surface water through direct diversions, without reservoir storage, will increase surface water gaps and is not recommended.

Increasing Reliance on Groundwater

Increased reliance on the Canadian River aquifer or Garber-Wellington aquifer could mitigate surface water gaps. Any increases in storage depletions would be minimal relative to the volume of water stored in these major aquifers. However, localized storage depletions may occur and adversely affect well yields, water quality, and/or pumping costs.

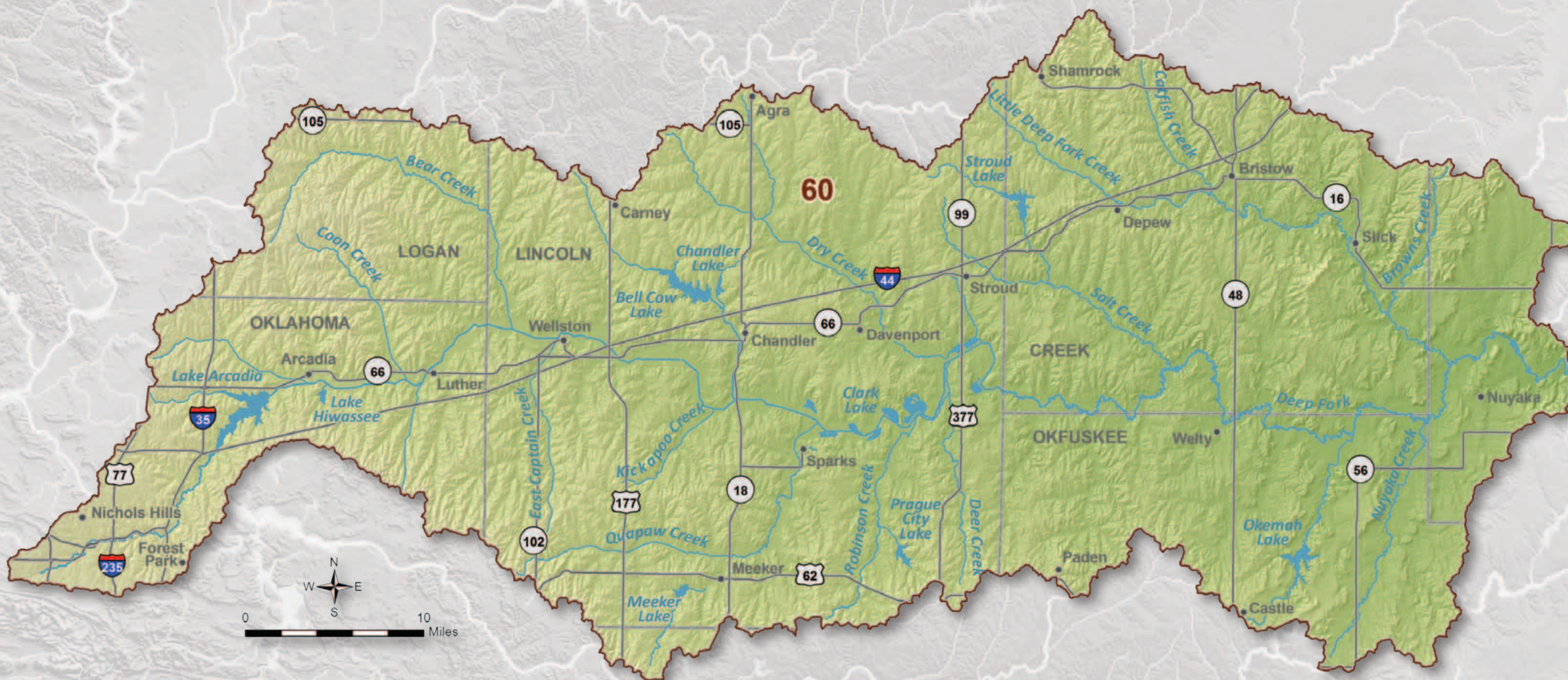
Notes & Assumptions

- Water quality may limit the use of supply sources, which may require new or additional treatment before use.
- Infrastructure related to the diversion, conveyance, treatment, and distribution of water will affect the cost-effectiveness of using any new source of supply.
- The ability to reduce demands will vary based on local acceptance of additional conservation and temporary drought management activities.
- Gaps and depletions may be mitigated in individual calendar months without reductions in the annual probability (chance of having shortage during another month).
- River diversion for new or additional reservoir storage is based on a hypothetical on-channel reservoir at the basin outlet. Reported yields will vary depending upon the reservoir location; placement at the basin outlet would likely result in a higher yield.
- Aquifer storage and recovery may provide additional storage or an alternative to surface storage and should be evaluated on a case by case basis.

Oklahoma Comprehensive Water Plan

Data & Analysis
Central Watershed Planning Region

Basin 60



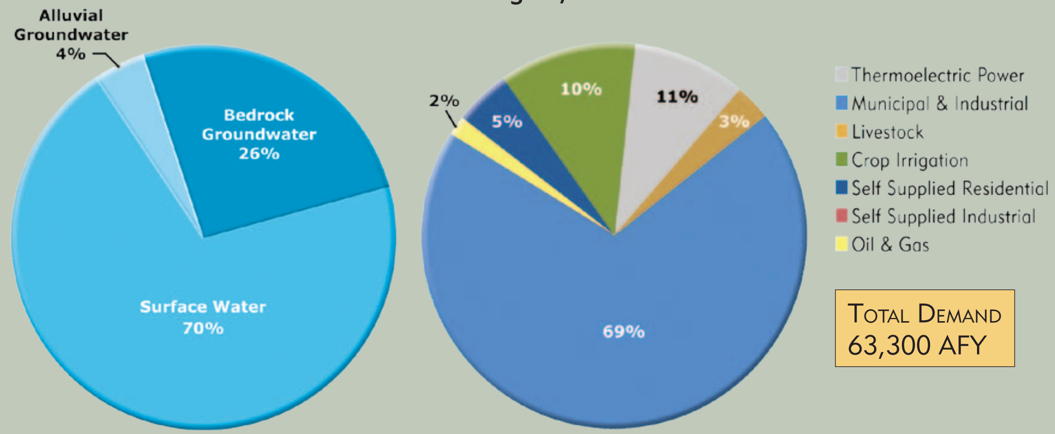
Basin 60 Summary

Synopsis

- Water users are expected to continue to rely primarily on surface water and bedrock groundwater, and to a lesser extent alluvial groundwater.
- Alluvial groundwater storage depletions from minor aquifers may occur by 2020. Future alluvial groundwater withdrawals are expected to occur from minor aquifers. Therefore, the severity of the alluvial groundwater storage depletions cannot be evaluated due to insufficient information. However, localized storage depletions may cause adverse effects for users.
- To reduce the risk of adverse impacts on water supplies, it is recommended that alluvial groundwater storage depletions be decreased where economically feasible.
- Additional conservation measures could reduce alluvial groundwater storage depletions.
- Reservoir storage could be used as an alternative to mitigate alluvial groundwater storage depletions.

Current Demand by Source and Sector

Central Region, Basin 60



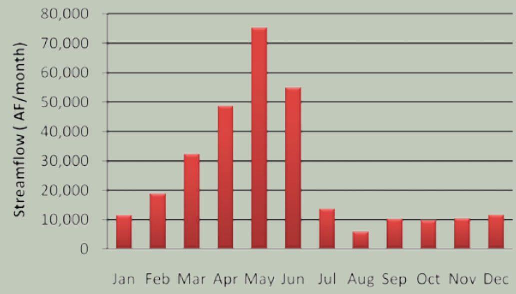
Basin 60 accounts for about 19% of the current demand in the Central Watershed Planning Region. About 69% of the basin's 2010 demand was from the Municipal and Industrial demand sector. Thermoelectric Power is the second largest demand sector at 11%, followed by Crop Irrigation at 10%. Surface water satisfies about 70% of the current demand in the basin. Groundwater satisfies about 30% of the current demand (4% alluvial and 26% bedrock). The peak summer month total water demand in Basin 60 is about 2.5 times the winter monthly demand, which is similar to the overall statewide pattern.

The flow in the Deep Fork River near Beggs is typically greater than 5,900 AF/month throughout the year and greater than 32,000 AF/month in the spring and early summer. However, the river can have periods of low to no flow in winter, summer, or fall. Basin 60 has one major federal reservoir and 6 significant municipal reservoirs. Lake Arcadia was completed in 1986 on the Deep Fork River by the U.S. Army Corps of Engineers for the purposes of water supply, recreation, and fish and wildlife purposes. The lake provides 12,320 AFY of dependable yield to the City of Edmond and other users and is fully allocated. Bell Cow Lake provides 4,558 AFY of dependable yield to the City of Chandler and may have a small amount of unpermitted yield to meet the needs of new users. Stroud Lake provides 1,299 AFY of dependable yield to the City of Stroud and may have a small amount of unpermitted yield to meet the needs of new users. Okemah Lake provides the City of Okemah 2,200 AFY of dependable yield and may have a small amount of unpermitted yield. Prague City Lake provides 549 AFY of dependable yield to the City of Prague and is fully allocated. Meeker Lake provides 202 AFY of dependable yield to the City of Meeker and is fully allocated. The water supply yield of Chandler Lake is unknown; therefore, the ability of this lake to provide future water supplies could not be evaluated. The availability of permits is not expected to limit the development of surface water supplies for in-basin use through 2060. Relative to other basins in the state, the surface water quality in Basin 60 is considered fair. The Deep Fork River, the northwest

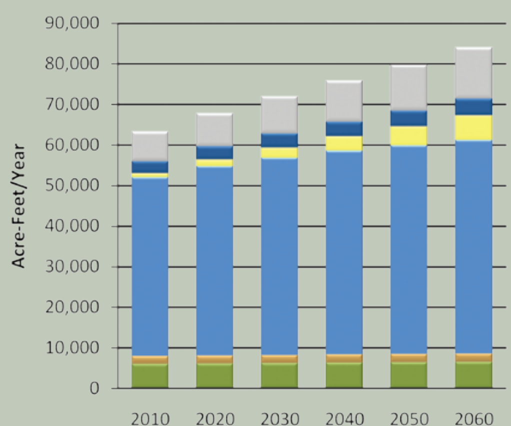
Water Resources

Central Region, Basin 60

Median Historical Streamflow at the Basin Outlet
Central Region, Basin 60



Projected Water Demand
Central Region, Basin 60



tributary to Chandler Lake, and Lake Arcadia are impaired for Public and Private Water Supply due to high levels of chromium, oil and grease, and Chlorophyll-a.

The majority of groundwater rights in Basin 60 are from the Garber-Wellington major bedrock aquifer. There are also water rights in the Vamoosa-Ada major bedrock aquifer and minor alluvial and bedrock aquifers. The Garber-Wellington aquifer has more than 15.5 million AF of groundwater storage in Basin 60 and underlies the western portion of the basin (about 40% of the basin area). The OWRB and USGS are currently conducting a detailed study of the Garber-Wellington that will establish a maximum annual yield and equal proportionate share for the aquifer, which may change the current two AFY/acre allocated for temporary permits.

The Vamoosa-Ada aquifer has more than 2.7 million AF of groundwater storage in Basin 60 and underlies the central portion of the basin (about 23% of the total basin area). Basin 60 contributes 92,000 AFY of recharge to these aquifers. Site-specific information on the suitability of the minor aquifers for supply should be considered before large scale use. The use of groundwater to meet in-basin demand is not expected to be limited by the availability of permits through 2060. High concentrations of nitrate, arsenic, chromium, radionuclides, and selenium have been found locally in the Garber-Wellington aquifer and may limit its use for Municipal and Industrial and other demand sectors. The OWRB and USGS are currently conducting a detailed study to better characterize the water quality of the aquifer for all users. There are no significant groundwater quality issues in other aquifers in the basin.

The projected 2060 water demand of 84,000 AFY in Basin 60 reflects a 20,700 AFY increase (33%) over the 2010 demand. The majority of the demand and largest growth in demand over this period will be in the Municipal and Industrial demand sector. Substantial growth in demand is also projected in the Thermoelectric Power and Oil and Gas demand sectors.

Gaps & Depletions

Based on projected demand and historical hydrology, alluvial groundwater storage depletions may occur by 2020. No surface water gaps or bedrock groundwater storage depletions are expected through 2060. However, localized storage depletions may cause adverse effects for users. Alluvial groundwater storage depletions will be up to 430 AFY and have a 31% probability of occurring in at least one month of the year by 2060. Future alluvial groundwater withdrawals are expected to occur from minor aquifers. Therefore, the severity of the storage depletions cannot be evaluated due to insufficient information. Localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Water Supply Limitations
Central Region, Basin 60

Surface Water
Alluvial Groundwater
Bedrock Groundwater

Minimal Potential Significant

Water Supply Option Effectiveness
Central Region, Basin 60

Demand Management
Out-of-Basin Supplies
Reservoir Use
Increasing Supply from Surface Water
Increasing Supply from Groundwater

Typically Effective Potentially Effective
Likely Ineffective No Option Necessary

Options

Water users are expected to continue to rely primarily on surface water and bedrock groundwater, and to a lesser extent alluvial groundwater. To reduce the risk of adverse impacts to the basin's water users, alluvial groundwater storage depletions should be decreased where economically feasible.

Moderately expanded permanent conservation activities in the Municipal and Industrial and Self-Supplied Residential demand sectors could reduce alluvial groundwater storage depletions. Temporary drought management activities may not be needed for this basin, since groundwater storage could continue to provide supplies during droughts.

Out-of-basin supplies could mitigate groundwater storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified twelve potential out-of-basin sites in the Central Region. However, in light of the distance to reliable water source, out-of-basin supplies may not be cost-effective for many users in the basin.

The major reservoirs in Basin 60 are capable of providing dependable water supplies to their existing users, and with new infrastructure, could be used to meet all of Basin 60 future surface water demand during periods of low streamflow. Any future use of these sources would need to take into consideration existing water rights. Additional reservoir storage in Basin 60 could effectively supplement supplies during dry months. The entire increase in demand from 2010 to 2060 could be supplied by a new river diversion and 10,900 AF of reservoir storage at the basin outlet. The OCWP Reservoir Viability Study also identified four potential sites in Basin 60.

Increased reliance on surface water through direct diversions, without reservoir storage, may create surface water gaps and is not recommended.

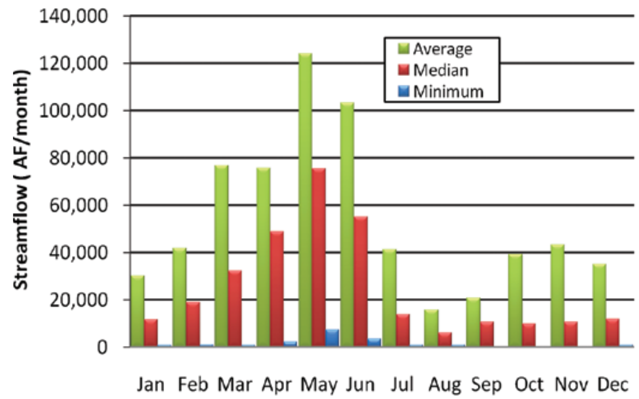
Increased reliance on the Garber-Wellington aquifer could mitigate surface water gaps. Any increases in storage depletions would be minimal relative to the volume of water in stored in this major aquifer. However, the aquifer only underlies the western portion of the basin.

Basin 60 Data & Analysis

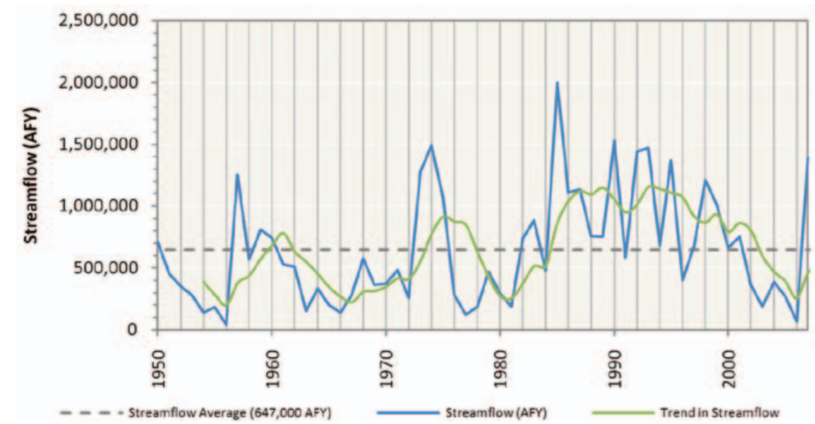
Surface Water Resources

- Historical streamflow from 1950 through 2007 was used to estimate the range of future surface water supplies. The Deep Fork River near Beggs had a period of below-average streamflow from the early 1960s to the early 1970s. From the mid 1980s through the late 1990s, the basin went through a prolonged period of above-average streamflow and precipitation, demonstrating hydrologic variability in the basin.
- The median flow in the Deep Fork River near Beggs is greater than 5,900 AF/month throughout the year and greater than 32,000 AF/month in the spring and early summer. However, the river can have periods of low to no flow in winter, summer, or fall. Relative to other basins in the state, the surface water quality in Basin 60 is considered fair.
- Lake Arcadia provides 12,320 AFY of dependable water supply yield to the City of Edmond and other users; it is fully allocated. Bell Cow Lake provides 4,558 AFY of yield to the City of Chandler and may have a small amount of unpermitted yield to meet the needs of new users. Stroud Lake provides 1,299 AFY of yield to the City of Stroud and may have a small amount of unpermitted yield. Okemah Lake provides 2,200 AFY of dependable yield to the City of Okemah; some unpermitted yield may be available. Prague City Lake provides 549 AFY of yield to the City of Prague and is fully allocated. Meeker Lake provides 202 AFY of dependable yield to the City of Meeker and is fully allocated. The yield of Chandler Lake is unknown so future supplies could not be evaluated.

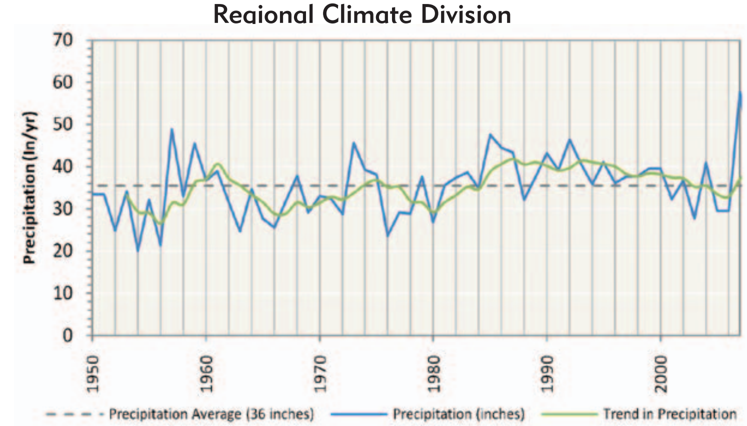
Monthly Historical Streamflow at the Basin Outlet
Central Region, Basin 60



Historical Streamflow at the Basin Outlet
Central Region, Basin 60



Historical Precipitation
Regional Climate Division



Notes & Assumptions

- Precipitation data are based on regional information, while streamflow is basin-specific.
- Measured streamflow implicitly reflects the conditions that exist in the stream at the time the data were recorded (e.g., hydrology, diversions, reservoirs, and infrastructure).
- For water supply planning, the range of potential future hydrologic conditions, including droughts, is represented by 58 years of monthly surface water flows (1950 to 2007). Climate change variations to these flows are documented in a separate OCWP report.
- Surface water supplies are calculated by adjusting the historical streamflow to account for upstream demands, return flows, and out-of-basin supplies.
- The upstream state is assumed to use 60 percent of the flow at the state line based on OWRB permitting protocol.
- Historical flow is based on USGS stream gages at or near the basin outlet. Where a gage did not exist near the outlet or there were missing data in the record, an estimation of flow was determined from representative, nearby gages using statistical techniques.
- Existing surface water rights may restrict the quantity of available surface water to meet future demands. Additional permits would decrease the amount of available water.

Groundwater Resources - Aquifer Summary (2010)

Central Region, Basin 60

Aquifer			Portion of Basin Overlaying Aquifer	Current Groundwater Rights	Aquifer Storage in Basin	Equal Proportionate Share	Groundwater Available for New Permits
Name	Type	Class[1]	Percent	AFY	AF	AFY/Acre	AFY
Garber-Wellington	Bedrock	Major	40%	42,800	15,529,000	temporary 2.0	968,100
Vamoosa-Ada	Bedrock	Major	23%	2,000	2,715,000	2.0	593,900
East-Central Oklahoma	Bedrock	Minor	10%	700	1,892,000	temporary 2.0	243,100
Non-Delineated Groundwater Source	Bedrock	Minor	N/A	4,200	N/A	temporary 2.0	N/A
Non-Delineated Groundwater Source	Alluvial	Minor	N/A	1,300	N/A	temporary 2.0	N/A

1 Bedrock aquifers with typical yields greater than 50 gpm and alluvial aquifers with typical yields greater than 150 gpm are considered major.

Groundwater Resources

- The majority of groundwater rights in Basin 60 are from the Garber-Wellington major bedrock aquifer. There are also water rights in the Vamoosa-Ada major bedrock aquifer and minor alluvial and bedrock aquifers. The Garber-Wellington aquifer has more than 15.5 million AF of groundwater storage in Basin 60 and underlies the western portion of the basin (about 40% of the basin area). The OWRB and USGS are currently conducting a detailed study of the Garber-Wellington that will establish an equal proportionate share for the aquifer and may change the current EPS of 2 AFY/acre allocation under temporary permits. The Vamoosa-Ada aquifer has more than 2.7 million AF of groundwater storage in Basin 60 and underlies the central portion of the basin (about 23% of the total basin area). Basin 60 contributes 92,000 AFY of recharge to these aquifers. Site-specific information on the suitability of the minor aquifers for supply should be considered before large scale use.
- High concentrations of nitrate, arsenic, chromium, radionuclides, and selenium have been found locally in the Garber-Wellington aquifer and may limit its use for Municipal and Industrial and other demand sectors. The OWRB and USGS are currently conducting a detailed study to better characterize the water quality of the aquifer for all users. There are no significant groundwater quality issues in other aquifers in the basin.

Notes & Assumptions

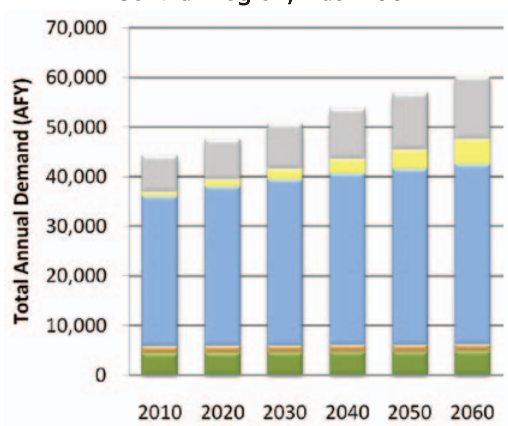
- Alluvial groundwater recharge is not considered separately from streamflow in physical supply availability analyses because any increases or decreases in alluvial groundwater recharge or storage would affect streamflow. Therefore, surface water flows are used to represent available alluvial groundwater recharge.
- Site-specific information on minor aquifers should be considered before large scale use. Suitability for long term supply is typically based on recharge, storage yield, capital and operational costs, and water quality.
- Groundwater permit availability is generally based on the amount of land owned or leased that overlies a specific aquifer.
- Temporary permit amounts are subject to change when the aquifer's equal proportionate share is set by the OWRB.
- Current groundwater rights represent the maximum allowable use. Actual use may be lower than the permitted amount.
- Bedrock groundwater recharge is the long-term annual average recharge to aquifers in the basin. Recharge rates on a county- or aquifer-wide level of detail were established from literature (published reports) of each aquifer. Seasonal or annual variability is not considered; therefore the modeled bedrock groundwater supply is independent of changing hydrologic conditions.

Water Demand

- Basin 60's water needs are about 19% of the demand in the Central Watershed Planning Region and will increase by 33% (20,700 AFY) from 2010 to 2060. The majority of the demand and largest growth in demand over this period will be in the Municipal and Industrial demand sector. Substantial growth in demand is also projected in the Thermoelectric Power and Oil and Gas demand sectors.
- Surface water is used to meet 70% of total demand in the basin and its use will increase by 36% (15,900 AFY) from 2010 to 2060. The majority of surface water use and growth in surface water use over this period will be in the Municipal and Industrial demand sector. Substantial growth in surface water use is also projected in the Thermoelectric Power and Oil and Gas demand sectors.
- Alluvial groundwater is used to meet 4% of total demand in the basin and its use will increase by 32% (870 AFY) from 2010 to 2060. The majority of alluvial groundwater use and growth in alluvial groundwater use over this period will be in the Self-Supplied Residential demand sector.
- Bedrock groundwater is used to meet 26% of total demand in the basin and its use will increase by 24% (3,930 AFY) from 2010 to 2060. The majority of bedrock groundwater use and growth in bedrock groundwater use over this period will be in the Municipal and Industrial demand sector.

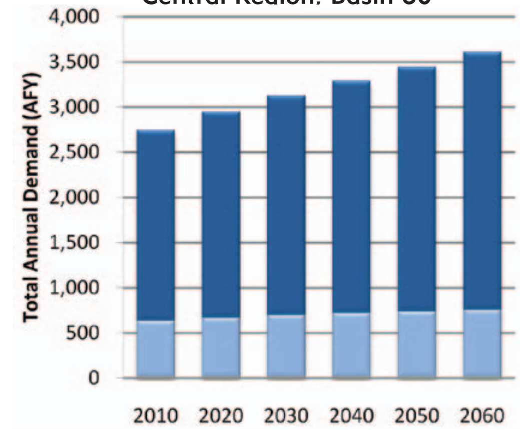
Surface Water Demand by Sector

Central Region, Basin 60



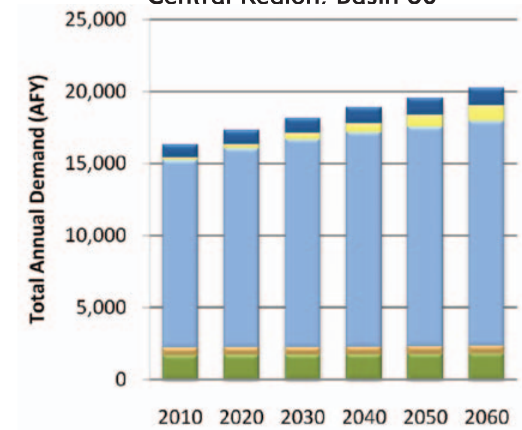
Alluvial Groundwater Demand by Sector

Central Region, Basin 60



Bedrock Groundwater Demand by Sector

Central Region, Basin 60



Thermoelectric Power | Self-Supplied Residential | Self-Supplied Industrial | Oil & Gas | Municipal & Industrial | Livestock | Crop Irrigation

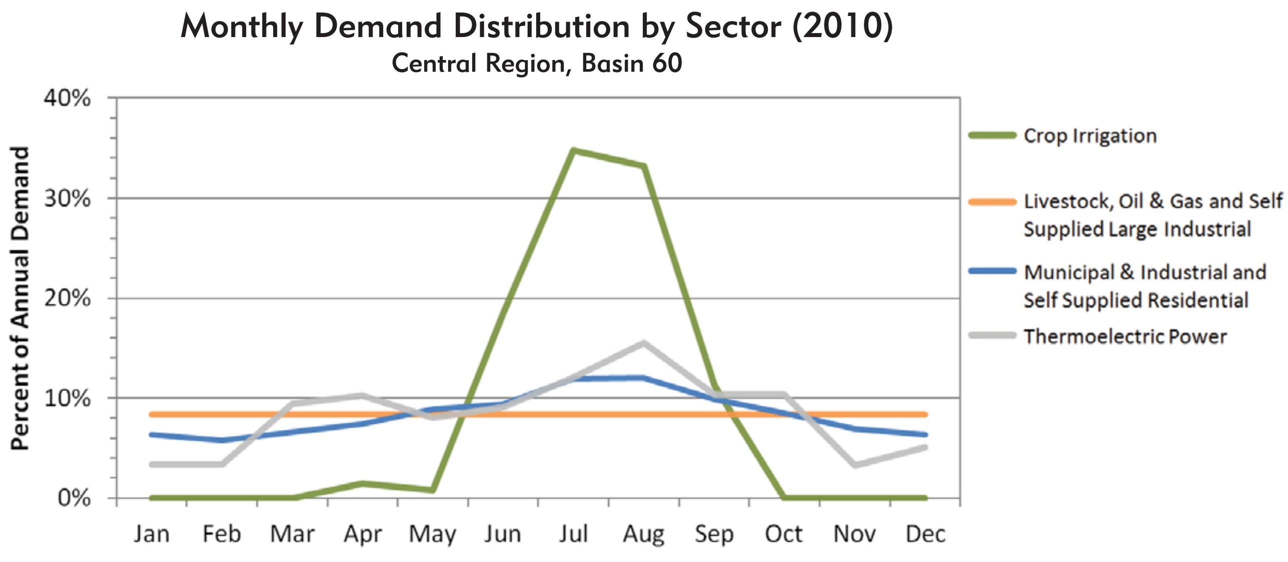
Total Demand by Sector

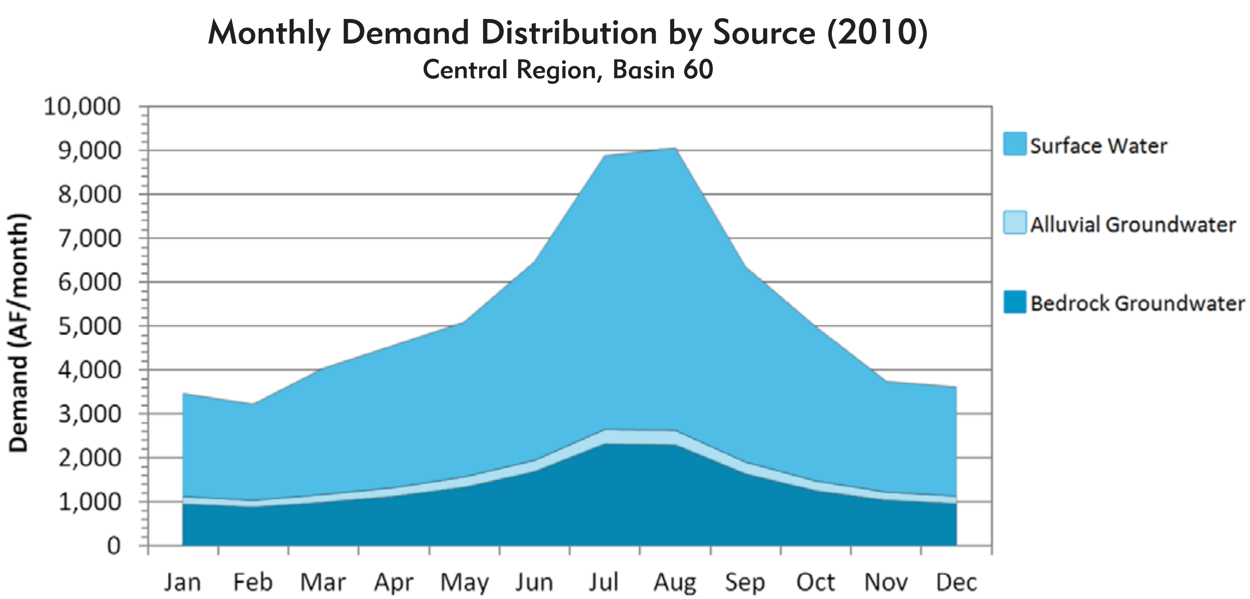
Central Region, Basin 60

Planning Horizon	Crop Irrigation	Livestock	Municipal & Industrial	Oil & Gas	Self-Supplied Industrial	Self-Supplied Residential	Thermoelectric Power	Total
	AFY							
2010	6,080	1,910	44,020	1,010	0	3,000	7,280	63,300
2020	6,190	1,940	46,660	1,680	0	3,240	8,120	67,830
2030	6,290	1,960	48,640	2,520	0	3,450	9,060	71,920
2040	6,400	1,980	50,200	3,550	0	3,650	10,100	75,880
2050	6,480	2,000	51,400	4,750	0	3,850	11,270	79,750
2060	6,610	2,020	52,600	6,140	0	4,060	12,570	84,000

Notes & Assumptions

- Demand values represent total demand (the amount of water pumped or diverted to meet the needs of the user).
- Values are based on the baseline demand forecast from the OCWP *Water Demand Forecast Report*.
- The effect of climate change, conservation, and non-consumptive uses, such as hydropower, are not represented in this baseline demand analysis but are documented in separate OCWP reports.
- The proportion of each supply source used to meet each water use sector's demand was assumed to be equal to the existing proportion, as represented in water rights.
- The proportions of future demands between water use sectors will vary due to differing growth rates.
- The overall proportion of supplies used to meet demand will change due to differing growth rates among the water use sectors.





Current Monthly Demand Distribution by Sector

- The Municipal and Industrial and Self-Supplied Residential demand sectors use 81% more water in summer months than in winter months. Crop Irrigation has a high demand in summer months and little or no demand in winter months. Thermoelectric Power demand peaks in August and is lowest in the winter. Other demand sectors have more consistent demand throughout the year.

Current Monthly Demand Distribution by Source

- The peak summer month total water demand in Basin 60 is 2.5 times the monthly winter demand, which is similar to the overall statewide pattern. Surface water use in the peak summer month is about 2.6 times the monthly winter use. Monthly alluvial groundwater use peaks in the summer at about 1.9 times the monthly winter use. Monthly bedrock groundwater use peaks in the summer at about 2.4 times the monthly winter use.

Gaps and Storage Depletions

- Based on projected demand and historical hydrology, alluvial groundwater storage depletions may occur by 2020. No surface water gaps or bedrock groundwater storage depletions are expected through 2060. However, localized storage depletions may cause adverse effects for users.
- Alluvial groundwater storage depletions in Basin 60 may occur throughout the year. Alluvial groundwater storage depletions in 2060 will be up to 20% (90 AF/month) of the alluvial groundwater demand in the peak summer month, and as much as 22% (50 AF/month) of the winter monthly alluvial groundwater demand.
- There will be a 31% probability of alluvial groundwater storage depletions occurring in at least one month of the year by 2060. Alluvial groundwater storage depletions are most likely to occur during the summer and fall months.
- Future alluvial groundwater withdrawals are expected to occur from minor aquifers. Therefore, the severity of the storage depletions cannot be evaluated due to insufficient information. Localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Surface Water Gaps by Season (2060 Demand)

Central Region, Basin 60

Months (Season)	Maximum Gap [1]	Median Gap	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	0	0	0%
Mar-May (Spring)	0	0	0%
Jun-Aug (Summer)	0	0	0%
Sep-Nov (Fall)	0	0	0%

1 Amount shown represents largest amount for any one month in season indicated.

Alluvial Groundwater Storage Depletions by Season (2060 Demand)

Central Region, Basin 60

Months (Season)	Maximum Storage Depletion[1]	Median Storage Depletion	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	50	30	3%
Mar-May (Spring)	10	10	2%
Jun-Aug (Summer)	90	40	17%
Sep-Nov (Fall)	80	40	22%

1 Amount shown represents largest amount for any one month in season indicated.

Magnitude and Probability of Annual Gaps and Storage Depletions

Central Region, Basin 60

Planning Horizon	Maximum Gaps/Storage Depletions			Probability of Gaps/ Storage Depletions	
	Surface Water	Alluvial Groundwater	Bedrock Groundwater	Surface Water	Alluvial Groundwater
	AFY			Percent	
2020	0	40	0	0%	9%
2030	0	120	0	0%	9%
2040	0	210	0	0%	16%
2050	0	310	0	0%	22%
2060	0	430	0	0%	31%

Bedrock Groundwater Storage Depletions by Season (2060 Demand)

Central Region, Basin 60

Months (Season)	Average Storage Depletion[1]
	AF/month
Dec-Feb (Winter)	0
Mar-May (Spring)	0
Jun-Aug (Summer)	0
Sep-Nov (Fall)	0

1 Amount shown represents largest amount for any one month in season indicated.

Notes & Assumptions

- Gaps and Storage Depletions reflect deficiencies in physically available water. Permitting, water quality, infrastructure, and nonconsumptive demand constraints are considered in separate OCWP analyses.
- Local gaps and storage depletions may vary from basin-level values due to local variations in demands and local availability of supply sources.
- For this baseline analysis, each basin's future demand is met by the basin's available supplies.
- For this baseline analysis, the proportion of future demand supplied by surface water and groundwater for each sector is assumed equal to current proportions.
- The amount of available surface water supplies used for OCWP water supply availability analysis includes changes in historical streamflow due to increased upstream demand, return flows, and increases in out-of-basin supplies from existing infrastructure.
- Analysis of bedrock groundwater supplies is based upon recharge from major aquifers.
- Groundwater storage depletions are defined as the amount that future demands exceed available recharge.
- Median gaps and storage depletions are based only on months with gaps or storage depletions.
- Annual probability is based upon the number of years that a gap or depletion occurs in at least one month of that year.

Reducing Water Needs Through Conservation

Central Region, Basin 60

Conservation Activities[1]	2060 Gap/Storage Depletion			2060 Gap/Storage Depletion Probability	
	Surface Water	Alluvial GW	Bedrock GW	Surface Water	Alluvial GW
	AFY			Percent	
Existing Conditions	0	430	0	0%	31%
Moderately Expanded Conservation in Crop Irrigation Water Use	0	420	0	0%	31%
Moderately Expanded Conservation in M&I Water Use	0	190	0	0%	16%
Moderately Expanded Conservation in Crop Irrigation and M&I Water Use	0	180	0	0%	16%
Substantially Expanded Conservation in Crop Irrigation and M&I Water Use	0	40	0	0%	9%

1 Conservation Activities are documented in the OCWP Water Demand Forecast Report

Reliable Diversions Based on Available Streamflow and New Reservoir Storage

Central Region, Basin 60

Reservoir Storage	Diversion
AF	AFY
100	2,500
500	3,700
1,000	4,700
2,500	7,300
5,000	11,500
Required Storage to Meet Growth in Demand (AF)	10,900
Required Storage to Meet Growth in Surface Water Demand (AF)	7,700

Water Supply Options & Effectiveness

Typically Effective | Potentially Effective | Likely Ineffective | No Option Necessary

Demand Management

Moderately expanded permanent conservation activities in the Municipal and Industrial and Self-Supplied Residential demand sectors could reduce alluvial groundwater storage depletions by 58%. Temporary drought management activities may not be needed for this basin, since groundwater storage could continue to provide supplies during droughts.

Out-of-Basin Supplies

Out-of-basin supplies could mitigate groundwater storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified twelve potential out-of-basin sites in the Central Region: Centerpoint in Basin 50; Asher and Scissortail in Basin 56; Dibble and Purcell in Basin 57; Union in Basin 58; Sasakwa in Basin 61; Tate Mountain and West Elm Creek (terminal storage) in Basin 62; and Crescent, Hennessey and Navina in Basin 64. However, in light of the distance to reliable water supplies and substantial groundwater supplies, out-of-basin supplies may not be cost-effective for many users in the basin.

Reservoir Use

The major reservoirs in Basin 60 are capable of providing dependable water supplies to their existing users, and with new infrastructure, could be used to meet all of Basin 60 future surface water demand during periods of low streamflow. Any future use of these sources would need to take into consideration existing water rights. Additional reservoir storage in Basin 60 could effectively supplement supplies during dry months. The entire increase in demand from 2010 to 2060 could be supplied by a new river diversion and 10,900 AF of reservoir storage at the basin outlet. The use of multiple reservoirs in the basin or reservoirs upstream of the basin's outlet may increase the amount of storage necessary to mitigate future storage depletions. The OCWP *Reservoir Viability Study* also identified four potential sites in Basin 60: Fallis Lake, Nuyaka Reservoir, Wellston Lake, and Welty Lake.

Increasing Reliance on Surface Water

Increased reliance on surface water through direct diversions, without reservoir storage, may create surface water gaps and is not recommended.

Increasing Reliance on Groundwater

Increased reliance on the Garber-Wellington aquifer could mitigate surface water gaps. Any increases in storage depletions would be minimal relative to the volume of water stored in this major aquifer. However, the aquifer only underlies the western portion of the basin.

Notes & Assumptions

- Water quality may limit the use of supply sources, which may require new or additional treatment before use.
- Infrastructure related to the diversion, conveyance, treatment, and distribution of water will affect the cost-effectiveness of using any new source of supply.
- The ability to reduce demands will vary based on local acceptance of additional conservation and temporary drought management activities.
- Gaps and depletions may be mitigated in individual calendar months without reductions in the annual probability (chance of having shortage during another month).
- River diversion for new or additional reservoir storage is based on a hypothetical on-channel reservoir at the basin outlet. Reported yields will vary depending upon the reservoir location; placement at the basin outlet would likely result in a higher yield.
- Aquifer storage and recovery may provide additional storage or an alternative to surface storage and should be evaluated on a case by case basis.

Oklahoma Comprehensive Water Plan

Data & Analysis
Central Watershed Planning Region

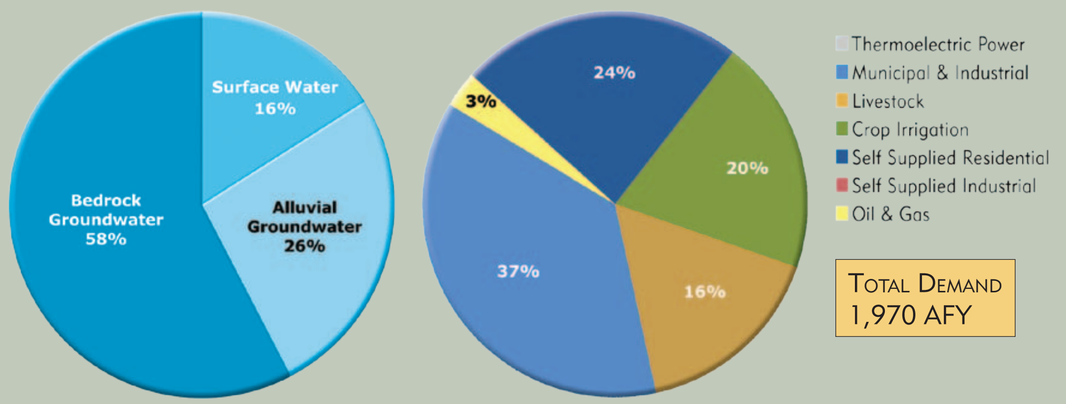
Basin 61

Basin 61 Summary

Synopsis

- Water users are expected to continue to rely primarily on bedrock groundwater and to a lesser extent surface water and alluvial groundwater.
- By 2020, there is a moderate to high probability of surface water gaps from increased demands on existing supplies during low flow periods.
- Alluvial groundwater storage depletions may occur by 2020 from minor aquifers. However, the severity of the alluvial groundwater storage depletions cannot be evaluated due to lack of information.
- To reduce the risk of adverse impacts on water supplies, it is recommended that surface water gaps and groundwater depletions be decreased where economically feasible.
- Additional conservation measures could reduce surface water gaps and alluvial groundwater storage depletions.
- To mitigate surface water gaps, dependable groundwater supplies and/or new reservoirs could be developed as alternatives. These supply sources could be used without major impacts to groundwater storage.

Current Demand by Source and Sector
Central Region, Basin 61



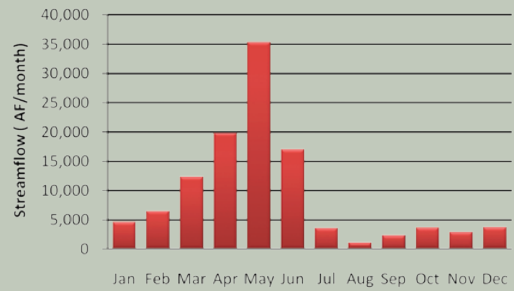
Basin 61 accounts for about 1% of the current demand in the Central Watershed Planning Region. About 37% of the basin's 2010 demand was from the Municipal and Industrial demand sector. Self-Supplied Residential is the second largest demand sector at 24%, followed by Crop Irrigation at 20%. Surface water satisfies about 16% of the current demand in the basin. Groundwater satisfies about 84% of the current demand (26% alluvial and 58% bedrock). The peak summer month total water demand in Basin 61 is about 2.8 times the winter monthly demand, which is similar to the overall statewide pattern.

The flow in the Little River near Sasakwa is typically greater than 1,100 AF/month throughout the year and greater than 12,000 AF/month in the spring and early summer. However, the river can have periods of low to no flow in any month of the year. There are no major reservoirs in Basin 61. The availability of permits is not expected to limit the development of surface water supplies for in-basin use through 2060. Relative to other basins in the state, the surface water quality in Basin 61 is considered good. Cudjo Creek, Salt Creek, and some of its tributaries are impaired for Agricultural use due to chloride and total dissolved solids (TDS).

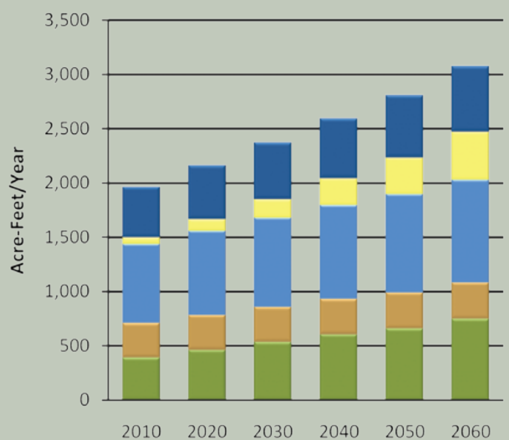
The largest amount of groundwater rights in Basin 61 is from minor alluvial and bedrock aquifers. The Garber-Wellington and Vamoosa-Ada major bedrock aquifers combined have more than 3.2 million AF of groundwater storage and underlie much of the basin, but currently have very little use. Basin 61 contributes 14,000 AFY of recharge to these aquifers. The OWRB and USGS are currently conducting a detailed study of the Garber-Wellington that will establish the maximum annual yield and equal proportionate share for the aquifer, which may change the current amount of two AFY/acre allowed under a temporary permit. Site-specific information on the suitability of the minor aquifers for supply should be considered

Water Resources
Central Region, Basin 61

Median Historical Streamflow at the Basin Outlet
Central Region, Basin 61



Projected Water Demand
Central Region, Basin 61



before large scale use. The use of groundwater to meet in-basin demand is not expected to be limited by the availability of permits through 2060. High concentrations of nitrate, arsenic, chromium, radionuclides, and selenium have been found locally in the Garber-Wellington aquifer and may limit its use for Municipal and Industrial and other demand sectors. The OWRB and USGS are currently conducting a detailed study to better characterize the water quality of the aquifer for all users. There are no significant groundwater quality issues in other aquifers in the basin.

The projected 2060 water demand of 3,080 AFY in Basin 61 reflects a 1,110 AFY increase (57%) over the 2010 demand. The largest demand over this period will be in the Municipal and Industrial demand sector. The Crop Irrigation and Oil and Gas demand sectors are projected to have the largest growth in demand.

Gaps & Depletions

Based on projected demand and historical hydrology, surface water gaps and alluvial groundwater storage depletions may occur by 2020. No bedrock groundwater storage depletions are expected through 2060. However, localized storage depletions may cause adverse effects for users. Surface water gaps will be up to 250 AFY and have a 52% probability of occurring in at least one month of the year by 2060. Alluvial groundwater storage depletions will be up to 220 AFY and have a 52% probability of occurring in at least one month of the year by 2060. Surface water gaps and alluvial groundwater storage depletions in Basin 61 may occur throughout the year, peaking in size in the summer. Future alluvial groundwater withdrawals are expected to occur from minor aquifers. Therefore, the severity of the storage depletions cannot be evaluated due to insufficient information. Localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Options

Water users are expected to continue to rely primarily on bedrock groundwater and to a lesser extent surface water and alluvial groundwater. To reduce the risk of adverse impacts to the basin's water users, surface water gaps and alluvial groundwater storage depletions should be decreased where economically feasible.

Moderately expanded permanent conservation activities in the Municipal and Industrial, Self-Supplied Residential, and Crop Irrigation demand sectors could reduce surface water gaps and alluvial groundwater storage depletions. Temporary drought management activities may not be effective for this basin, since there is a moderate probability of surface water gaps and groundwater storage could continue to provide supplies during droughts.

Water Supply Limitations
Central Region, Basin 61

Surface Water	Potential
Alluvial Groundwater	Potential
Bedrock Groundwater	Minimal

Minimal | Potential | Significant

Water Supply Option Effectiveness
Central Region, Basin 61

Demand Management	Potentially Effective
Out-of-Basin Supplies	Potentially Effective
Reservoir Use	Typically Effective
Increasing Supply from Surface Water	Likely Ineffective
Increasing Supply from Groundwater	Typically Effective

Typically Effective | Potentially Effective | Likely Ineffective | No Option Necessary

Out-of-basin supplies could mitigate surface water gaps and groundwater storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified fifteen potential out-of-basin sites in the Central Region. However, in light of the distance to reliable water supplies and substantial groundwater supplies, out-of-basin supplies may not be cost-effective for many users in the basin.

Additional reservoir storage in Basin 61 could effectively supplement supplies during dry months. The entire increase in demand from 2010 to 2060 could be supplied by a new river diversion and 900 AF of reservoir storage at the basin outlet. The OCWP *Reservoir Viability Study* also identified one potential site in Basin 61.

Increased reliance on surface water through direct diversions, without reservoir storage, will increase surface water gaps and is not recommended.

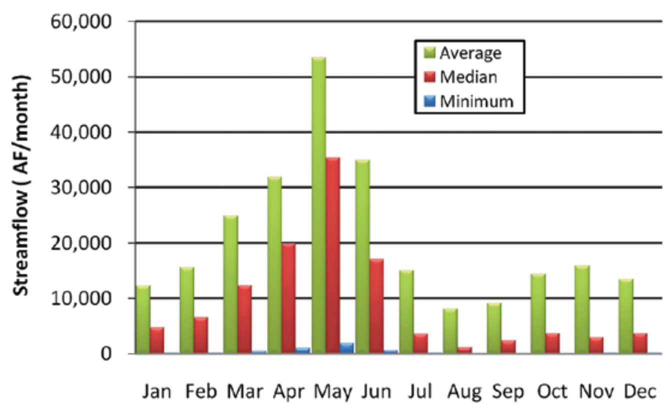
Increased reliance on the Garber-Wellington and Vamoosa-Ada aquifers could mitigate surface water gaps and alluvial groundwater storage depletions. Any increases in storage depletions would be small relative to the volume of water stored in these major aquifers. However, localized storage depletions may occur and adversely affect well yields, water quality, and/or pumping costs.

Basin 61 Data & Analysis

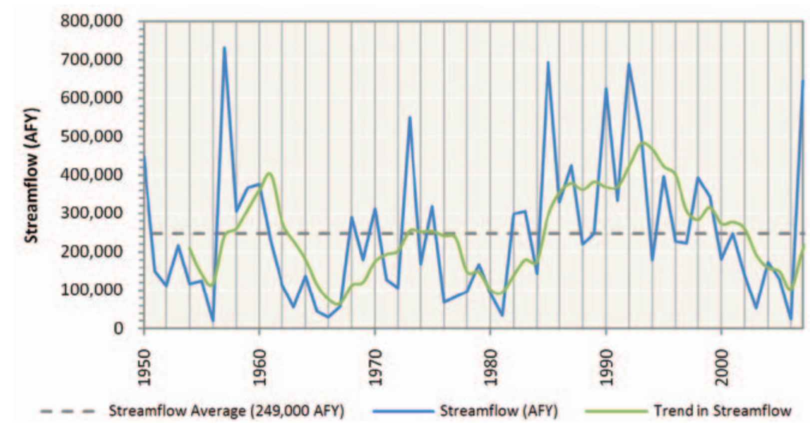
Surface Water Resources

- Historical streamflow from 1950 through 2007 was used to estimate the range of future surface water supplies. The Little River near Sasakwa had a period of below-average streamflow from the early 1960s to the early 1970s. From the mid 1980s through the late 1990s, the basin went through a prolonged period of above-average streamflow and precipitation, demonstrating the hydrologic variability in the basin.
- The median flow in the Little River near Sasakwa is greater than 1,100 AF/month throughout the year and greater than 12,000 AF/month in the spring and early summer. However, the river can have periods of low to no flow in any month of the year. Relative to other basins in the state, the surface water quality in Basin 61 is considered good.
- There are no major reservoirs in Basin 61.

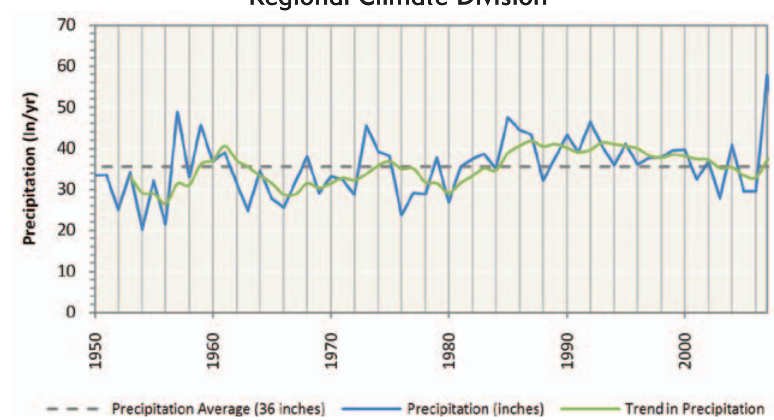
Monthly Historical Streamflow at the Basin Outlet
Central Region, Basin 61



Historical Streamflow at the Basin Outlet
Central Region, Basin 61



Historical Precipitation
Regional Climate Division



Notes & Assumptions

- Precipitation data are based on regional information, while streamflow is basin-specific.
- Measured streamflow implicitly reflects the conditions that exist in the stream at the time the data were recorded (e.g., hydrology, diversions, reservoirs, and infrastructure).
- For water supply planning, the range of potential future hydrologic conditions, including droughts, is represented by 58 years of monthly surface water flows (1950 to 2007). Climate change variations to these flows are documented in a separate OCWP report.
- Surface water supplies are calculated by adjusting the historical streamflow to account for upstream demands, return flows, and out-of-basin supplies.
- The upstream state is assumed to use 60 percent of the flow at the state line based on OWRB permitting protocol.
- Historical flow is based on USGS stream gages at or near the basin outlet. Where a gage did not exist near the outlet or there were missing data in the record, an estimation of flow was determined from representative, nearby gages using statistical techniques.
- Existing surface water rights may restrict the quantity of available surface water to meet future demands. Additional permits would decrease the amount of available water.

Groundwater Resources - Aquifer Summary (2010)

Central Region, Basin 61

Aquifer			Portion of Basin Overlaying Aquifer	Current Groundwater Rights	Aquifer Storage in Basin	Equal Proportionate Share	Groundwater Available for New Permits
Name	Type	Class[1]	Percent	AFY	AF	AFY/Acre	AFY
Canadian River	Alluvial	Major	3%	0	20,000	temporary 2.0	12,800
Garber-Wellington	Bedrock	Major	46%	0	2,146,000	temporary 2.0	163,800
Vamoosa-Ada	Bedrock	Major	30%	400	1,131,000	2.0	113,300
East-Central Oklahoma	Bedrock	Minor	16%	500	498,000	temporary 2.0	63,400
Non-Delineated Groundwater Source	Bedrock	Minor	N/A	500	N/A	temporary 2.0	N/A
Non-Delineated Groundwater Source	Alluvial	Minor	N/A	1,000	N/A	temporary 2.0	N/A

1 Bedrock aquifers with typical yields greater than 50 gpm and alluvial aquifers with typical yields greater than 150 gpm are considered major.

Groundwater Resources

- Most groundwater rights in Basin 61 are from minor alluvial and bedrock aquifers. The Garber-Wellington and Vamoosa-Ada major bedrock aquifers combined have more than 3.2 million AF of groundwater storage and underlie much of the basin, but currently have very little use. Basin 61 contributes 14,000 AFY of recharge to these aquifers. The OWRB and USGS are currently conducting a detailed study of the Garber-Wellington that will establish an equal proportionate share for the aquifer and may change the current EPS of 2 AFY/acre allocation under temporary permits. Site-specific information on the suitability of the minor aquifers for supply should be considered before large scale use.
- High concentrations of nitrate, arsenic, chromium, radionuclides, and selenium have been found locally in the Garber-Wellington aquifer and may limit its use for Municipal and Industrial and other demand sectors. The OWRB and USGS are currently conducting a detailed study to better characterize the water quality of the aquifer for all users. There are no significant groundwater quality issues in other aquifers in the basin.

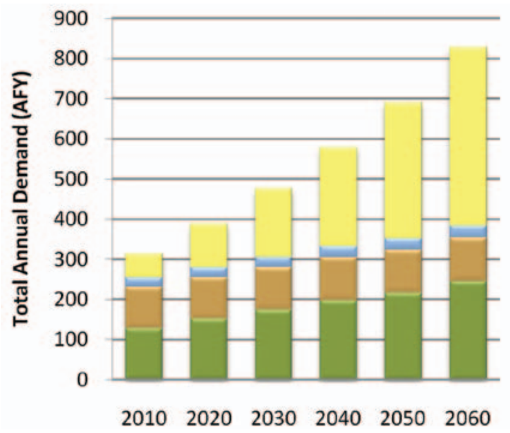
Notes & Assumptions

- Alluvial groundwater recharge is not considered separately from streamflow in physical supply availability analyses because any increases or decreases in alluvial groundwater recharge or storage would affect streamflow. Therefore, surface water flows are used to represent available alluvial groundwater recharge.
- Site-specific information on minor aquifers should be considered before large scale use. Suitability for long term supply is typically based on recharge, storage yield, capital and operational costs, and water quality.
- Groundwater permit availability is generally based on the amount of land owned or leased that overlies a specific aquifer.
- Temporary permit amounts are subject to change when the aquifer's equal proportionate share is set by the OWRB.
- Current groundwater rights represent the maximum allowable use. Actual use may be lower than the permitted amount.
- Bedrock groundwater recharge is the long-term annual average recharge to aquifers in the basin. Recharge rates on a county- or aquifer-wide level of detail were established from literature (published reports) of each aquifer. Seasonal or annual variability is not considered; therefore the modeled bedrock groundwater supply is independent of changing hydrologic conditions.

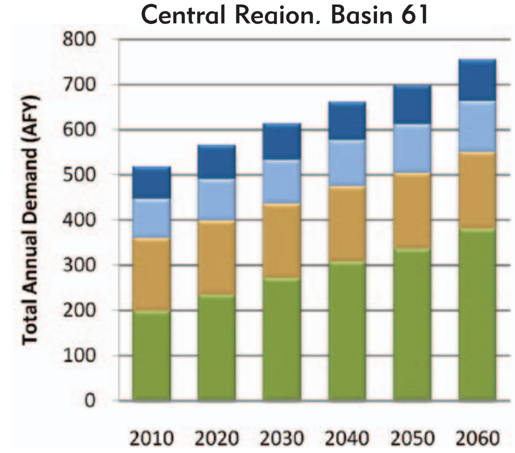
Water Demand

- Basin 61's water needs are about 1% of the demand in the Central Watershed Planning Region and will increase by 57% (1,110 AFY) from 2010 to 2060. The largest demand over this period will be in the Municipal and Industrial demand sector. The Crop Irrigation and Oil and Gas demand sectors are projected to have the largest growth in demand.
- Surface water is used to meet 16% of total demand in the basin and its use will increase by about 160% (520 AFY) from 2010 to 2060. Oil and Gas will become the largest surface water user by 2040.
- Alluvial groundwater is used to meet 26% of total demand in the basin and its use will increase by 46% (230 AFY) from 2010 to 2060. The largest alluvial groundwater use and greatest growth in alluvial groundwater use over this period will be in the Crop Irrigation demand sector.
- Bedrock groundwater is used to meet 58% of total demand in the basin and its use will increase by 32% (360 AFY) from 2010 to 2060. The majority of bedrock groundwater use and growth in bedrock groundwater use over this period will be in the Municipal and Industrial and Self-Supplied Residential demand sectors.

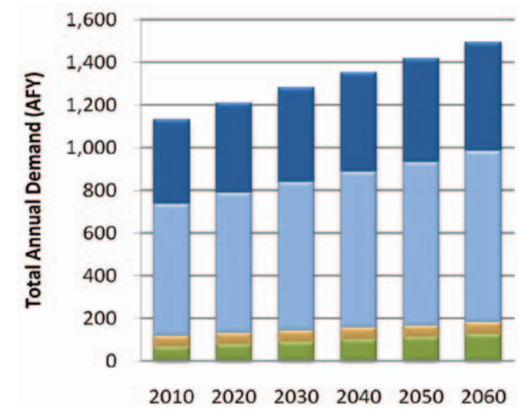
Surface Water Demand by Sector
Central Region, Basin 61



Alluvial Groundwater Demand by Sector
Central Region, Basin 61



Bedrock Groundwater Demand by Sector
Central Region, Basin 61



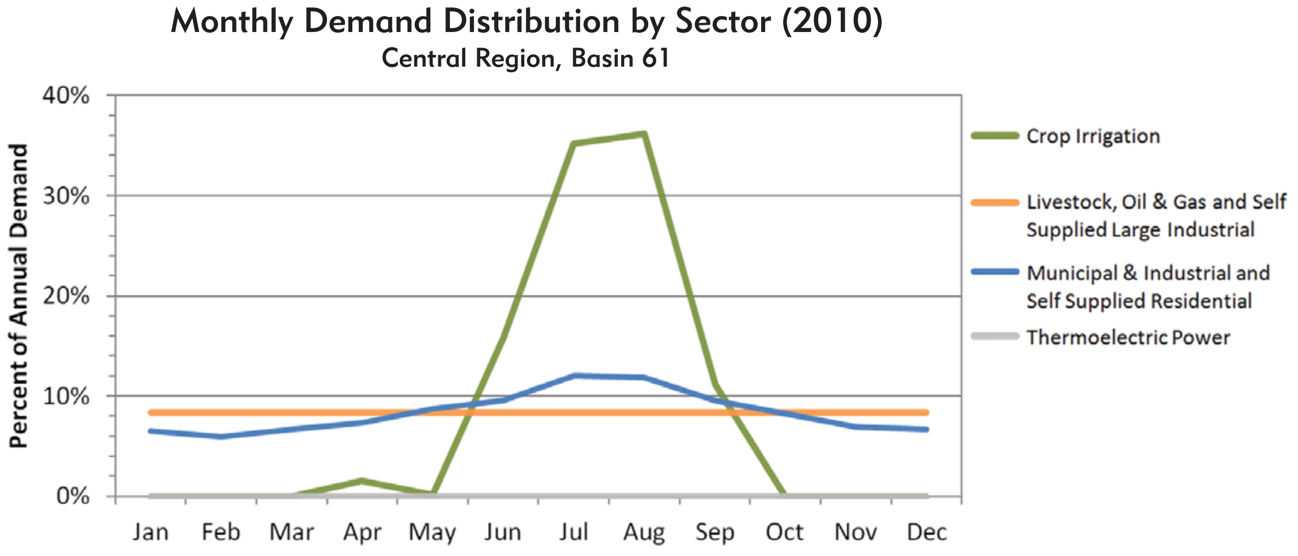
Thermoelectric Power | Self-Supplied Residential | Self-Supplied Industrial | Oil & Gas | Municipal & Industrial | Livestock | Crop Irrigation

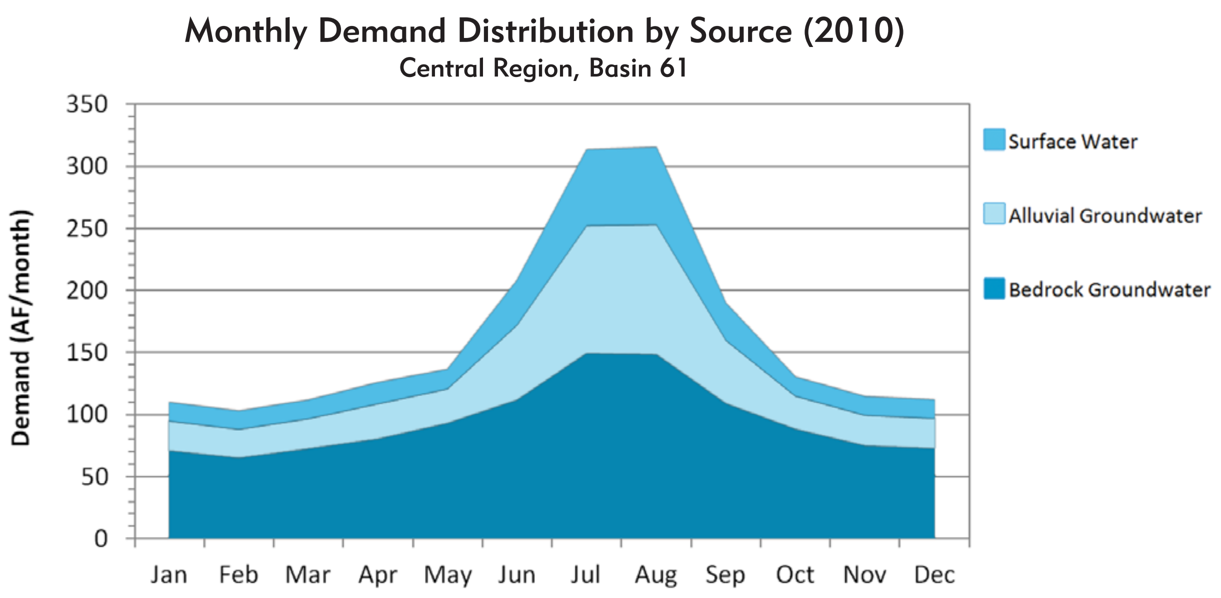
Total Demand by Sector
Central Region, Basin 61

Planning Horizon	Crop Irrigation	Livestock	Municipal & Industrial	Oil & Gas	Self-Supplied Industrial	Self-Supplied Residential	Thermoelectric Power	Total
	AFY							
2010	390	320	730	60	0	470	0	1,970
2020	460	320	780	110	0	490	0	2,160
2030	540	320	820	170	0	520	0	2,370
2040	610	330	860	250	0	550	0	2,600
2050	660	330	900	340	0	570	0	2,800
2060	750	340	950	440	0	600	0	3,080

Notes & Assumptions

- Demand values represent total demand (the amount of water pumped or diverted to meet the needs of the user).
- Values are based on the baseline demand forecast from the OCWP *Water Demand Forecast Report*.
- The effect of climate change, conservation, and non-consumptive uses, such as hydropower, are not represented in this baseline demand analysis but are documented in separate OCWP reports.
- The proportion of each supply source used to meet each water use sector's demand was assumed to be equal to the existing proportion, as represented in water rights.
- The proportions of future demands between water use sectors will vary due to differing growth rates.
- The overall proportion of supplies used to meet demand will change due to differing growth rates among the water use sectors.





Current Monthly Demand Distribution by Sector

- The Municipal and Industrial and Self-Supplied Residential demand sectors use 74% more water in summer months than in winter months. Crop Irrigation has a high demand in summer months and little or no demand in winter months. Other demand sectors have more consistent demand throughout the year.

Current Monthly Demand Distribution by Source

- The peak summer month total water demand in Basin 61 is 2.8 times the monthly winter demand, which is similar to the overall statewide pattern. Surface water use in the peak summer month is about 4.1 times the monthly winter use. Monthly alluvial groundwater use peaks in the summer at about 4.3 times the monthly winter use. Monthly bedrock groundwater use peaks in the summer at about 2.1 times the monthly winter use.

Gaps and Storage Depletions

- Based on projected demand and historical hydrology, surface water gaps and alluvial groundwater storage depletions may occur by 2020. No bedrock groundwater storage depletions are expected through 2060. However, localized storage depletions may cause adverse effects for users.
- Surface water gaps in Basin 61 may occur throughout the year, peaking in size during the summer. Surface water gaps in 2060 will be up to 43% (60 AF/month) of the surface water demand in the peak summer month, and as much as 40% (20 AF/month) of the winter monthly surface water demand.
- There will be a 52% probability of gaps occurring in at least one month of the year by 2060. Surface water gaps are most likely to occur during summer and fall months.
- Alluvial groundwater storage depletions in Basin 61 may occur throughout the year, peaking in size during the summer. Alluvial groundwater storage depletions in 2060 will be up to 44% (80 AF/month) of the alluvial groundwater demand in the peak summer month, and as much as 33% (10 AF/month) of the winter monthly alluvial groundwater demand.
- There will be a 52% probability of alluvial groundwater storage depletions occurring in at least one month of the year by 2060. Alluvial groundwater storage depletions are most likely to occur during summer and fall months.
- Future alluvial groundwater withdrawals are expected to occur from minor aquifers. Therefore, the severity of the storage depletions cannot be evaluated. Localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Surface Water Gaps by Season (2060 Demand)

Central Region, Basin 61

Months (Season)	Maximum Gap [1]	Median Gap	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	20	20	17%
Mar-May (Spring)	20	20	2%
Jun-Aug (Summer)	60	60	38%
Sep-Nov (Fall)	30	20	31%

1 Amount shown represents largest amount for any one month in season indicated.

Alluvial Groundwater Storage Depletions by Season (2060 Demand)

Central Region, Basin 61

Months (Season)	Maximum Storage Depletion[1]	Median Storage Depletion	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	10	10	16%
Mar-May (Spring)	10	10	2%
Jun-Aug (Summer)	80	70	38%
Sep-Nov (Fall)	30	10	31%

1 Amount shown represents largest amount for any one month in season indicated.

Magnitude and Probability of Annual Gaps and Storage Depletions

Central Region, Basin 61

Planning Horizon	Maximum Gaps/Storage Depletions			Probability of Gaps/Storage Depletions	
	Surface Water	Alluvial Groundwater	Bedrock Groundwater	Surface Water	Alluvial Groundwater
	AFY			Percent	
2020	20	40	0	17%	22%
2030	100	120	0	40%	40%
2040	130	160	0	45%	45%
2050	190	200	0	47%	48%
2060	250	220	0	52%	52%

Bedrock Groundwater Storage Depletions by Season (2060 Demand)

Central Region, Basin 61

Months (Season)	Average Storage Depletion[1]
	AF/month
Dec-Feb (Winter)	0
Mar-May (Spring)	0
Jun-Aug (Summer)	0
Sep-Nov (Fall)	0

1 Amount shown represents largest amount for any one month in season indicated.

Notes & Assumptions

- Gaps and Storage Depletions reflect deficiencies in physically available water. Permitting, water quality, infrastructure, and nonconsumptive demand constraints are considered in separate OCWP analyses.
- Local gaps and storage depletions may vary from basin-level values due to local variations in demands and local availability of supply sources.
- For this baseline analysis, each basin's future demand is met by the basin's available supplies.
- For this baseline analysis, the proportion of future demand supplied by surface water and groundwater for each sector is assumed equal to current proportions.
- The amount of available surface water supplies used for OCWP water supply availability analysis includes changes in historical streamflow due to increased upstream demand, return flows, and increases in out-of-basin supplies from existing infrastructure.
- Analysis of bedrock groundwater supplies is based upon recharge from major aquifers.
- Groundwater storage depletions are defined as the amount that future demands exceed available recharge.
- Median gaps and storage depletions are based only on months with gaps or storage depletions.
- Annual probability is based upon the number of years that a gap or depletion occurs in at least one month of that year.

Reducing Water Needs Through Conservation

Central Region, Basin 61

Conservation Activities[1]	2060 Gap/Storage Depletion			2060 Gap/Storage Depletion Probability	
	Surface Water	Alluvial GW	Bedrock GW	Surface Water	Alluvial GW
	AFY			Percent	
Existing Conditions	250	220	0	52%	52%
Moderately Expanded Conservation in Crop Irrigation Water Use	230	210	0	52%	52%
Moderately Expanded Conservation in M&I Water Use	250	220	0	47%	47%
Moderately Expanded Conservation in Crop Irrigation and M&I Water Use	230	200	0	47%	47%
Substantially Expanded Conservation in Crop Irrigation and M&I Water Use	140	110	0	38%	36%

1 Conservation Activities are documented in the OCWP Water Demand Forecast Report

Reliable Diversions Based on Available Streamflow and New Reservoir Storage

Central Region, Basin 61

Reservoir Storage	Diversion
AF	AFY
100	200
500	700
1,000	1,300
2,500	2,900
5,000	5,700
Required Storage to Meet Growth in Demand (AF)	900
Required Storage to Meet Growth in Surface Water Demand (AF)	400

Water Supply Options & Effectiveness

Typically Effective | Potentially Effective | Likely Ineffective | No Option Necessary

Demand Management

Moderately expanded permanent conservation activities in the Municipal and Industrial, Self-Supplied Residential, and Crop Irrigation demand sectors could reduce surface water gaps by 8% and alluvial groundwater storage depletions by 9%. Temporary drought management activities may not be effective for this basin, since there is a high probability of surface water gaps and groundwater storage could continue to provide supplies during droughts.

Out-of-Basin Supplies

Out-of-basin supplies could mitigate surface water gaps and groundwater storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified fifteen potential out-of-basin sites in the Central Region: Centerpoint in Basin 50; Asher and Scissortail in Basin 56; Dibble and Purcell in Basin 57; Union in Basin 58; Fallis, Nuyaka, Wellston and Welty in Basin 60; Tate Mountain and West Elm Creek (terminal storage) in Basin 62; and Crescent, Hennessey and Navina in Basin 64. However, in light of the distance to reliable water supplies and substantial groundwater supplies, out-of-basin supplies may not be cost-effective for many users in the basin.

Reservoir Use

Additional reservoir storage in Basin 61 could effectively supplement supplies during dry months. The entire increase in demand from 2010 to 2060 could be supplied by a new river diversion and 900 AF of reservoir storage at the basin outlet. The use of multiple reservoirs in the basin or reservoirs upstream of the basin's outlet may increase the amount of storage necessary to mitigate future gaps and storage depletions. The OCWP *Reservoir Viability Study* also identified Sasakwa as a potential site in Basin 61.

Increasing Reliance on Surface Water

Increased reliance on surface water through direct diversions, without reservoir storage, will increase surface water gaps and is not recommended.

Increasing Reliance on Groundwater

Increased reliance on the Garber-Wellington and Vamoosa-Ada aquifers could mitigate surface water gaps. Any increases in storage depletions would be small relative to the volume of water stored in these major aquifers. However, localized storage depletions may occur and adversely affect well yields, water quality, and/or pumping costs.

Notes & Assumptions

- Water quality may limit the use of supply sources, which may require new or additional treatment before use.
- Infrastructure related to the diversion, conveyance, treatment, and distribution of water will affect the cost-effectiveness of using any new source of supply.
- The ability to reduce demands will vary based on local acceptance of additional conservation and temporary drought management activities.
- Gaps and depletions may be mitigated in individual calendar months without reductions in the annual probability (chance of having shortage during another month).
- River diversion for new or additional reservoir storage is based on a hypothetical on-channel reservoir at the basin outlet. Reported yields will vary depending upon the reservoir location; placement at the basin outlet would likely result in a higher yield.
- Aquifer storage and recovery may provide additional storage or an alternative to surface storage and should be evaluated on a case by case basis.

Oklahoma Comprehensive Water Plan

Data & Analysis
Central Watershed Planning Region

Basin 62

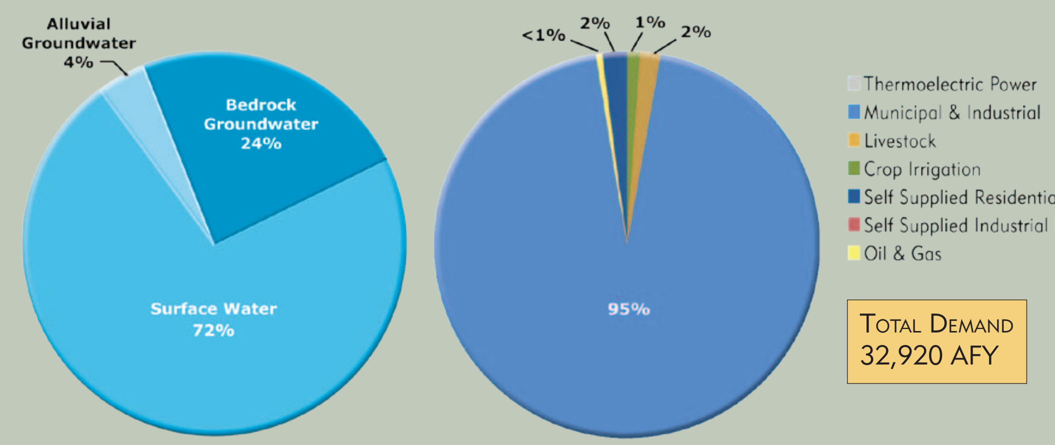
Basin 62 Summary

Synopsis

- Water users are expected to continue to rely primarily on surface water, and to a lesser extent on alluvial and bedrock groundwater.
- Alluvial groundwater storage depletions may occur by 2030 but will be minimal in size relative to aquifer storage in the basin. However, localized storage depletions may cause adverse effects for users.
- To reduce the risk of adverse impacts on water supplies, it is recommended that alluvial groundwater depletions be decreased where economically feasible.
- Additional conservation measures could mitigate alluvial groundwater storage depletions.
- Reservoir storage could be used as an alternative to mitigate alluvial groundwater storage depletions.

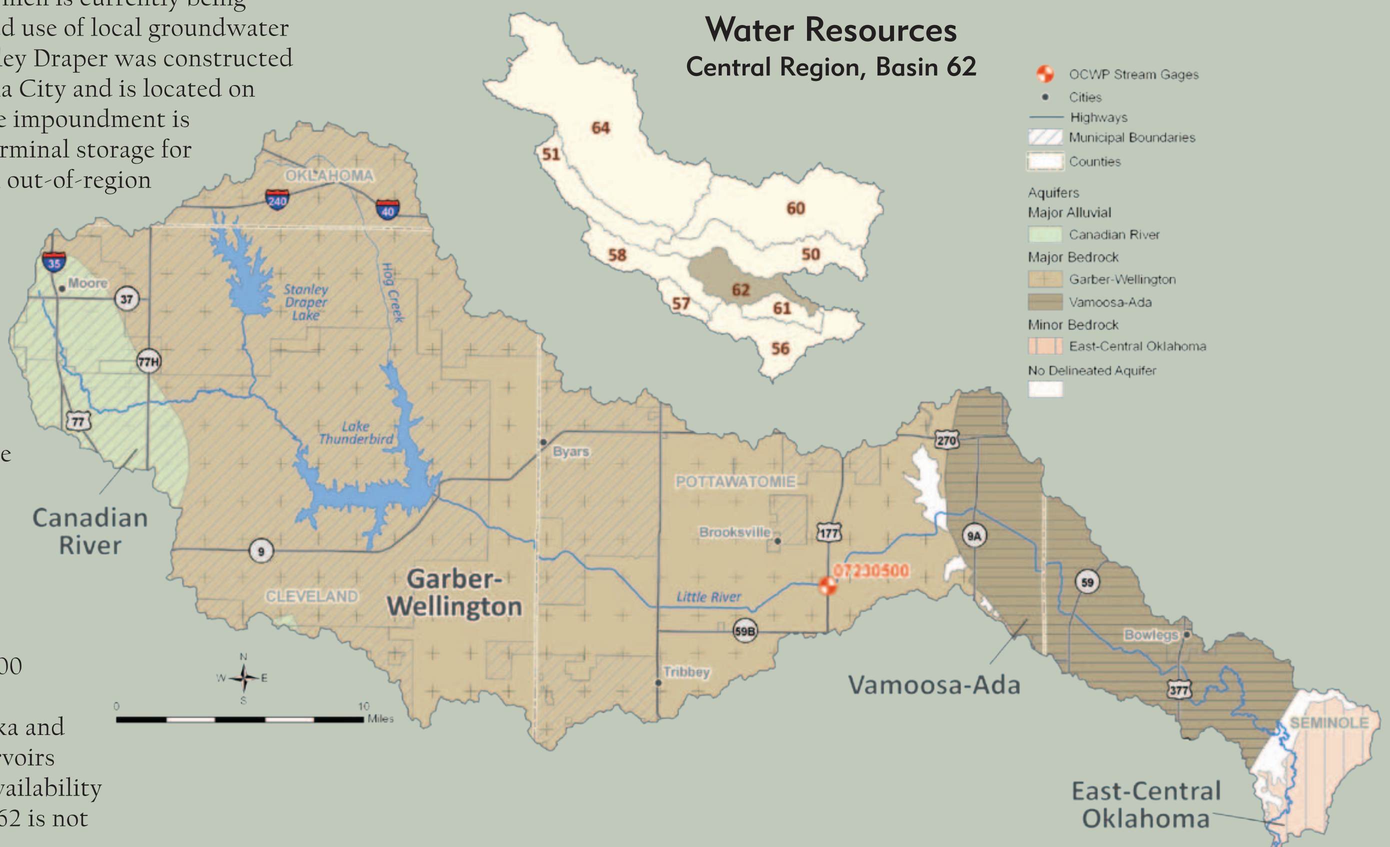
Current Demand by Source and Sector

Central Region, Basin 62



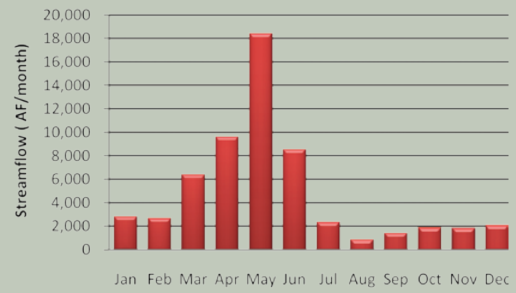
Basin 62 accounts for about 10% of the current demand in the Central Watershed Planning Region. About 95% of the basin's 2010 demand was from the Municipal and Industrial demand sector. Surface water satisfies about 72% of the current demand in the basin; groundwater satisfies about 28% of the current demand (4% alluvial and 24% bedrock). The peak summer month total water demand in Basin 62 is about 1.8 times the winter monthly demand, which is less than the overall statewide pattern.

The flow in the Little River upstream of Salt Creek is typically greater than 500 AF/month throughout the year and greater than 6,300 AF/month in the spring and early summer. However, the river can have periods of low to no flow in any month of the year. There is one major federal reservoir and one major municipal terminal storage lake in Basin 62. Lake Thunderbird was built in 1965 on the Little River by the U.S. Bureau of Reclamation. Project purposes include flood control, water supply, recreation, and fish and wildlife. All of Thunderbird's dependable yield is allocated to the Central Oklahoma Master Conservancy District, which supplies municipal and industrial water to its members—the Cities of Norman, Midwest City and Del City. The lake is expected to continue to provide supplies to its members in the future. However, this future dependability could be constrained by a possible decrease in Lake Thunderbird's dependable yield, which is currently being studied, or decreased use of local groundwater supplies. Lake Stanley Draper was constructed in 1962 by Oklahoma City and is located on East Elm Creek. The impoundment is used primarily as terminal storage for water pumped from out-of-region sources—Atoka Lake and McGee Creek Reservoir in the Blue-Boggy Watershed Planning Region—via the 90 mgd Atoka pipeline. While Lake Stanley Draper has little dependable yield of its own, it can provide an approximate dependable yield of approximately 86,000 AFY comprised of deliveries from Atoka and McGee Creek Reservoirs minus losses. The availability of permits in Basin 62 is not



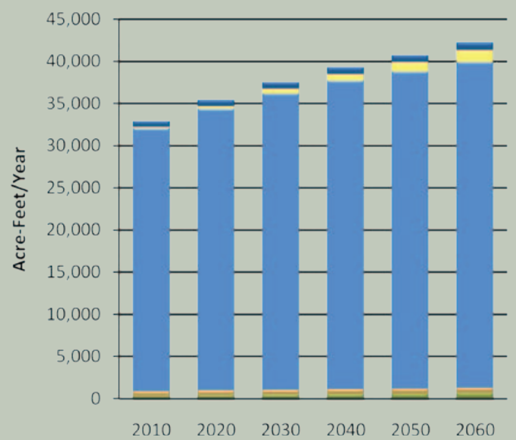
Median Historical Streamflow at the Basin Outlet

Central Region, Basin 62



Projected Water Demand

Central Region, Basin 62



expected to limit the development of surface water supplies for in-basin use through 2060. Relative to other basins in the state, the surface water quality in Basin 62 is considered fair to good. The segment of the Little River at the basin outlet and a small segment of Elm Creek are impaired for Agricultural use due to high levels of chloride and total dissolved solids (TDS). Lake Thunderbird is impaired for Public and Private water supply due to high levels of chlorophyll-a.

The majority of groundwater rights in Basin 62 are from the Garber-Wellington major bedrock aquifer. There are also water rights in the Canadian River major alluvial aquifer, and to a much lesser extent, the Vamoosa-Ada major bedrock aquifer, the East-Central Oklahoma minor bedrock aquifer and non-delineated aquifers. The Garber-Wellington aquifer has more than 11 million AF of groundwater storage in Basin 62 and underlies about 84% of the basin area. Basin 62 contributes up to 37,000 AFY of recharge to the Garber-Wellington and Vamoosa-Ada aquifers. The OWRB and USGS are currently conducting a detailed study of the Garber-Wellington that will establish the maximum annual yield and equal proportionate share of the aquifer, which may change the current amount of two AFY/acre allowed under temporary permits. Site-specific information on the suitability of the minor aquifers for supply should be considered before large scale use. The use of groundwater to meet in-basin demand is not expected to be limited by the availability of permits through 2060. High concentrations of nitrate, arsenic, chromium, radionuclides, and selenium have been found locally in the Garber-Wellington aquifer and may limit its use for Municipal and Industrial and other demand sectors. The OWRB and USGS are currently conducting a detailed study to better characterize the water quality of the aquifer for all users. There are no significant groundwater quality issues in other aquifers in the basin.

The projected 2060 water demand of 42,240 AFY in Basin 62 reflects a 9,320 AFY increase (28%) over the 2010 demand. The majority of the demand and growth in demand over this period will be in the Municipal and Industrial demand sector.

Gaps & Depletions

Based on projected demand and historical hydrology, alluvial groundwater storage depletions may occur by 2030 No surface water gaps or bedrock groundwater storage depletions are expected through 2060. However, localized storage depletions may cause adverse effects for users. Lake Thunderbird in Basin 62 may be capable of providing dependable water supplies to its existing users. However, Thunderbird's ability to supply additional water in the future may be constrained by the increased need of existing users due to decreased groundwater use. A substantial decrease in future supplies from the lake will likely cause surface water gaps in

Water Supply Limitations

Central Region, Basin 62

Surface Water	Potential
Alluvial Groundwater	Potential
Bedrock Groundwater	Minimal

Minimal | Potential | Significant

Water Supply Option Effectiveness

Central Region, Basin 62

Demand Management	Typically Effective
Out-of-Basin Supplies	Potentially Effective
Reservoir Use	Typically Effective
Increasing Supply from Surface Water	Likely Ineffective
Increasing Supply from Groundwater	Typically Effective

Typically Effective | Potentially Effective | Likely Ineffective | No Option Necessary

the future which could not be quantified. Alluvial groundwater storage depletions will be up to 100 AFY and have a 52% probability of occurring in at least one month of the year by 2060. Projected annual alluvial groundwater storage depletions are minimal relative to the amount of water in storage in the Canadian River aquifer in Basin 62. However, localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Options

Water users are expected to continue to rely primarily on surface water, and to a lesser extent alluvial and bedrock groundwater. To reduce the risk of adverse impacts to the basin's water users, alluvial groundwater storage depletions should be decreased where economically feasible.

Moderately expanded permanent conservation activities in the Municipal and Industrial, Self-Supplied Residential, and Crop Irrigation demand sectors could mitigate alluvial groundwater storage depletions. Temporary drought management activities may not be needed for this basin, since groundwater storage could continue to provide supplies during droughts.

Out-of-basin supplies could mitigate groundwater storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified fourteen potential out-of-basin sites in the Central Region. However, in light of the distance to reliable water supplies, out-of-basin supplies may not be cost-effective for many users in the basin.

Lake Thunderbird, through COMCD, may be capable of providing dependable supplies to its existing users. Thunderbird's ability to supply additional water in the future may be constrained by a decrease in its dependable yield (currently being studied) or increased need by existing users due to decreased groundwater use. A substantial decrease in future supplies from the lake will likely cause surface water gaps in the basin although the severity of gaps could not be quantified. Additional reservoir storage in Basin 62 could effectively supplement supplies during dry months. The entire increase in demand from 2010 to 2060 could be supplied by a new reservoir diversion and 3,500 AF of reservoir storage at the basin outlet. The use of multiple reservoirs in the basin or reservoirs upstream of the basin's outlet may increase the amount of storage necessary to mitigate future gaps and storage depletions. The OCWP *Reservoir Viability Study* also identified two potential sites in Basin 62.

Increased reliance on surface water through direct diversions, without reservoir storage, may create surface water gaps and is not recommended.

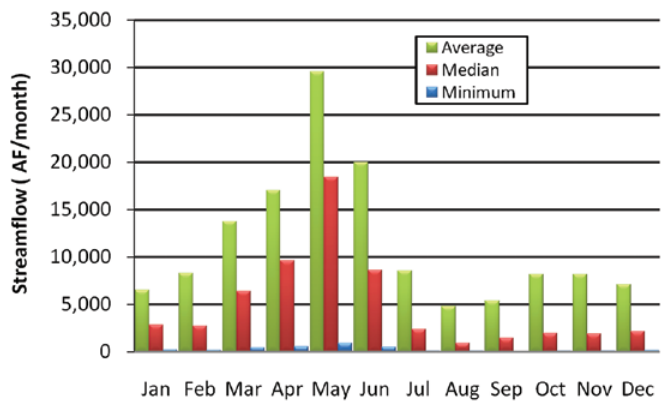
Increased reliance on the Garber-Wellington bedrock aquifer could mitigate alluvial groundwater depletions. Any bedrock groundwater storage depletions would be minimal relative to the volume of water stored in this major aquifer. However, localized storage depletions may occur and adversely affect wells yields, water quality, and/or pumping costs.

Basin 62 Data & Analysis

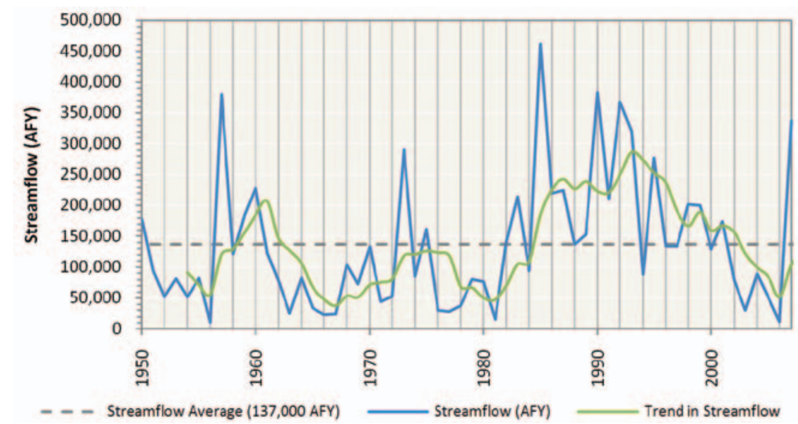
Surface Water Resources

- Historical streamflow from 1950 through 2007 was used to estimate the range of future surface water supplies. The Little River upstream of Salt Creek had a period of below-average streamflow from the early 1960s to the early1970s. From the mid 1980s through the late 1990s, the basin went through a prolonged period of above-average streamflow and precipitation, demonstrating hydrologic variability in the basin.
- The median flow in the Little River upstream of Salt Creek is greater than 800 AF/month throughout the year and greater than 6,300 AF/month in the spring and early summer. However, the river can have periods of low to no flow in any month of the year. Relative to other basins in the state, the surface water quality in Basin 62 is considered good.
- Lake Thunderbird provides all of its dependable yield to the Central Oklahoma Master Conservancy District and its members. Lake Stanley Draper is used by Oklahoma City as terminal storage for out-of-basin water supplies via the Atoka pipeline.

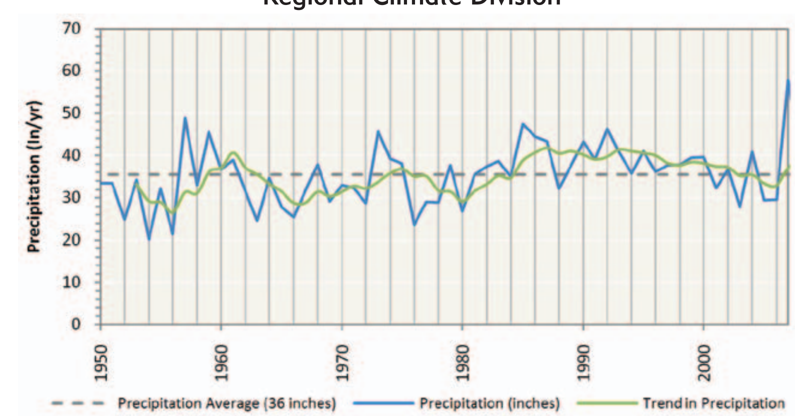
Monthly Historical Streamflow at the Basin Outlet
Central Region, Basin 62



Historical Streamflow at the Basin Outlet
Central Region, Basin 62



Historical Precipitation
Regional Climate Division



Notes & Assumptions

- Precipitation data are based on regional information, while streamflow is basin-specific.
- Measured streamflow implicitly reflects the conditions that exist in the stream at the time the data were recorded (e.g., hydrology, diversions, reservoirs, and infrastructure).
- For water supply planning, the range of potential future hydrologic conditions, including droughts, is represented by 58 years of monthly surface water flows (1950 to 2007). Climate change variations to these flows are documented in a separate OCWP report.
- Surface water supplies are calculated by adjusting the historical streamflow to account for upstream demands, return flows, and out-of-basin supplies.
- The upstream state is assumed to use 60 percent of the flow at the state line based on OWRB permitting protocol.
- Historical flow is based on USGS stream gages at or near the basin outlet. Where a gage did not exist near the outlet or there were missing data in the record, an estimation of flow was determined from representative, nearby gages using statistical techniques.
- Existing surface water rights may restrict the quantity of available surface water to meet future demands. Additional permits would decrease the amount of available water.

Groundwater Resources - Aquifer Summary (2010)

Central Region, Basin 62

Aquifer			Portion of Basin Overlaying Aquifer	Current Groundwater Rights	Aquifer Storage in Basin	Equal Proportionate Share	Groundwater Available for New Permits
Name	Type	Class[1]	Percent	AFY	AF	AFY/Acre	AFY
Canadian River	Alluvial	Major	7%	3,600	109,000	temporary 2.0	49,400
Garber-Wellington	Bedrock	Major	84%	38,800	11,416,000	temporary 2.0	615,700
Vamoosa-Ada	Bedrock	Major	13%	100	861,000	2.0	102,200
East-Central Oklahoma	Bedrock	Minor	3%	<50	199,000	temporary 2.0	25,000
Non-Delineated Groundwater Source	Bedrock	Minor	N/A	400	N/A	temporary 2.0	N/A
Non-Delineated Groundwater Source	Alluvial	Minor	N/A	200	N/A	temporary 2.0	N/A

1 Bedrock aquifers with typical yields greater than 50 gpm and alluvial aquifers with typical yields greater than 150 gpm are considered major.

Groundwater Resources

- The majority of groundwater rights in Basin 62 are from the Garber-Wellington major bedrock aquifer. There are also water rights in the Canadian River major alluvial aquifer and to a much lesser extent the Vamoosa-Ada major bedrock aquifer and in non-delineated minor aquifers. The Garber-Wellington aquifer has more than 11 million AF of groundwater storage in Basin 62 and underlies about 84% of the basin area. Basin 62 contributes up to 37,000 AFY of recharge to the Garber-Wellington and Vamoosa-Ada aquifers. The OWRB and USGS are currently conducting a detailed study of the Garber-Wellington that will establish an equal proportionate share for the aquifer and may change the current EPS of 2 AFY/acre allocation under temporary permits. Site-specific information on the suitability of the minor aquifers for supply should be considered before large scale use.
- High concentrations of nitrate, arsenic, chromium, radionuclides, and selenium have been found locally in the Garber-Wellington aquifer and may limit its use for Municipal and Industrial and other demand sectors. The OWRB and USGS are currently conducting a detailed study to better characterize the water quality of the aquifer for all users. There are no significant groundwater quality issues in other aquifers in the basin.

Notes & Assumptions

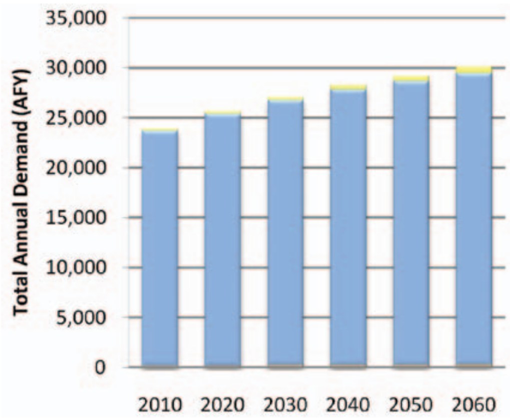
- Alluvial groundwater recharge is not considered separately from streamflow in physical supply availability analyses because any increases or decreases in alluvial groundwater recharge or storage would affect streamflow. Therefore, surface water flows are used to represent available alluvial groundwater recharge.
- Site-specific information on minor aquifers should be considered before large scale use. Suitability for long term supply is typically based on recharge, storage yield, capital and operational costs, and water quality.
- Groundwater permit availability is generally based on the amount of land owned or leased that overlies a specific aquifer.
- Temporary permit amounts are subject to change when the aquifer's equal proportionate share is set by the OWRB.
- Current groundwater rights represent the maximum allowable use. Actual use may be lower than the permitted amount.
- Bedrock groundwater recharge is the long-term annual average recharge to aquifers in the basin. Recharge rates on a county- or aquifer-wide level of detail were established from literature (published reports) of each aquifer. Seasonal or annual variability is not considered; therefore the modeled bedrock groundwater supply is independent of changing hydrologic conditions.

Water Demand

- Basin 62's water needs are about 10% of the demand in the Central Watershed Planning Region and will increase by 28% (9,320 AFY) from 2010 to 2060. The majority of the demand and growth in demand over this period will be in the Municipal and Industrial demand sector.
- Surface water is used to meet 72% of total demand in the basin and its use will increase by 27% (6,300 AFY) from 2010 to 2060. The majority of surface water use and growth in surface water use over this period will be in the Municipal and Industrial demand sector.
- Alluvial groundwater is used to meet 4% of total demand in the basin and its use will increase by 26% (350 AFY) from 2010 to 2060. The majority of alluvial groundwater use and growth in alluvial groundwater use over this period will be in the Municipal and Industrial demand sector.
- Bedrock groundwater is used to meet 24% of total demand in the basin and its use will increase by 34% (2,670 AFY) from 2010 to 2060. The majority of bedrock groundwater use and growth in bedrock groundwater use over this period will be in the Municipal and Industrial demand sector.

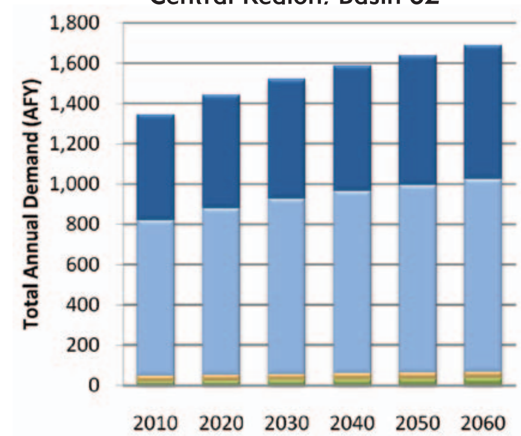
Surface Water Demand by Sector

Central Region, Basin 62



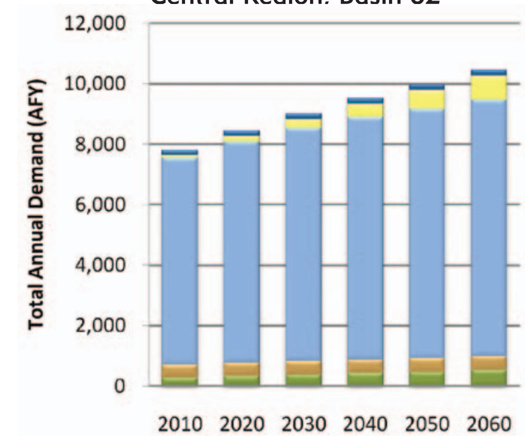
Alluvial Groundwater Demand by Sector

Central Region, Basin 62



Bedrock Groundwater Demand by Sector

Central Region, Basin 62



Thermoelectric Power | Self-Supplied Residential | Self-Supplied Industrial | Oil & Gas | Municipal & Industrial | Livestock | Crop Irrigation

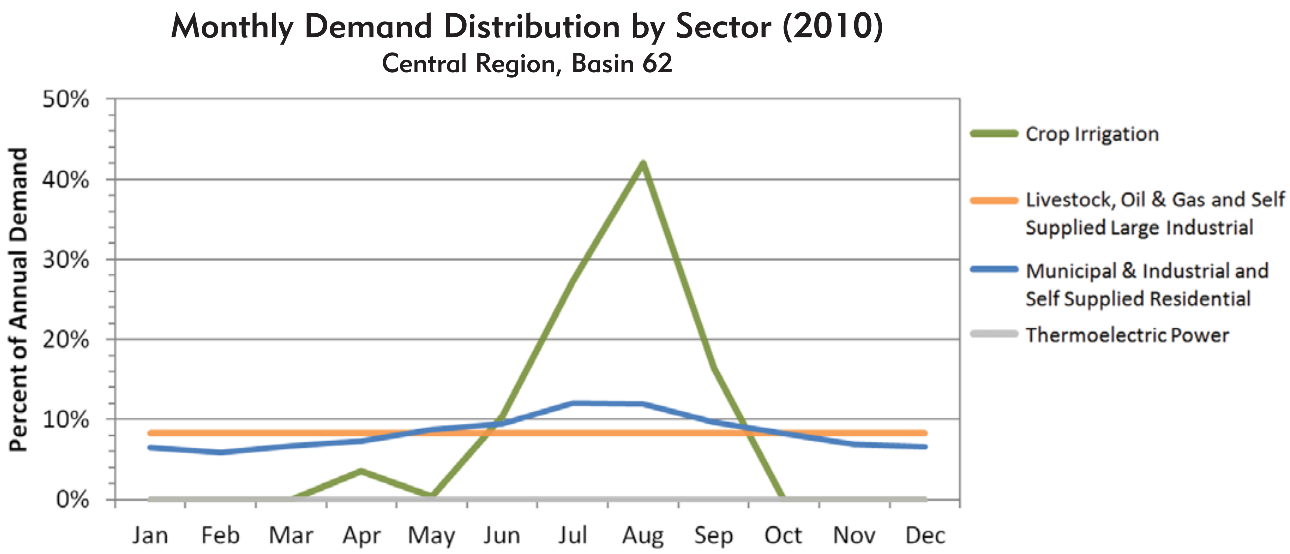
Total Demand by Sector

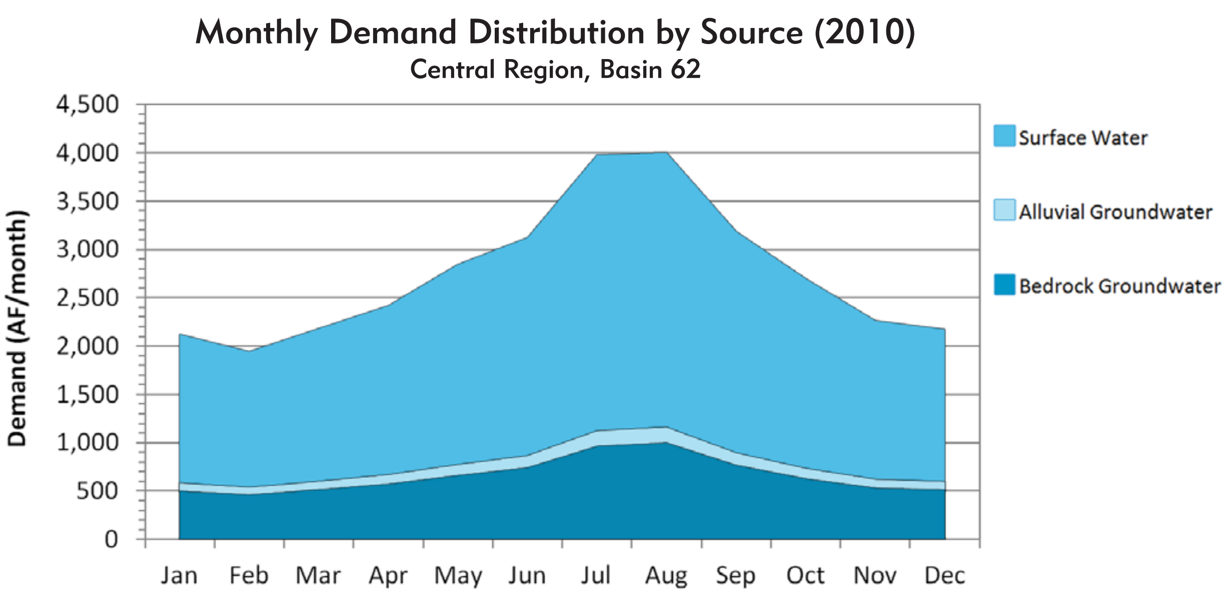
Central Region, Basin 62

Planning Horizon	Crop Irrigation	Livestock	Municipal & Industrial	Oil & Gas	Self-Supplied Industrial	Self-Supplied Residential	Thermoelectric Power	Total
	AFY							
2010	370	550	31,150	180	0	670	0	32,920
2020	430	560	33,390	340	0	720	0	35,440
2030	500	570	35,160	550	0	760	0	37,540
2040	560	580	36,580	800	0	790	0	39,310
2050	610	590	37,620	1,110	0	820	0	40,750
2060	690	600	38,640	1,460	0	850	0	42,240

Notes & Assumptions

- Demand values represent total demand (the amount of water pumped or diverted to meet the needs of the user).
- Values are based on the baseline demand forecast from the OCWP *Water Demand Forecast Report*.
- The effect of climate change, conservation, and non-consumptive uses, such as hydropower, are not represented in this baseline demand analysis but are documented in separate OCWP reports.
- The proportion of each supply source used to meet each water use sector's demand was assumed to be equal to the existing proportion, as represented in water rights.
- The proportions of future demands between water use sectors will vary due to differing growth rates.
- The overall proportion of supplies used to meet demand will change due to differing growth rates among the water use sectors.





Current Monthly Demand Distribution by Sector

- The Municipal and Industrial and Self-Supplied Residential demand sectors use 76% more water in summer months than in winter months. Crop Irrigation has a high demand in summer months and little or no demand in winter months. Other demand sectors have more consistent demand throughout the year.

Current Monthly Demand Distribution by Source

- The peak summer month total water demand in Basin 62 is 1.8 times the monthly winter demand, which is less pronounced than the overall statewide pattern. Surface water use in the peak summer month is about 1.8 times the monthly winter use. Monthly alluvial groundwater use peaks in the summer at about 1.9 times the monthly winter use. Monthly bedrock groundwater use peaks in the summer at about 2 times the monthly winter use.

Gaps and Storage Depletions

- Based on projected demand and historical hydrology, alluvial groundwater storage depletions may occur by 2030. No surface water gaps or bedrock groundwater storage depletions are expected through 2060. However, localized storage depletions may cause adverse effects for users.
- Alluvial groundwater storage depletions in Basin 62 may occur during the summer and fall. Alluvial depletions in 2060 will be up to 14% (30 AF/month) of the alluvial demand in the peak summer month and as much as 13% (20 AF/month) of the fall monthly alluvial groundwater demand.
- There will be a 52% probability of alluvial storage depletions occurring in at least one month of the year by 2060. Alluvial groundwater storage depletions are most likely to occur during the summer months.
- Projected annual alluvial groundwater storage depletions are minimal relative to the amount of water stored in the Canadian River aquifer in Basin 62. However, localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Surface Water Gaps by Season (2060 Demand)
Central Region, Basin 62

Months (Season)	Maximum Gap [1]	Median Gap	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	0	0	0%
Mar-May (Spring)	0	0	0%
Jun-Aug (Summer)	0	0	0%
Sep-Nov (Fall)	0	0	0%

1 Amount shown represents largest amount for any one month in season indicated.

Alluvial Groundwater Storage Depletions by Season (2060 Demand)
Central Region, Basin 62

Months (Season)	Maximum Storage Depletion[1]	Median Storage Depletion	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	0	0	0%
Mar-May (Spring)	0	0	0%
Jun-Aug (Summer)	30	20	40%
Sep-Nov (Fall)	20	20	26%

1 Amount shown represents largest amount for any one month in season indicated.

Magnitude and Probability of Annual Gaps and Storage Depletions
Central Region, Basin 62

Planning Horizon	Maximum Gaps/Storage Depletions			Probability of Gaps/Storage Depletions	
	Surface Water	Alluvial GW	Bedrock GW	Surface Water	Alluvial GW
	AFY			Percent	
2020	0	0	0	0%	0%
2030	0	20	0	0%	12%
2040	0	50	0	0%	36%
2050	0	70	0	0%	41%
2060	0	100	0	0%	52%

Bedrock Groundwater Storage Depletions by Season (2060 Demand)
Central Region, Basin 62

Months (Season)	Average Storage Depletion[1]
	AF/month
Dec-Feb (Winter)	0
Mar-May (Spring)	0
Jun-Aug (Summer)	0
Sep-Nov (Fall)	0

1 Amount shown represents largest amount for any one month in season indicated.

Notes & Assumptions

- Gaps and Storage Depletions reflect deficiencies in physically available water. Permitting, water quality, infrastructure, and nonconsumptive demand constraints are considered in separate OCWP analyses.
- Local gaps and storage depletions may vary from basin-level values due to local variations in demands and local availability of supply sources.
- For this baseline analysis, each basin's future demand is met by the basin's available supplies.
- For this baseline analysis, the proportion of future demand supplied by surface water and groundwater for each sector is assumed equal to current proportions.
- The amount of available surface water supplies used for OCWP water supply availability analysis includes changes in historical streamflow due to increased upstream demand, return flows, and increases in out-of-basin supplies from existing infrastructure.
- Analysis of bedrock groundwater supplies is based upon recharge from major aquifers.
- Groundwater storage depletions are defined as the amount that future demands exceed available recharge.
- Median gaps and storage depletions are based only on months with gaps or storage depletions.
- Annual probability is based upon the number of years that a gap or depletion occurs in at least one month of that year.

Reducing Water Needs Through Conservation

Central Region, Basin 62

Conservation Activities[1]	2060 Gap/Storage Depletion			2060 Gap/Storage Depletion Probability	
	Surface Water	Alluvial GW	Bedrock GW	Surface Water	Alluvial GW
	AFY			Percent	
Existing Conditions	0	100	0	0%	52%
Moderately Expanded Conservation in Crop Irrigation Water Use	0	100	0	0%	52%
Moderately Expanded Conservation in M&I Water Use	0	0	0	0%	0%
Moderately Expanded Conservation in Crop Irrigation and M&I Water Use	0	0	0	0%	0%
Substantially Expanded Conservation in Crop Irrigation and M&I Water Use	0	0	0	0%	0%

1 Conservation Activities are documented in the OCWP Water Demand Forecast Report

Reliable Diversions Based on Available Streamflow and New Reservoir Storage

Central Region, Basin 62

Reservoir Storage	Diversion
AF	AFY
100	2,500
500	3,900
1,000	5,000
2,500	7,800
5,000	11,500
Required Storage to Meet Growth in Demand (AF)	3,500
Required Storage to Meet Growth in Surface Water Demand (AF)	1,600

Water Supply Options & Effectiveness

Typically Effective | Potentially Effective | Likely Ineffective | No Option Necessary

Demand Management

Moderately expanded permanent conservation activities in the Municipal and Industrial, Self-Supplied Residential, and Crop Irrigation demand sectors could mitigate alluvial groundwater storage depletions. Temporary drought management activities may not be needed for this basin, since groundwater storage could continue to provide supplies during droughts.

Out-of-Basin Supplies

Out-of-basin supplies could mitigate groundwater storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified fourteen potential out-of-basin sites in the Central Region: Centerpoint in Basin 50; Asher and Scissortail in Basin 56; Dibble and Purcell in Basin 57; Union in Basin 58; Fallis, Nuyaka, Wellston and Welty in Basin 60; Sasakwa in Basin 61; and Crescent, Hennessey and Navina in Basin 64. However, in light of the distance to reliable water supplies, out-of-basin supplies may not be cost-effective for many users in the basin.

Reservoir Use

Lake Thunderbird, through COMCD, may be capable of providing dependable supplies to its existing users. Thunderbird's ability to supply additional water in the future may be constrained by a decrease in its dependable yield (currently being studied) or increased need by existing users due to decreased groundwater use. A substantial decrease in future supplies from the lake will likely cause surface water gaps in the basin although the severity of gaps could not be quantified. Additional reservoir storage in Basin 62 could effectively supplement supplies during dry months. The entire increase in demand from 2010 to 2060 could be supplied by a new reservoir diversion and 3,500 AF of reservoir storage at the basin outlet. The use of multiple reservoirs in the basin or reservoirs upstream of the basin's outlet may increase the amount of storage necessary to mitigate future gaps and storage depletions. The OCWP *Reservoir Viability Study* identified two potential sites in Basin 62 (Tate Mountain Reservoir and terminal storage in West Elm Creek Reservoir).

Increasing Reliance on Surface Water

Increased reliance on surface water through direct diversions, without reservoir storage, may create surface water gaps and is not recommended.

Increasing Reliance on Groundwater

Increased reliance on the Garber-Wellington bedrock aquifer could mitigate alluvial groundwater depletions. Any bedrock groundwater storage depletions would be minimal relative to the volume of water stored in this major aquifer. However, localized storage depletions may occur and adversely affect well yields, water quality, and/or pumping costs.

Notes & Assumptions

- Water quality may limit the use of supply sources, which may require new or additional treatment before use.
- Infrastructure related to the diversion, conveyance, treatment, and distribution of water will affect the cost-effectiveness of using any new source of supply.
- The ability to reduce demands will vary based on local acceptance of additional conservation and temporary drought management activities.
- Gaps and depletions may be mitigated in individual calendar months without reductions in the annual probability (chance of having shortage during another month).
- River diversion for new or additional reservoir storage is based on a hypothetical on-channel reservoir at the basin outlet. Reported yields will vary depending upon the reservoir location; placement at the basin outlet would likely result in a higher yield.
- Aquifer storage and recovery may provide additional storage or an alternative to surface storage and should be evaluated on a case by case basis.

Oklahoma Comprehensive Water Plan

Data & Analysis
Central Watershed Planning Region

Basin 64

Basin 64 Summary

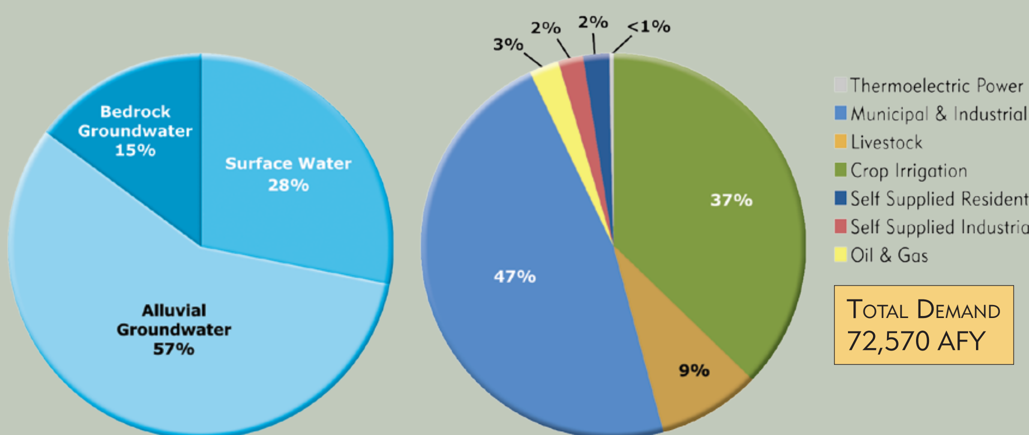
Synopsis

- Water users are expected to continue to rely primarily on alluvial groundwater and to a lesser extent surface water and bedrock groundwater.
- By 2020, there is a low probability of surface water gaps from increased demands on existing supplies during low flow periods.
- Alluvial and bedrock groundwater storage depletions may occur by 2020, but will be minimal in size relative to aquifer storage in the basin. However, localized storage depletions in both sources may cause adverse effects for users.
- To reduce the risk of adverse impacts on water supplies, it is recommended that surface water gaps and groundwater storage depletions be decreased where economically feasible.
- Additional conservation measures could reduce surface water gaps and groundwater storage depletions.
- To mitigate surface water gaps, dependable groundwater supplies and/or developing new reservoirs could be used as alternatives. These supply sources could be used without major impacts to groundwater storage.

Basin 64 accounts for about 22% of the current demand in the Central Watershed Planning Region. About 47% of the basin's 2010 demand was from the Municipal and Industrial demand sector. Crop Irrigation is the second largest demand sector at 37%. Surface water satisfies about 28% of the current demand in the basin. Groundwater satisfies about 72% of the current demand (57% alluvial and 15% bedrock). The peak summer month total water demand in Basin 64 is about 4.7 times the winter monthly demand, which is similar to the overall statewide pattern.

The flow in the Cimarron River upstream of Skeleton Creek is typically greater than 18,300 AF/month throughout the year and greater than 35,900 AF/month in the spring and early summer. However, the river can have periods of low flow in any month of the year. Lake Hefner provides terminal storage for withdrawals of 75,000 AFY from releases from Canton Reservoir in the Panhandle Region and diversions from the North Canadian River. The yield is fully allocated to Oklahoma City. The water supply yield of Guthrie Lake and Liberty Lake are unknown; therefore, the ability of these lakes to provide future water supplies could not be evaluated. The availability of permits is not expected to limit the development of surface water supplies for in-basin use through 2060. Relative to other basins in the state, the surface water quality in Basin 64 is considered fair. A large segment of the Cimarron River and multiple tributaries to the river in Basin 64 are impaired for Agricultural use due to high levels of chloride,

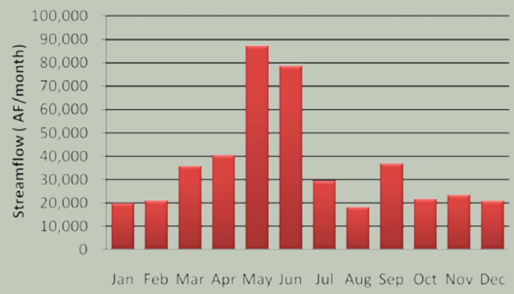
Current Demand by Source and Sector
Central Region, Basin 64



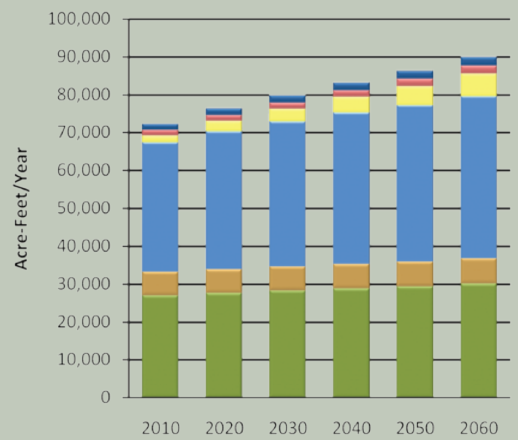
TOTAL DEMAND
72,570 AFY

Water Resources
Central Region, Basin 64

Median Historical Streamflow at the Basin Outlet
Central Region, Basin 64



Projected Water Demand
Central Region, Basin 64



sulfate, and total dissolved solids (TDS). Chisholm Creek, Liberty Lake, and Guthrie Lake are impaired for Public and Private Water supply due to high levels of nitrates and chlorophyll-a.

The majority of groundwater rights in Basin 64 are from the Cimarron River major alluvial aquifer. There are also substantial water rights in the Garber-Wellington major bedrock aquifer and El Reno minor bedrock aquifer. There are also groundwater rights in the North Canadian major alluvial aquifer and multiple minor alluvial and bedrock aquifers. The Cimarron River aquifer has more than 3.4 million AF of groundwater storage in Basin 64 and underlies the central portion of the basin (about 32% of the basin area). The Garber-Wellington aquifer underlies the eastern most portion of the basin (about 10% of the basin area) and has more than 6.7 million AF of groundwater storage in Basin 64. Basin 64 contributes 25,000 AFY of recharge to the Garber-Wellington aquifer. The OWRB and USGS are currently conducting a detailed study of the Garber-Wellington that will establish a permanent Equal Proportionate Share for the aquifer, which may change the amount of permittable withdrawals from the two AFY/acre currently allowed under temporary permits. Site-specific information on the suitability of the minor aquifers for supply, including the El Reno aquifer, should be considered before large scale use. The use of groundwater to meet in-basin demand is not expected to be limited by the availability of permits through 2060. High concentrations of nitrate, arsenic, chromium, radionuclides, and selenium have been found locally in the Garber-Wellington aquifer and may limit its use for Municipal and Industrial and other demand sectors. The OWRB and USGS are currently conducting a detailed study to better characterize the water quality of the aquifer for all users. There are no significant groundwater quality issues in other aquifers in the basin.

The projected 2060 water demand of 90,350 AFY in Basin 64 reflects a 17,780 AFY increase (25%) over the 2010 demand. The largest demand and growth in demand over this period will be in the Municipal and Industrial demand sector.

Gaps & Depletions

Based on projected demand and historical hydrology, surface water gaps and alluvial and bedrock groundwater storage depletions may occur by 2020. Surface water gaps will be up to 3,140 AFY and have a 17% probability of occurring in at least one month of the year by 2060. Surface water gaps in Basin 64 may occur throughout the year, peaking in size in the summer. Alluvial groundwater storage depletions will be up to 5,310 AFY and have a 17% probability of occurring in at least one month of the year by 2060. Projected annual alluvial groundwater storage depletions are minimal relative to the amount of water in storage in the Canadian River aquifer. Bedrock groundwater storage depletions will be up to 740 AFY by 2060. Bedrock groundwater storage depletions in Basin 64 may occur in the summer. Projected annual groundwater storage depletions are minimal relative to the amount of water in storage in the Canadian River and Garber-Wellington aquifers. However, localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Water Supply Limitations
Central Region, Basin 64

- Surface Water
- Alluvial Groundwater
- Bedrock Groundwater

Minimal | Potential | Significant

Water Supply Option Effectiveness
Central Region, Basin 64

- Demand Management
- Out-of-Basin Supplies
- Reservoir Use
- Increasing Supply from Surface Water
- Increasing Supply from Groundwater

Typically Effective | Potentially Effective | Likely Ineffective | No Option Necessary

Options

Water users are expected to continue to rely on all supply sources: surface water, alluvial groundwater, and bedrock groundwater. To reduce the risk of adverse impacts to the basin's water users, surface water gaps and groundwater storage depletions should be decreased where economically feasible.

Moderately expanded permanent conservation activities in the Municipal and Industrial, Self-Supplied Residential, and Crop Irrigation demand sectors could reduce surface water gaps and groundwater storage depletions. Temporary drought management activities may be effective for surface water supplies in this basin, since gaps have a low probability of occurring. Temporary drought management activities may not be needed for groundwater supplies, since groundwater storage could continue to provide supplies during droughts.

Out-of-basin supplies could mitigate surface water gaps and groundwater storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified thirteen potential out-of-basin sites in the Central Region. However, in light of the distance to reliable water supplies and substantial groundwater supplies, out-of-basin supplies may not be cost-effective for many users in the basin.

Additional reservoir storage in Basin 64 could effectively supplement supplies during dry months. The entire increase in demand from 2010 to 2060 could be supplied by a new river diversion and 11,000 AF of reservoir storage at the basin outlet. The OCWP *Reservoir Viability Study* also identified three potential sites in Basin 64.

Increased reliance on surface water, without reservoir storage, will increase surface water gaps and is not recommended.

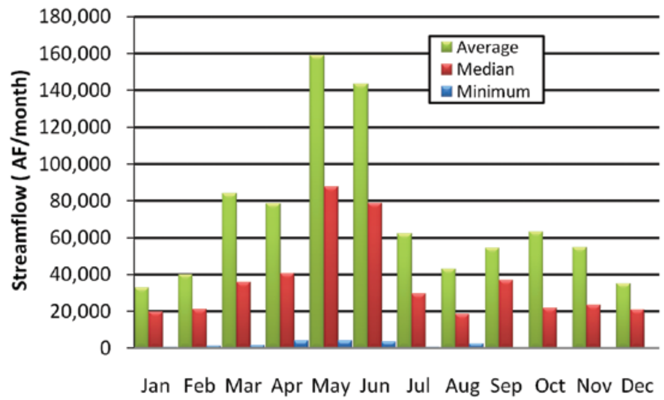
Increased reliance on the Cimarron River aquifer or Garber-Wellington aquifer could mitigate surface water gaps. Any increases in storage depletions would be minimal relative to the volume of water in stored in this major aquifer. However, these aquifers only underlie about 40% of the basin. Additionally, localized storage depletions may occur and adversely affect well yields, water quality, and/or pumping costs.

Basin 64 Data & Analysis

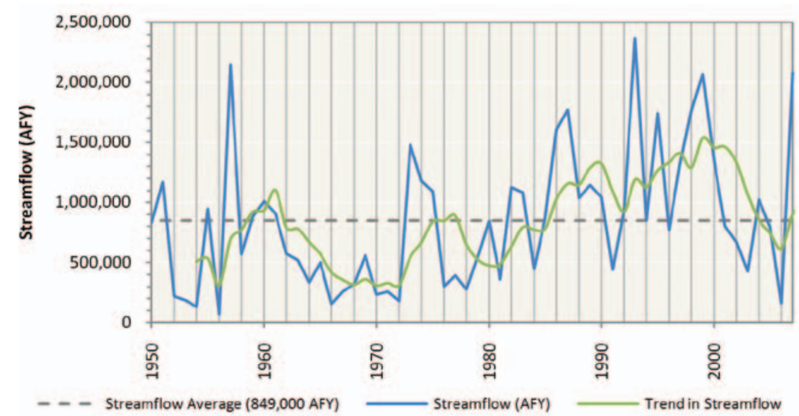
Surface Water Resources

- Historical streamflow from 1950 through 2007 was used to estimate the range of future surface water supplies. The Cimarron River upstream of Skeleton Creek had a period of below-average streamflow from the early 1960s to the early1970s. From the mid 1980s through the late 1990s, the basin went through a prolonged period of above-average streamflow and precipitation, demonstrating the hydrologic variability in the basin.
- The median flow in the Cimarron River upstream of Skeleton Creek is greater than 18,300 AF/month throughout the year and greater than 35,900 AF/month in the spring and early summer. However, the river can have periods of low flow in any month of the year. Relative to other basins in the state, the surface water quality in Basin 64 is considered fair.
- Lake Hefner provides terminal storage for withdrawal of 75,000 AFY releases from Lake Canton and diversions from the North Canadian River and is fully allocated to Oklahoma City. The water supply yield of Guthrie and Liberty Lakes are unknown; therefore, the ability of these reservoirs to provide future water supplies could not be evaluated.

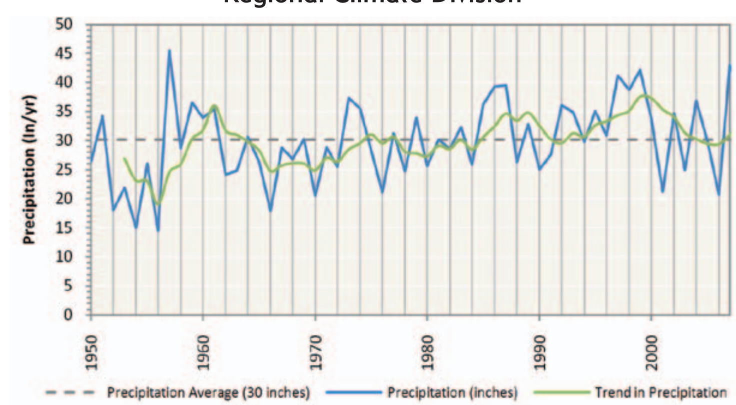
Monthly Historical Streamflow at the Basin Outlet
Central Region, Basin 64



Historical Streamflow at the Basin Outlet
Central Region, Basin 64



Historical Precipitation
Regional Climate Division



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Groundwater Resources - Aquifer Summary (2010)

Central Region, Basin 64

Aquifer			Portion of Basin Overlaying Aquifer	Current Groundwater Rights	Aquifer Storage in Basin	Equal Proportionate Share	Groundwater Available for New Permits
Name	Type	Class[1]	Percent	AFY	AF	AFY/Acre	AFY
Cimarron River	Alluvial	Major	32%	152,500	3,425,000	temporary 2.0	1,257,200
Enid Isolated Terrace	Alluvial	Major	0%	1,300	33,000	0.5	2,600
Garber-Wellington	Bedrock	Major	9%	28,500	6,712,000	temporary 2.0	391,400
North Canadian River	Alluvial	Major	3%	4,600	490,000	1.0	63,100
El Reno	Bedrock	Minor	69%	17,500	8,330,000	temporary 2.0	3,192,400
Fairview Isolated Terrace	Alluvial	Minor	1%	700	78,000	temporary 2.0	50,800
Isabella Isolated Terrace	Alluvial	Minor	0%	700	26,000	temporary 2.0	11,800
Loyal Isolated Terrace	Alluvial	Minor	1%	1,000	63,000	temporary 2.0	24,500
North-Central Oklahoma	Bedrock	Minor	4%	1,200	688,000	temporary 2.0	176,600
Non-Delineated Groundwater Source	Bedrock	Minor	N/A	200	N/A	temporary 2.0	N/A
Non-Delineated Groundwater Source	Alluvial	Minor	N/A	<50	N/A	temporary 2.0	N/A

1 Bedrock aquifers with typical yields greater than 50 gpm and alluvial aquifers with typical yields greater than 150 gpm are considered major.

Groundwater Resources

- The majority of groundwater rights in Basin 64 are from the Cimarron River major alluvial aquifer. There are also substantial water rights in the Garber-Wellington major bedrock aquifer and El Reno minor bedrock aquifer. There are also groundwater rights in the North Canadian major alluvial aquifer and multiple minor alluvial and bedrock aquifers. The Cimarron River aquifer has more than 3.4 million AF of groundwater storage in Basin 64 and underlies the central portion of the basin (about 32% of the basin area). The Garber-Wellington aquifer underlies the eastern most portion of the basin (about 9% of the basin area) and has more than 6.7 million AF of groundwater storage in Basin 64. Basin 64 contributes 25,000 AFY of recharge to the Garber-Wellington aquifer. The OWRB and USGS are currently conducting a detailed study of the Garber-Wellington that will establish an equal proportionate share for the aquifer and may change the current EPS of 2 AFY/acre allocation under temporary permits. Site-specific information on the suitability of the minor aquifers for supply, including the El Reno aquifer, should be considered before large scale use.
- High concentrations of nitrate, arsenic, chromium, radionuclides, and selenium have been found locally in the Garber-Wellington aquifer and may limit its use for Municipal and Industrial and other demand. The OWRB and USGS are conducting a detailed study to better characterize the water quality of the aquifer for all users. There are no significant groundwater quality issues in other aquifers in the basin.

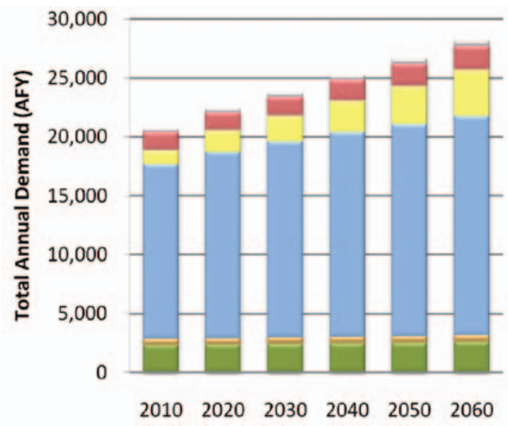
Notes & Assumptions

- Alluvial groundwater recharge is not considered separately from streamflow in physical supply availability analyses because any increases or decreases in alluvial groundwater recharge or storage would affect streamflow. Therefore, surface water flows are used to represent available alluvial groundwater recharge.
- Site-specific information on minor aquifers should be considered before large scale use. Suitability for long term supply is typically based on recharge, storage yield, capital and operational costs, and water quality.
- Groundwater permit availability is generally based on the amount of land owned or leased that overlies a specific aquifer.
- Temporary permit amounts are subject to change when the aquifer's equal proportionate share is set by the OWRB.
- Current groundwater rights represent the maximum allowable use. Actual use may be lower than the permitted amount.
- Bedrock groundwater recharge is the long-term annual average recharge to aquifers in the basin. Recharge rates on a county- or aquifer-wide level of detail were established from literature (published reports) of each aquifer. Seasonal or annual variability is not considered; therefore the modeled bedrock groundwater supply is independent of changing hydrologic conditions.

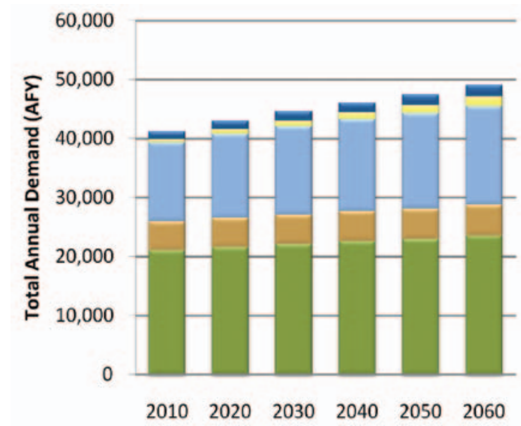
Water Demand

- Basin 64's water needs are about 22% of the demand in the Central Watershed Planning Region and will increase by 25% (17,780 AFY) from 2010 to 2060. The largest demand and growth in demand over this period will be in the Municipal and Industrial demand sector.
- Surface water is used to meet 28% of total demand in the basin and its use will increase by 36% (7,480 AFY) from 2010 to 2060. The majority of surface water use and growth in surface water use over this period will be in the Municipal and Industrial demand sector.
- Alluvial groundwater is used to meet 57% of total demand in the basin and its use will increase by 19% (7,880 AFY) from 2010 to 2060. The largest alluvial groundwater use over this period will be in the Crop Irrigation demand sector. However, the largest growth in alluvial groundwater use will be in the Municipal and Industrial demand sector.
- Bedrock groundwater is used to meet 15% of total demand in the basin and its use will increase by 23% (2,440 AFY) from 2010 to 2060. The largest bedrock groundwater use and growth in bedrock groundwater use over this period will be in the Municipal and Industrial demand sector.

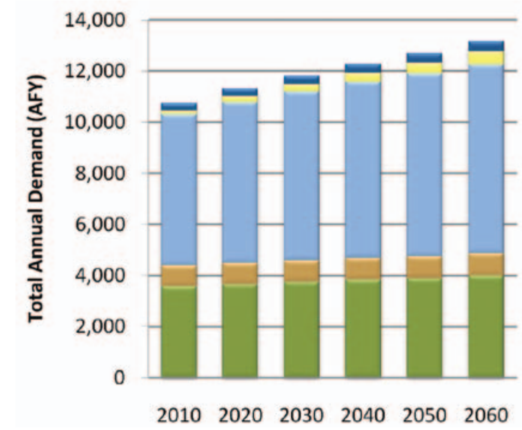
Surface Water Demand by Sector
Central Region, Basin 64



Alluvial Groundwater Demand by Sector
Central Region, Basin 64



Bedrock Groundwater Demand by Sector
Central Region, Basin 64



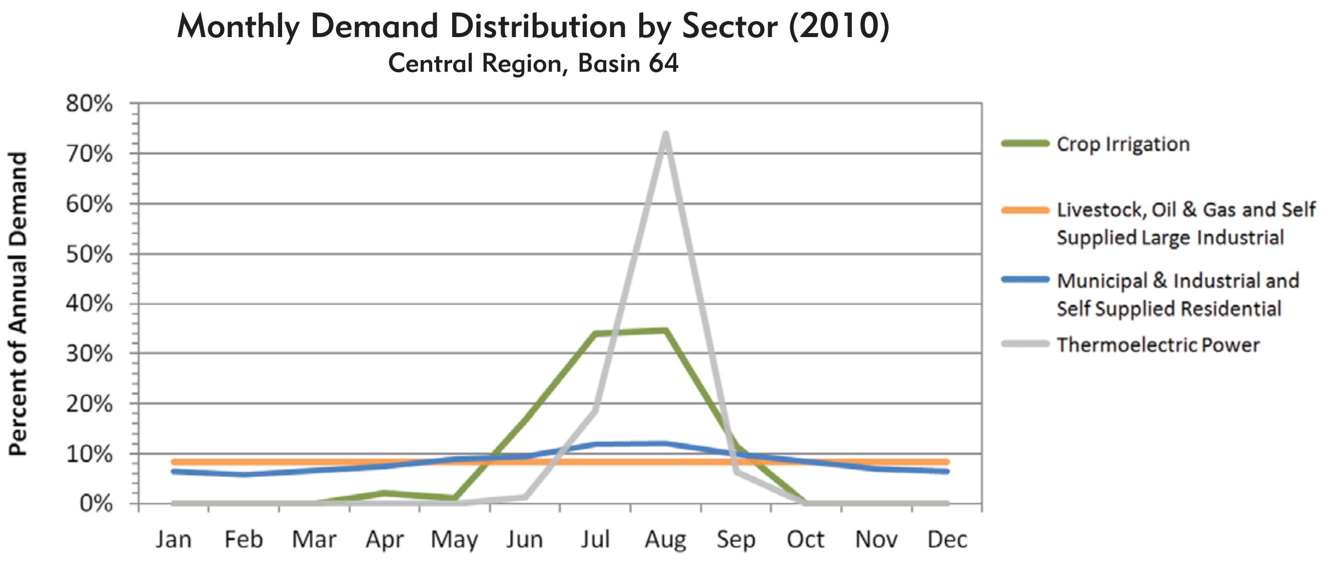
Thermoelectric Power | Self-Supplied Residential | Self-Supplied Industrial | Oil & Gas | Municipal & Industrial | Livestock | Crop Irrigation

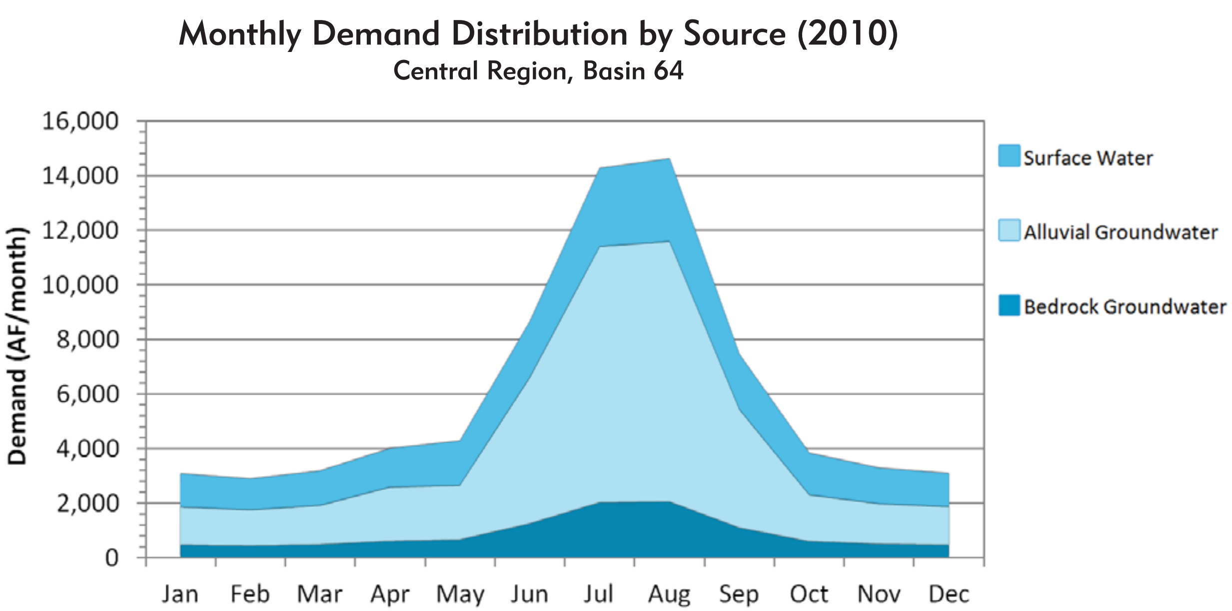
Total Demand by Sector
Central Region, Basin 64

Planning Horizon	Crop Irrigation	Livestock	Municipal & Industrial	Oil & Gas	Self-Supplied Industrial	Self-Supplied Residential	Thermoelectric Power	Total
	AFY							
2010	27,010	6,220	34,170	1,810	1,520	1,590	250	72,570
2020	27,640	6,300	36,400	2,820	1,520	1,720	280	76,680
2030	28,280	6,380	38,280	3,390	1,600	1,850	310	80,090
2040	28,910	6,460	39,910	4,170	1,740	1,980	350	83,520
2050	29,400	6,540	41,340	5,050	1,880	2,110	390	86,710
2060	30,180	6,620	42,840	6,000	2,020	2,260	430	90,350

Notes & Assumptions

- Demand values represent total demand (the amount of water pumped or diverted to meet the needs of the user).
- Values are based on the baseline demand forecast from the OCWP *Water Demand Forecast Report*.
- The effect of climate change, conservation, and non-consumptive uses, such as hydropower, are not represented in this baseline demand analysis but are documented in separate OCWP reports.
- The proportion of each supply source used to meet each water use sector's demand was assumed to be equal to the existing proportion, as represented in water rights.
- The proportions of future demands between water use sectors will vary due to differing growth rates.
- The overall proportion of supplies used to meet demand will change due to differing growth rates among the water use sectors.





Current Monthly Demand Distribution by Sector

- The Municipal and Industrial and Self-Supplied Residential demand sectors use 75% more water in summer months than in winter months. Crop Irrigation has a high demand in summer months and little or no demand in winter months. Thermoelectric Power demand peaks in the late summer. Other demand sectors have more consistent demand throughout the year.

Current Monthly Demand Distribution by Source

- The peak summer month total water demand in Basin 64 is 4.7 times the monthly winter demand, which is similar to the overall statewide pattern. Surface water use in the peak summer month is about 2.5 times the monthly winter use. Monthly alluvial groundwater use peaks in the summer at about 6.9 times the monthly winter use. Monthly bedrock groundwater use peaks in the summer at about 4.3 times the monthly winter use.

Gaps and Storage Depletions

- Based on projected demand and historical hydrology, surface water gaps and groundwater storage depletions may occur by 2020.
- Surface water gaps in Basin 64 may occur throughout the year, peaking in size during the summer. Surface water gaps in 2060 will be up to 14% (570 AF/month) of the surface water demand in the peak summer month, and as much as 17% (300 AF/month) of the winter monthly surface water demand. There will be a 17% probability of gaps occurring in at least one month of the year by 2060. Surface water gaps are most likely to occur during summer months.
- Alluvial groundwater storage depletions in Basin 64 may occur throughout the year, peaking in size in the summer. Alluvial groundwater storage depletions in 2060 will be up to 13% (1,480 AF/month) of the alluvial groundwater demand in the peak summer month, and as much as 18% (310 AF/month) of the winter monthly alluvial groundwater demand. There will be a 17% probability of alluvial groundwater storage depletions occurring in at least one month of the year by 2060. Alluvial groundwater storage depletions are most likely to occur during summer months.
- Bedrock groundwater storage depletions in Basin 64 will occur during the summer and be up to 15% (370 AF/month) of the monthly bedrock groundwater demand in the peak summer month.
- Projected annual groundwater storage depletions are minimal relative to the amount of water in storage in the Canadian River and Garber-Wellington aquifers. Localized storage depletions may adversely affect well yields, water quality, and/or pumping costs.

Surface Water Gaps by Season (2060 Demand)

Central Region, Basin 64

Months (Season)	Maximum Gap [1]	Median Gap	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	300	300	7%
Mar-May (Spring)	400	360	3%
Jun-Aug (Summer)	570	530	16%
Sep-Nov (Fall)	420	390	5%

1 Amount shown represents largest amount for any one month in season indicated.

Alluvial Groundwater Storage Depletions by Season (2060 Demand)

Central Region, Basin 64

Months (Season)	Maximum Storage Depletion[1]	Median Storage Depletion	Probability
	AF/month	AF/month	Percent
Dec-Feb (Winter)	310	310	7%
Mar-May (Spring)	440	380	3%
Jun-Aug (Summer)	1,480	1,425	16%
Sep-Nov (Fall)	760	390	5%

1 Amount shown represents largest amount for any one month in season indicated.

Magnitude and Probability of Annual Gaps and Storage Depletions

Central Region, Basin 64

Planning Horizon	Maximum Gaps/Storage Depletions			Probability of Gaps/ Storage Depletions	
	Surface Water	Alluvial Groundwater	Bedrock Groundwater	Surface Water	Alluvial Groundwater
	AFY			Percent	
2020	410	880	170	12%	12%
2030	960	1,860	320	12%	12%
2040	1,660	3,000	460	12%	12%
2050	2,330	4,060	580	16%	16%
2060	3,140	5,310	740	17%	17%

Bedrock Groundwater Storage Depletions by Season (2060 Demand)

Central Region, Basin 64

Months (Season)	Average Storage Depletion[1]
	AF/month
Dec-Feb (Winter)	0
Mar-May (Spring)	0
Jun-Aug (Summer)	370
Sep-Nov (Fall)	0

1 Amount shown represents largest amount for any one month in season indicated.

Notes & Assumptions

- Gaps and Storage Depletions reflect deficiencies in physically available water. Permitting, water quality, infrastructure, and nonconsumptive demand constraints are considered in separate OCWP analyses.
- Local gaps and storage depletions may vary from basin-level values due to local variations in demands and local availability of supply sources.
- For this baseline analysis, each basin's future demand is met by the basin's available supplies.
- For this baseline analysis, the proportion of future demand supplied by surface water and groundwater for each sector is assumed equal to current proportions.
- The amount of available surface water supplies used for OCWP water supply availability analysis includes changes in historical streamflow due to increased upstream demand, return flows, and increases in out-of-basin supplies from existing infrastructure.
- Analysis of bedrock groundwater supplies is based upon recharge from major aquifers.
- Groundwater storage depletions are defined as the amount that future demands exceed available recharge.
- Median gaps and storage depletions are based only on months with gaps or storage depletions.
- Annual probability is based upon the number of years that a gap or depletion occurs in at least one month of that year.

Reducing Water Needs Through Conservation

Central Region, Basin 64

Conservation Activities[1]	2060 Gap/Storage Depletion			2060 Gap/ Storage Depletion Probability	
	Surface Water	Alluvial GW	Bedrock GW	Surface Water	Alluvial GW
	AFY			Percent	
Existing Conditions	3,140	5,310	740	17%	17%
Moderately Expanded Conservation in Crop Irrigation Water Use	2,880	4,570	600	16%	16%
Moderately Expanded Conservation in M&I Water Use	1,190	2,670	400	12%	12%
Moderately Expanded Conservation in Crop Irrigation and M&I Water Use	930	1,770	250	12%	12%
Substantially Expanded Conservation in Crop Irrigation and M&I Water Use	0	0	0	0%	0%

1 Conservation Activities are documented in the OCWP Water Demand Forecast Report

Reliable Diversions Based on Available Streamflow and New Reservoir Storage

Central Region, Basin 64

Reservoir Storage	Diversion
AF	AFY
100	2,100
500	3,200
1,000	4,300
2,500	6,600
5,000	10,200
Required Storage to Meet Growth in Demand (AF)	11,000
Required Storage to Meet Growth in Surface Water Demand (AF)	2,900

Water Supply Options & Effectiveness

Typically Effective | Potentially Effective | Likely Ineffective | No Option Necessary

Demand Management

Moderately expanded permanent conservation activities in the Municipal and Industrial, Self-Supplied Residential, and Crop Irrigation demand sectors could reduce surface water gaps by 70%, alluvial groundwater storage depletions by 67%, and bedrock groundwater storage depletions by 66%. Temporary drought management activities may be effective for surface water supplies in this basin, since gaps have a low probability of occurring. Temporary drought management activities may not be needed for groundwater supplies, since groundwater storage could continue to provide supplies during droughts.

Out-of-Basin Supplies

Out-of-basin supplies could mitigate surface water gaps and groundwater storage depletions. The OCWP *Reservoir Viability Study*, which evaluated the potential for reservoirs throughout the state, identified thirteen potential out-of-basin sites in the Central Region: Centerpoint in Basin 50; Asher and Scissortail in Basin 56; Dibble and Purcell in Basin 57; Union in Basin 58; Fallis, Nuyaka, Wellston and Welty in Basin 60; Sasakwa in Basin 61; and Tate Mountain and West Elm Creek (terminal storage) in Basin 62. However, in light of the distance to reliable water supplies and substantial groundwater supplies, out-of-basin supplies may not be cost-effective for many users in the basin.

Reservoir Use

Additional reservoir storage in Basin 64 could effectively supplement supplies during dry months. The entire increase in demand from 2010 to 2060 could be supplied by a new river diversion and 11,000 AF of reservoir storage at the basin outlet. The use of multiple reservoirs in the basin or reservoirs upstream of the basin's outlet may increase the amount of storage necessary to mitigate future gaps and storage depletions. The OCWP *Reservoir Viability Study* also identified three potential sites in Basin 64 (Crescent Reservoir, Hennessey Reservoir and Navina Reservoir).

Increasing Reliance on Surface Water

Increased reliance on surface water through direct diversions, without reservoir storage, will increase surface water gaps and is not recommended.

Increasing Reliance on Surface Water

Increased reliance on the Cimarron River aquifer or Garber-Wellington aquifer could mitigate surface water gaps. Any increases in storage depletions would be minimal relative to the volume of water stored in this major aquifer. However, these aquifers only underlie about 40% of the basin. Additionally, localized storage depletions may occur and adversely affect well yields, water quality, and/or pumping costs.

Notes & Assumptions

- Water quality may limit the use of supply sources, which may require new or additional treatment before use.
- Infrastructure related to the diversion, conveyance, treatment, and distribution of water will affect the cost-effectiveness of using any new source of supply.
- The ability to reduce demands will vary based on local acceptance of additional conservation and temporary drought management activities.
- Gaps and depletions may be mitigated in individual calendar months without reductions in the annual probability (chance of having shortage during another month).
- River diversion for new or additional reservoir storage is based on a hypothetical on-channel reservoir at the basin outlet. Reported yields will vary depending upon the reservoir location; placement at the basin outlet would likely result in a higher yield.
- Aquifer storage and recovery may provide additional storage or an alternative to surface storage and should be evaluated on a case by case basis.

Glossary

Acre-foot: volume of water that would cover one acre of land to a depth of one foot; equivalent to 43,560 cubic feet or 325,851 gallons.

Alkalinity: measurement of the water's ability to neutralize acids. High alkalinity usually indicates the presence of carbonate, bicarbonates, or hydroxides. Waters that have high alkalinity values are often considered undesirable because of excessive hardness and high concentrations of sodium salts. Waters with low alkalinity have little capacity to buffer acidic inputs and are susceptible to acidification (low pH).

Alluvial aquifer: aquifer with porous media consisting of loose, unconsolidated sediments deposited by fluvial (river) or aeolian (wind) processes, typical of river beds, floodplains, dunes, and terraces.

Alluvial groundwater: water found in an alluvial aquifer.

Alluvium: sediments of clay, silt, gravel, or other unconsolidated material deposited over time by a flowing stream on its floodplain or delta; frequently associated with higher-lying terrace deposits of groundwater.

Appendix B areas: waters of the state into which discharges may be limited and that are located within the boundaries of areas listed in Appendix B of OWRB rules Chapter 45 on Oklahoma's Water Quality Standards (OWQS); including but not limited to National and State parks, forests, wilderness areas, wildlife management areas, and wildlife refuges. Appendix B may include areas inhabited by federally listed threatened or endangered species and other appropriate areas.

Appropriative right: right acquired under the procedure provided by law to take a specific quantity of water by direct diversion from a stream, an impoundment thereon, or a playa lake, and to apply such water to a specific beneficial use or uses.

Aquifer: geologic unit or formation that contains sufficient saturated, permeable material to yield economically significant quantities of water to wells and springs.

Artificial recharge: any man-made process specifically designed for the primary purpose of increasing the amount of water entering into an aquifer.

Attainable uses: best uses achievable for a particular waterbody given water of adequate quality.

Background: ambient condition upstream or upgradient from a facility, practice, or activity that has not been affected by that facility, practice or activity.

Basin: see Surface water basin.

Basin outlet: the furthest downstream geographic point in an OCWP planning basin.

Bedrock aquifer: aquifer with porous media consisting of lithified (semi-consolidated or consolidated) sediments, such as limestone, sandstone, siltstone, or fractured crystalline rock.

Bedrock groundwater: water found in a bedrock aquifer.

Beneficial use: (1) The use of stream or groundwater when reasonable intelligence and diligence are exercised in its application for a lawful purpose and as is economically necessary for that purpose. Beneficial uses include but are not limited to municipal, industrial, agricultural, irrigation, recreation, fish and wildlife, etc., as defined in OWRB rules Chapter 20 on stream water use and Chapter 30 on groundwater use. (2) A classification in OWQS of the waters of the State, according to their best uses in the interest of the public set forth in OWRB rules Chapter 45 on OWQS.

Board: Oklahoma Water Resources Board.

Chlorophyll-a: primary photosynthetic plant pigment used in water quality analysis as a measure of algae growth.

Conductivity: a measure of the ability of water to pass electrical current. High specific conductance indicates high concentrations of dissolved solids.

Conjunctive management: water management approach that takes into account the interactions between groundwaters and surface waters and how those interactions may affect water availability.

Conservation: protection from loss and waste. Conservation of water may mean to save or store water for later use or to use water more efficiently.

Conservation pool: reservoir storage of water for the project's authorized purpose other than flood control.

Consumptive use: a use of water that diverts it from a water supply.

Cultural eutrophication: condition occurring in lakes and streams whereby normal processes of eutrophication are accelerated by human activities.

CWSRF: see State Revolving Fund (SRF).

Dam: any artificial barrier, together with appurtenant works, which does or may impound or divert water.

Degradation: any condition caused by the activities of humans resulting in the prolonged impairment of any constituent of an aquatic environment.

Demand: amount of water required to meet the needs of people, communities, industry, agriculture, and other users.

Demand forecast: estimate of expected water demands for a given planning horizon.

Demand management: adjusting use of water through temporary or permanent conservation measures to meet the water needs of a basin or region.

Demand sectors: distinct consumptive users of the state's waters. For OCWP analysis, seven demand sectors were identified: thermoelectric power, self-supplied residential, self-supplied industrial, oil and gas, municipal and industrial, livestock, and crop irrigation.

Dependable yield: the maximum amount of water a reservoir can dependably supply from storage during a drought of record.

Depletion: a condition that occurs when the amount of existing and future demand for groundwater exceeds available recharge.

Dissolved oxygen: amount of oxygen gas dissolved in a given volume of water at a particular temperature and pressure, often expressed as a concentration in parts of oxygen per million parts of water. Low levels of dissolved oxygen facilitate the release of nutrients from sediments.

Diversion: to take water from a stream or waterbody into a pipe, canal, or other conduit, either by pumping or gravity flow.

Domestic use: in relation to OWRB permitting, the use of water by a natural individual or by a family or household for household purposes, for farm and domestic animals up to the normal grazing capacity of the land whether or not the animals are actually owned by such natural individual or family, and for the irrigation of land not exceeding a total of three acres in area for the growing of gardens, orchards, and lawns. Domestic use also includes: (1) the use of water for agriculture purposes by natural individuals, (2) use of water for fire protection, and (3) use of water by non-household entities for drinking water purposes, restroom use, and the watering of lawns, provided that the amount of water used for any such purposes does not exceed five acre-feet per year.

Drainage area: total area above the discharge point drained by a receiving stream.

DWSRF: see State Revolving Fund (SRF).

Drought management: short-term measures to conserve water to sustain a basin's or region's needs during times of below normal rainfall.

Ecoregion (ecological region): an ecologically and geographically defined area; sometimes referred to as a bioregion.

Effluent: any fluid emitted by a source to a stream, reservoir, or basin, including a partially or completely treated waste fluid that is produced by and flows out of an industrial or wastewater treatment plant or sewer.

Elevation: elevation in feet in relation to mean sea level (MSL).

Equal proportionate share (EPS): portion of the maximum annual yield of water from a groundwater basin that is allocated to each acre of land overlying the basin or subbasin.

Eutrophic: a water quality characterization, or "trophic status," that indicates abundant nutrients and high rates of productivity in a lake, frequently resulting in oxygen depletion below the surface.

Eutrophication: the process whereby the condition of a waterbody changes from one of low biologic productivity and clear water to one of high productivity and water made turbid by the accelerated growth of algae.

Flood control pool: reservoir storage of excess runoff above the conservation pool storage capacity that is discharged at a regulated rate to reduce potential downstream flood damage.

Floodplain: the land adjacent to a body of water which has been or may be covered by flooding, including, but not limited to, the one-hundred year flood (the flood expected to be equaled or exceeded every 100 years on average).

Fresh water: water that has less than five thousand (5,000) parts per million total dissolved solids.

Gap: an anticipated shortage in supply of surface water due to a deficiency of physical water supply or the inability or failure to obtain necessary water rights.

Groundwater: fresh water under the surface of the earth regardless of the geologic structure in which it is standing or moving outside the cut bank of a definite stream.

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

Groundwater recharge: see Recharge.

Hardness: a measure of the mineral content of water. Water containing high concentrations (usually greater than 60 ppm) of iron, calcium, magnesium, and hydrogen ions is usually considered "hard water."

High Quality Waters (HQW): a designation in the OWQS referring to waters that exhibit water quality exceeding levels necessary to support the propagation of fishes, shellfishes, wildlife, and recreation in and on the water. This designation prohibits any new point source discharge or additional load or increased concentration of specified pollutants.

Hydraulic conductivity: the capacity of rock to transmit groundwater under pressure.

Hydrologic unit code: a numerical designation utilized by the United States Geologic Survey and other federal and state agencies as a way of identifying all drainage basins in the U.S. in a nested arrangement from largest to smallest, consisting of a multi-digit code that identifies each of the levels of classification within two-digit fields.

Hypereutrophic: a surface water quality characterization, or "trophic status," that indicates excessive primary productivity and excessive nutrient levels in a lake.

Impaired water: waterbody in which the quality fails to meet the standards prescribed for its beneficial uses.

Impoundment: body of water, such as a pond or lake, confined by a dam, dike, floodgate, or other barrier established to collect and store water.

Infiltration: the gradual downward flow of water from the surface of the earth into the subsurface.

Instream flow: a quantity of water to be set aside in a stream or river to ensure downstream environmental, social, and economic benefits are met (further defined in the OCWP *Instream Flow Issues & Recommendations* report).

Interbasin transfer: the physical conveyance of water from one basin to another.

Levee: a man-made structure, usually an earthen embankment, designed and constructed to contain, control, or divert the flow of water so as to provide protection from temporary flooding.

Major groundwater basin: a distinct underground body of water overlain by contiguous land and having essentially the same geological and hydrological characteristics and from which groundwater wells yield at least fifty (50) gallons per minute on the average basinwide if from a bedrock aquifer, and at least one hundred fifty (150) gallons per minute on the average basinwide if from an alluvium and terrace aquifer, or as otherwise designated by the OWRB.

Marginal quality water: waters that have been historically unusable due to technological or economic issues associated with diversion, treatment, or conveyance.

Maximum annual yield (MAY): determination by the OWRB of the total amount of fresh groundwater that can be produced from each basin or subbasin allowing a minimum twenty-year life of such basin or subbasin.

Mesotrophic: a surface water quality characterization, or "trophic status," describing those lakes with moderate primary productivity and moderate nutrient levels.

Million gallons per day (mgd): a rate of flow equal to 1.54723 cubic feet per second or 3.0689 acre-feet per day.

Minor groundwater basin: a distinct underground body of water overlain by contiguous land and having substantially the same geological and hydrological characteristics and which is not a major groundwater basin.

Nitrogen limited: in reference to water chemistry, where growth or amount of primary producers (e.g., algae) is restricted in a waterbody due in large part to available nitrogen.

Non-consumptive use: use of water in a manner that does not reduce the amount of supply, such as navigation, hydropower production, protection of habitat for hunting, maintaining water levels for boating recreation, or maintaining flow, level and/or temperature for fishing, swimming, habitat, etc.

Nonpoint source (NPS): a source of pollution without a well-defined point of origin. Nonpoint source pollution is commonly caused by sediment, nutrients, and organic or toxic substances originating from land use activities. It occurs when the rate of material entering a waterbody exceeds its natural level.

Normal pool elevation: the target lake elevation at which a reservoir was designed to impound water to create a dependable water supply; sometimes referred to as the top of the conservation pool.

Normal pool storage: volume of water held in a reservoir when it is at normal pool elevation.

Numerical criteria: concentrations or other quantitative measures of chemical, physical or biological parameters that are assigned to protect the beneficial use of a waterbody.

Numerical standard: the most stringent of the OWQS numerical criteria assigned to the beneficial uses for a given stream.

Nutrient-impaired reservoir: reservoir with a beneficial use or uses impaired by human-induced eutrophication as determined by a Nutrient-Limited Watershed Impairment Study.

Nutrient-Limited Watershed (NLW): watershed of a waterbody with a designated beneficial use that is adversely affected by excess nutrients as determined by a Carlson's Trophic State Index (using chlorophyll-a) of 62 or greater, or is otherwise listed as "NLW" in Appendix A of the OWQS.

Nutrients: elements or compounds essential as raw materials for an organism's growth and development; these include carbon, oxygen, nitrogen, and phosphorus.

Oklahoma Water Quality Standards (OWQS): rules promulgated by the OWRB in Oklahoma Administrative Code Title 785, Chapter 45, which establish classifications of uses of waters of the state, criteria to maintain and protect such classifications, and other standards or policies pertaining to the quality of such waters.

Oligotrophic: a surface water quality characterization, or "trophic status," describing those lakes with low primary productivity and/or low nutrient levels.

Outfall: a point source that contains the effluent being discharged to the receiving water.

Percolation: the movement of water through unsaturated subsurface soil layers, usually continuing downward to the groundwater or water table (distinguished from Seepage).

Permit availability: the amount of water that could be made available for withdrawals under permits issued in accordance with Oklahoma water law.

pH: the measurement of the hydrogen-ion concentration in water. A pH below 7 is acidic (the lower the number, the more acidic the water, with a decrease of one full unit representing an increase in acidity of ten times) and a pH above 7 (to a maximum of 14) is basic (the higher the number, the more basic the water). In Oklahoma, fresh waters typically exhibit a pH range from 5.5 in the southeast to almost 9.0 in central areas.

Phosphorus limited: in reference to water chemistry, where growth or amount of primary producers (e.g., algae) is restricted in a waterbody due in large part to the amount of available phosphorus.

Physical water availability: amount of water currently in streams, rivers, lakes, reservoirs, and aquifers; sometimes referred to as "wet water."

Point source: any discernible, confined and discrete conveyance, including any pipe, ditch, channel, tunnel, well, discrete fissure, container, rolling stock or concentrated animal feeding operation from which pollutants are or may be discharged. This term does not include return flows from irrigation agriculture.

Potable: describing water suitable for drinking.

Primary Body Contact Recreation (PBCR): a classification in OWQS of a waterbody's use; involves direct body contact with the water where a possibility of ingestion exists. In these cases, the water shall not contain chemical, physical or biological substances in concentrations that irritate the skin or sense organs or are toxic or cause illness upon ingestion by human beings.

Primary productivity: the production of chemical energy in organic compounds by living organisms. In lakes and streams, this is essentially the lowest denominator of the food chain (phytoplankton) bringing energy into the system via photosynthesis.

Prior groundwater right: comparable to a permit, a right to use groundwater recognized by the OWRB as having been established by compliance with state groundwater laws in effect prior to 1973.

Provider: private or public entity that supplies water to end users or other providers. For OCWP analyses, "public water providers" included approximately 785 non-profit, local governmental municipal or community water systems and rural water districts.

Recharge: the inflow of water to an alluvial or bedrock aquifer.

Reservoir: a surface depression containing water impounded by a dam.

Return water or return flow: the portion of water diverted from a water supply that returns to a watercourse.

Reverse osmosis: a process that removes salts and other substances from water. Pressure is placed on the stronger of two unequal concentrations separated by a semi-permeable membrane; a common method of desalination.

Riparian water right (riparian right): the right of an owner of land adjoining a stream or watercourse to use water from that stream for reasonable purposes.

Riverine: relating to, formed by, or resembling a river (including tributaries), stream, etc.

Salinity: the concentration of salt in water measured in milligrams per liter (mg/L) or parts per million (ppm).

Salt water: any water containing more than five thousand (5,000) parts per million total dissolved solids.

Saturated thickness: thickness below the zone of the water table in which the interstices are filled with groundwater.

Scenic Rivers: streams in "Scenic River" areas designated by the Oklahoma Legislature that possess unique natural scenic beauty, water conservation, fish, wildlife and outdoor recreational values. These areas are listed and described in Title 82 of Oklahoma Statutes, Section 1451.

Sediment: particles transported and deposited by water deriving from rocks, soil, or biological material.

Seepage: the movement of water through saturated material often indicated by the appearance or disappearance of water at the ground surface, as in the loss of water from a reservoir through an earthen dam (distinguished from Percolation).

Sensitive sole source groundwater basin or subbasin: a major groundwater basin or subbasin all or a portion of which has been designated by the U.S. Environmental Protection Agency (EPA) as a "Sole Source Aquifer" and serves as a mechanism to protect drinking water supplies in areas with limited water supply alternatives. It includes any portion of a contiguous aquifer located within five miles of the known areal extent of the surface outcrop of the designated groundwater basin or subbasin.

Sensitive Water Supplies (SWS): designation that applies to public and private water supplies possessing conditions that make them more susceptible to pollution events. This designation restricts point source discharges in the watershed and institutes a 10 μg/L (micrograms per liter) chlorophyll-a criterion to protect against taste and odor problems and reduce water treatment costs.

Soft water: water that contains little to no magnesium or calcium salts.

State Revolving Fund (SRF): fund or program used to provide loans to eligible entities for qualified projects in accordance with Federal law, rules and guidelines administered by the EPA and state. Two separate SRF programs are administered in Oklahoma: the Clean Water SRF is intended to control water pollution and is administered by OWRB; the Drinking Water SRF was created to provide safe drinking water and is administered jointly by the OWRB and ODEQ.

Storm sewer: a sewer specifically designed to control and convey stormwater, surface runoff, and related drainage.

Stream system: drainage area of a watercourse or series of watercourses that converges in a large watercourse with defined boundaries.

Stream water: water in a definite stream that includes water in ponds, lakes, reservoirs, and playa lakes.

Streamflow: the rate of water discharged from a source indicated in volume with respect to time.

Surface water: water in streams and waterbodies as well as diffused over the land surface.

Surface water basin: geographic area drained by a single stream system. For OCWP analysis, Oklahoma has been divided into 82 surface water basins (also referenced as “planning basins”).

Temporary permit: for groundwater basins or subbasins for which a maximum annual yield has not been determined, temporary permits are granted to users allocating two acre-feet of water per acre of land per year. Temporary permits are for one-year terms that can be revalidated annually by the permittee. When the maximum annual yield and equal proportionate share are approved by the OWRB, all temporary permits overlying the studied basin are converted to regular permits at the new approved allocation amount.

Terrace deposits: fluvial or wind-blown deposits occurring along the margin and above the level of a body of water and representing the former floodplain of a stream or river.

Total dissolved solids (TDS): a measure of the amount of dissolved material in the water column, reported in mg/L, with values in fresh water naturally ranging from 0-1000 mg/L. High concentrations of TDS limit the suitability of water as a drinking and livestock watering source as well as irrigation supply.

Total maximum daily load (TMDL): sum of individual wasteload allocations for point sources, safety reserves, and loads from nonpoint source and natural backgrounds.

Total nitrogen: for water quality analysis, a measure of all forms of nitrogen (organic and inorganic). Excess nitrogen can lead to harmful algae blooms, hypoxia, and declines in wildlife and habitat.

Total phosphorus: for water quality analysis, a measure of all forms of phosphorus, often used as an indicator of eutrophication and excessive productivity.

Transmissivity: measure of how much water can be transmitted horizontally through an aquifer. Transmissivity is the product of hydraulic conductivity of the rock and saturated thickness of the aquifer.

Tributary: stream or other body of water, surface or underground, that contributes to another larger stream or body of water.

Trophic State Index (TSI): one of the most commonly used measurements to compare lake trophic status, based on algal biomass. Carlson’s TSI uses chlorophyll-a concentrations to define the level of eutrophication on a scale of 1 to 100, thus indicating the general biological condition of the waterbody.

Trophic status: a lake’s trophic state, essentially a measure of its biological productivity. The various trophic status levels (Oligotrophic, Mesotrophic, Eutrophic, and Hypereutrophic) provide a relative measure of overall water quality conditions in a lake.

Turbidity: a combination of suspended and colloidal materials (e.g., silt, clay, or plankton) that reduce the transmission of light through scattering or absorption. Turbidity values are generally reported in Nephelometric Turbidity Units (NTUs).

Vested stream water right (vested right): comparable to a permit, a right to use stream water recognized by the OWRB as having been established by compliance with state stream water laws in effect prior to 1963.

Waste by depletion: unauthorized use of wells or groundwater; drilling a well, taking, or using fresh groundwater without a permit, except for domestic use; taking more fresh groundwater than is authorized by permit; taking or using fresh groundwater so that the water is lost for beneficial use; transporting fresh groundwater from a well to the place of use in such a manner that there is an excessive loss in transit; allowing fresh groundwater to reach a pervious stratum and be lost into cavernous or otherwise pervious materials encountered in a well; drilling wells and producing fresh groundwater there from except in accordance with well spacing requirements; or using fresh groundwater for air conditioning or cooling purposes without providing facilities to aerate and reuse such water.

Waste by pollution: permitting or causing the pollution of a fresh water strata or basin through any act that will permit fresh groundwater polluted by minerals or other waste to filter or intrude into a basin or subbasin, or failure to properly plug abandoned fresh water wells.

Water quality: physical, chemical, and biological characteristics of water that determine diversity, stability, and productivity of the climax biotic community or affect human health.

Water right: right to the use of stream or groundwater for beneficial use reflected by permits or vested rights for stream water or permits or prior rights for groundwater.

Wastewater reuse: treated municipal and industrial wastewater captured and reused commonly for non-potable irrigation and industrial applications to reduce demand upon potable water systems.

Water supply: a body of water, whether static or moving on or under the surface of the ground, or in a man-made reservoir, available for beneficial use on a dependable basis.

Water supply availability: for OCWP analysis, the consideration of whether or not water is available that meets three necessary requirements: physical water is present, the water is of a usable quality, and a water right or permit to use the water has been or can be obtained.

Water supply options: alternatives that a basin or region may implement to meet changing water demands. For OCWP analysis, “primary options“ include demand management, use of out-of-basin supplies, reservoir use, increasing reliance on surface water, and increasing reliance on groundwater; “expanded options” include expanding conservation measures, artificial aquifer recharge, use of marginal quality water sources, and potential reservoir development.

Water table: The upper surface of a zone of saturation; the upper surface of the groundwater.

Waterbody: any specified segment or body of waters of the state, including but not limited to an entire stream or lake or a portion thereof.

Watercourse: the channel or area that conveys a flow of water.

Waters of the state: all streams, lakes, ponds, marshes, watercourses, waterways, wells, springs, irrigation systems, drainage systems, and other bodies or accumulations of water, surface and underground, natural or artificial, public or private, which are contained within, flow through, or border upon the state.

Watershed: the boundaries of a drainage area of a watercourse or series of watercourses that diverge above a designated location or diversion point determined by the OWRB.

Well: any type of excavation for the purpose of obtaining groundwater or to monitor or observe conditions under the surface of the earth; does not include oil and gas wells.

Well yield: amount of water that a water supply well can produce (usually in gpm), which generally depends on the geologic formation and well construction.

Wholesale: for purposes of OCWP Public Water Provider analyses, water sold from one public water provider to another.

Withdrawal: water removed from a supply source.

AF: acre-foot or acre-feet

AFD: acre-feet per day

AFY: acre-feet per year

BMPs: best management practices

BOD: biochemical oxygen demand

cfs: cubic feet per second

CWAC: Cool Water Aquatic Community

CWSRF: Clean Water State Revolving Fund

DO: dissolved oxygen

DWSRF: Drinking Water State Revolving Fund

EPS: equal proportionate share

FACT: Funding Agency Coordinating Team

gpm: gallons per minute

HLAC: Habitat Limited Aquatic Community

HQW: High Quality Waters

HUC: hydrologic unit code

M&I: municipal and industrial

MAY: maximum annual yield

mgd: million gallons per day

µS/cm: microsiemens per centimeter (see specific conductivity)

mg/L: milligrams per liter

NLW: nutrient-limited watershed

NPS: nonpoint source

NPDES: National Pollutant Discharge Elimination System

NRCS: Natural Resources Conservation Service

NTU: Nephelometric Turbidity Unit (see "Turbidity")

OCWP: Oklahoma Comprehensive Water Plan

ODEQ: Oklahoma Department of Environmental Quality

O&G: Oil and Gas

ORW: Outstanding Resource Water

OWQS: Oklahoma Water Quality Standards

OWRB: Oklahoma Water Resources Board

PBCR: Primary Body Contact Recreation

pH: hydrogen ion activity

ppm: parts per million

RD: Rural Development

REAP: Rural Economic Action Plan

SBCR: Secondary Body Contact Recreation

SDWIS: Safe Drinking Water Information System

SRF: State Revolving Fund

SSI: Self-Supplied Industrial

SSR: Self-Supplied Residential

SWS: Sensitive Water Supply

TDS: total dissolved solids

TMDL: total maximum daily load

TSI: Trophic State Index

TSS: total suspended solids

USACE: United States Army Corps of Engineers

USEPA: United States Environmental Protection Agency

USGS: United States Geological Survey

WLA: wasteload allocation

WWAC: Warm Water Aquatic Community

Water Quantity Conversion Factors

Initial Unit \ Desired Unit	CFS	GPM	MGD	AFY	AFD
CFS	—	450	.646	724	1.98
GPM	.00222	—	.00144	1.61	.00442
MGD	1.55	695	—	1120	3.07
AFY	.0014	.62	.00089	—	.00274
AFD	.504	226	.326	365	—

EXAMPLE: Converting from MGD to CFS. To convert from an initial value of 140 MGD to CFS, multiply 140 times 1.55 to come up with the desired conversion, which would be 217 CFS (140 X 1.55 = 217).

CFS: cubic feet per second
GPM: gallons per minute
MGD: millions gallons per day
AFY: acre-feet per year
AFD: acre-feet per day
1 acre-foot: 325,851 gallons

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