Oklahoma Comprehensive Water Plan
2011 Update

Technical Memorandum:
Conjunctive Water Management in Oklahoma and Other States

November 2010

This study was funded through an agreement with the Oklahoma Water Resources Board under its authority to update the Oklahoma Comprehensive Water Plan, the state's long-range water planning strategy, due for submittal to the State Legislature in 2012. Results from this and other studies have been incorporated where appropriate in the OCWP's technical and policy considerations. The general goal of the OCWP is to ensure reliable water supplies for all Oklahomans through integrated and coordinated water resources planning and to 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.

Prepared by CDM under a cooperative agreement between the United States Army Corps of Engineers and the Oklahoma Water Resources Board

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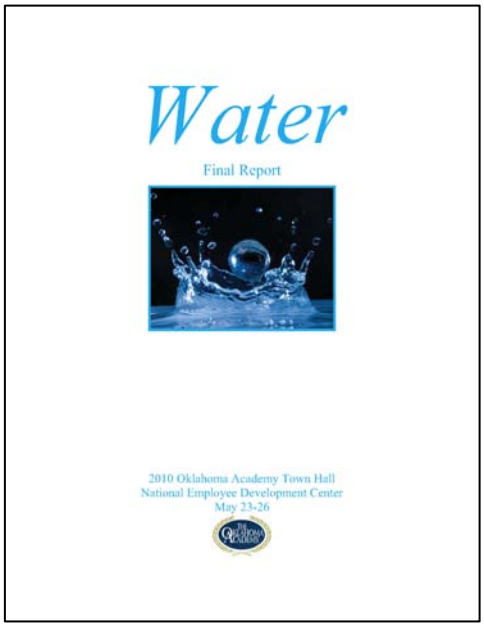
Acronyms

AF	acre-feet
AFY	acre-feet per year
ASR	Aquifer Storage and Recovery
AWS	Available Water Supply
BOR	Bureau of Reclamation
BWS	Basin Water Supply
CDWR	California Department of Natural Resources
cfs	cubic feet per second
DNR	Division of Natural Resources
DWR	Department of Water Resources
ESA	Endangered Species Act
HB	House Bill
IGUCAs	Intensive Groundwater Use Control Areas
IMP	Integrated Management Process
LB	Legislative Bill
NRDs	Natural Resource Districts
OARs	Oregon Administrative Rules
OCWP	Oklahoma Comprehensive Water Plan
ODWR	Oregon Department of Natural Resources
OWRB	Oklahoma Water Resources Board
SB	Senate Bill
SWRCB	State Water Resources Control Board
TCEQ	Texas Commission on Environmental Quality
TM	Technical Memorandum
TWDB	Texas Water Development Board
USGS	U.S. Geological Survey

Introduction

Through development of a major update to the Oklahoma Comprehensive Water Plan (OCWP), the Oklahoma Water Resources Board (OWRB) is taking an unprecedented look at Oklahoma's water resources and supplies needed to meet the state's needs through 2060 and beyond. Included are analyses of water demands and the physical supply availability, permitting, water quality, and infrastructure needs over the 50-year planning period.

Participants in OCWP's public policy development process have identified the conjunctive management of Oklahoma's surface water and groundwater supplies as an important topic in meeting Oklahomans' current and future water needs. The final report from the 2010 Town Hall meeting (Oklahoma Academy 2010) included the following regarding conjunctive water management:



The OCWP Water Town Hall in May 2010 included discussion of conjunctive water management in Oklahoma.

> *There was no consensus as to the conjunctive use and management of groundwater and surface water resources. Better coordination and management of the interrelation of surface and groundwater resources is essential. Our surface water allocation system (prior appropriation) does not recognize groundwater/surface water interactions. These interactions can be a significant source of problems limiting the effective management of water.*
>
> *Increased public awareness of the connection between groundwater and surface water is essential. In recognition of our stewardship role with respect to our state's natural resources, we must better understand and manage the very real connection between the use of those resources while balancing the right of a beneficial, consumptive use of those resources.*
>
> *A comprehensive, independent hydrologic study should be undertaken to identify how the two systems are related and better understand how to effectively manage the two. Any such study should also include a determination of the quantity and the quality of groundwater, including levels of contamination, the maximum annual yields of aquifers, the impact of precipitation levels, the impact of pumping groundwater on the appropriation of surface water, and the effect of the depletion of surface water on groundwater. Long-term hydrological studies are also needed to predict impacts on use and recharge.*

Coordinating management of groundwater and surface water raises concerns about private property rights. In developing new policies for the coordinated management of surface water and groundwater, the rights and needs of private property owners, municipalities, and water districts must be balanced with the need for additional regulation in this area.

One approach to a coordinated management system is the development of regional basin organizations to monitor and manage groundwater resources. In preserving surface water resources, more reservoirs could be constructed for storage opportunities to reduce the need for groundwater withdrawal and increase groundwater recharge. In developing a local management system it should be recognized that any interactive management system is appropriate to each region and may not be necessary statewide. Incentives should be available to private property owners to encourage participation in any coordinated management system.

This technical memorandum (TM) provides a summary of conjunctive water management activities in Oklahoma and other selected states. This information is intended to support further consideration of processes to evaluate and prioritize any possible areas where further investigations (both hydrological and administrative) may need to occur in Oklahoma.

A definition of conjunctive water management is provided so that the reader has an understanding of the term and its use in this TM. Conjunctive water use is also a term used to describe conjunctive water management and the terms for the purposes of this TM are considered equivalent. Conjunctive water management is the management of hydraulically connected surface water and groundwater resources such that the total benefits of integrated management exceed the sum of the benefits that would result from an independent management of each water resource. Conjunctive management may be for one or more of the following purposes:

- Maximize beneficial use of water
- Reduce or prevent adverse effects of using a source
- Provide a sustainable and reliable water supply
- Protect environmental water supplies in the surface water system
- Protect spring flows discharging from an aquifer
- Protect senior water rights
- Use an aquifer for storage of surplus surface water and subsequent use (often referred to as Aquifer Storage and Recovery or ASR)

There are multiple conjunctive management definitions and certainly other possible purposes, but these are the major uses that have been identified in a survey of other states. As there are multiple definitions of conjunctive management, the OWRB may want to consider adopting or developing an Oklahoma specific-definition. Examples of definitions used in other states and other contexts are provided in the Appendix to this TM.

As indicated in the Town Hall report excerpt above, Town Hall participants recognized the ongoing interactions between surface and groundwater resources in Oklahoma, but did not draw firm conclusions regarding management practices and administration of supplies. A summary of the conjunctive management practices of several other plains and western states is provided below.

Conjunctive Management in Oklahoma and Other States

To provide background information for continued dialogue, several other plains and western states were surveyed regarding their conjunctive management practices. Clearly, the physical and administrative aspects of water resources are not alike in any two states. However, this survey of conjunctive management practices provides foundational information for consideration in dialogue regarding current and future conjunctive use and management of Oklahoma's water resources.

States were selected for surveys based in part on their proximity to Oklahoma and relative similarity in hydrologic conditions, but also to document a broad range of approaches taken by other states. Oklahoma's current practices are briefly documented below, followed by a synopsis of approaches taken by the water management authorities in the states of Texas, Kansas, Nebraska, Oregon, Colorado, Utah, and California. Surveys were conducted using publicly-available information sources augmented by direct communication with several states' water management agencies. Several other states were evaluated for inclusion in this report including Idaho, Montana, New Mexico, and Wyoming. In these states it was found that conjunctive management was limited to the administration or regulation of wells for the benefit of senior surface water rights, and therefore not discussed in detail in this report.

Oklahoma

Oklahoma water law requires any person who uses groundwater or water from a stream, lake, or pond in Oklahoma for agricultural, industrial, public water supply, and other non-domestic purposes to obtain a permit from the OWRB. The water flowing in a stream is considered public water and can be used by any person who obtains a permit for a non-domestic use. The permit would be senior to permits issued on the stream at a later time. This is referred to as the Doctrine of Prior Appropriation (first in time, first in right) that is used by many states in the west to allocate and administer water rights.

Groundwater is not considered public water in Oklahoma but belongs to the land surface owner. A permit is required for any non-domestic use. Oklahoma law requires that the OWRB issue the permit based on the maximum annual yield. The maximum annual yield is based on a study of the groundwater basin that assumes a useful aquifer life of at least 20 years. The maximum annual yield is divided into an "equal proportionate share" for each acre of land over the groundwater basin. If a groundwater basin has not been studied yet, then the law provides for a temporary permit to be issued based in the amount of 2 acre-feet (AF) per acre each year. Once an aquifer's maximum annual yield is determined, the permit will be converted to a regular permit and the authorized amount will be adjusted to the equal proportionate share.

With the exception of the Arbuckle-Simpson aquifer system, conjunctive management of supplies is not mandated under Oklahoma water law. Among other issues, many Town Hall participants voiced concerns over the potential of conjunctive management to infringe upon property rights and existing water permits. These issues are now being highlighted as OWRB implements the legislative directives of Senate Bill 288 in the Arbuckle-Simpson basin. Conjunctive management in other regions and states (permitting, administration, and enforcement) has in many cases been driven by conflicts between holders of water rights or permits for supplies that were impacted by others' withdrawals from hydraulically connected sources.

Clearly, the separate treatment of surface water and groundwater is not considered a form of conjunctive management, even though the water resources may be hydraulically connected and the uses of each can affect the other water resource. In other words, the pumping of groundwater could have an effect on a stream if the aquifer and stream are hydraulically connected. Likewise, the diversion of surface water could also have an effect on the aquifer's long-term water supply.

Blaine Aquifer Recharge

Artificial recharge of the Blaine aquifer in Southwestern Oklahoma has been conducted since the late 1960s. The Blaine aquifer is used for crop irrigation, but not for drinking water due to high mineral content. Groundwater is obtained from cavities, solution channels, and fractures in the Blaine formation. The Blaine aquifer experienced significant decline of water levels due to irrigation withdrawals during the 1950s and 1960s. In 1983, OWRB, the Southwest Water and Soil Conservation District, and other partners started the Blaine Gypsum Groundwater Recharge Demonstration Project. At the time, the district had 45 project recharge wells already in use, though the effectiveness of these wells was not well studied. The project constructed and monitored five recharge wells. The monitoring found that each recharge well could provide on average about half the water supply used by an irrigation well (70 AF). The recharge wells provided a short-term increase in water quality, where the Blaine aquifer is typically of poor quality. Long-term effects on water quality were not studied. The district had constructed about 70 recharge wells as of 1997.

Artificial Recharge Legislative Work Group

In 2009 and 2010, the OCWP Aquifer Recharge Workgroup evaluated opportunities for intentional conjunctive use in Oklahoma in accordance with Senate Bill (SB) 1410 (2008). The workgroup evaluated areas where surface water could be intentionally recharged into aquifer formations, stored in those aquifers, then subsequently withdrawn for use as supply and demand conditions warrant. The findings of that workgroup's efforts are documented in the Aquifer Recharge Pilot Project Site Evaluation Final Report (OWRB 2010).

The OCWP Aquifer Recharge Workgroup concluded that intentional recharge and conjunctive use has the potential to help increase the reliability of supplies in many areas, and recommended a short-list of sites in Oklahoma for a possible future recharge demonstration project.

Arbuckle-Simpson Aquifer

Oklahoma implemented a conjunctive water management policy associated with legislation passed in 2003 (SB288). This legislation essentially imposed a moratorium on any temporary permits to use groundwater for municipal or public water supply use outside of any county that overlays in whole or in part a sensitive sole source groundwater basin. This moratorium was to remain in effect until the OWRB conducts and completes a hydrological study and approves a maximum annual yield that will ensure that any permit for the removal of water from such a basin or subbasin will not reduce the natural flow of water from springs or streams emanating from said basin or subbasin (SB288 2003). SB288 also requires that a permit for the use of groundwater within the basin will not likely degrade or interfere with springs or streams emanating from the aquifer. Currently, this legislation has been applied to the Arbuckle-Simpson aquifer, which is the only aquifer in Oklahoma that has been declared a sole source groundwater basin.

The OWRB initiated a comprehensive study of the Arbuckle-Simpson aquifer in 2003 in cooperation with the U.S. Bureau of Reclamation (BOR), the U.S. Geological Survey (USGS), Oklahoma State University, and the University of Oklahoma. The study was completed in December 2009 when the final report was submitted to the BOR. The study included the development and calibration of a digital groundwater flow model to predict the impact of various well pumping scenarios on stream and spring flow. The OWRB is using the study results and model to develop a maximum annual yield that will not reduce the flow of springs and streams emanating from the aquifer (Arbuckle-Simpson Hydrology Study, December 2009). The OWRB has established a website to provide a significant amount of information about the study (http://www.owrb.ok.gov/studies/groundwater/arbuckle_simpson/arbuckle_study.php#288).

Texas

Texas does not directly have a conjunctive water management program for surface water and hydraulically connected groundwater. It has been directed by statute that the two state water management agencies—the Texas Commission on Environmental Quality (TCEQ) and Texas Water Development Board (TWDB)—be responsible for different areas of water resources in the state. The TCEQ is responsible for the permitting of the use of surface water and is required to consider the effects of a surface water application on groundwater and groundwater recharge (Texas Water Code § 11.151).

In Texas, the right to use groundwater by the overlying land owner has long been recognized as the "rule of capture" by a Texas Supreme Court case (Houston and Texas Central Railroad Co. vs. East, 81 S.W. 279, Tex. 1904). This decision resulted in the growth of groundwater use without any regulation or management until 1949, when the Texas Legislature passed legislation to establish underground water reservoirs and for creating groundwater conservation districts. Additional legislation was passed over the years dealing with the management of groundwater. For example, a groundwater conservation district was given the authority to permit the use of groundwater in its district. Significant changes occurred in 2001, in SB2, where the TWDB was given the responsibility to create groundwater management areas. As a result, the TWDB established 16 groundwater management areas that encompassed the entire state for the purpose of joint planning among groundwater conservation districts within a management area (Mace et al. 2008).

In 2005, in House Bill (HB) 1763, the Legislature mandated joint planning among groundwater conservation districts within a groundwater management area. The groundwater conservation districts are required to meet at least annually to conduct joint planning and to review groundwater management plans and accomplishments in the groundwater management area. A key part of the joint planning is determining "desired future conditions" that are used to calculate "managed available groundwater" values by the TWDB. These conditions and values are used for regional water plans, groundwater management plans, and permitting (Mace et al. 2008).

Desired future conditions are the desired, quantified conditions of groundwater resources such as water levels, water quality, spring flows, or volumes at a specified time or times in the future or in perpetuity. The groundwater conservation districts can choose to manage their groundwater resources in such a way as to protect spring flow and baseflow to streams (Mace et al. 2007). Once the groundwater conservation districts establish the desired future conditions, they are required to forward this to the TWDB, who uses groundwater availability models to determine "managed available groundwater." The districts are required to report the managed available groundwater in their groundwater management plans and to ensure that their groundwater plans contain goals and objectives consistent with achieving the desired future conditions. The districts are required to permit the use of groundwater, to the extent possible, up to the managed available groundwater (Mace et al. 2008).

There is one example in Texas where the interaction of groundwater and surface water has been evaluated. This is the Edwards Aquifer, where spring discharges flow into the Guadalupe River. A federal court order has been issued to protect endangered species in the river from excessive groundwater pumping. In 2005, the TWDB and TCEQ used groundwater and surface water models to evaluate different management scenarios impacting both the aquifer and the river (Mace et al. 2007).

Kansas

Kansas has implemented conjunctive water management of surface water and hydraulically connected groundwater in several ways, including protection of senior water rights and protecting streamflows.

The Kansas Division of Water Resources (DWR) conjunctively regulates surface water rights and groundwater rights that appropriate water from a common source. A priority number is assigned to each water right based on its date of use. A junior groundwater right may be curtailed if it is impairing a senior surface right or a minimum desirable streamflow. In practice, this is done only if such curtailment would not constitute a futile call; that is, curtailing the junior water right would not result in a significant improvement in water availability to a senior surface water right or a minimum desired streamflow gage (Graves 2010).

When considering applications for water appropriation, the Kansas DWR generally limits appropriations to the safe yield of a stream or aquifer. Safe yield means the long-term sustainable yield of the source of supply, including hydraulically connected surface water and groundwater (Kansas Administrative Regulations 5-1-1).

The Kansas Chief Engineer, Director of DWR, has authority under the Groundwater Management District Act (K.S.A. 82a-1020 through 1040) to establish "Intensive Groundwater Use Control Areas" (IGUCAs) when certain problems exist and when corrective controls are necessary to protect the public interest. A number of IGUCAs have been established in Kansas, most for the purpose of managing a groundwater source of supply to many wells. A notable exception is the Walnut Creek IGUCA in south-central Kansas that was established to address declining groundwater levels that in turn had reduced streamflows. The intent of the IGUCA is to allow the aquifer to recharge to a level where water levels are at or above the streambed elevation.

The key provisions of the order establishing the Walnut Creek IGUCA are as follows:

- Closed the area to further appropriations
- Required the installation of flow meters
- Required water users to file annual water use reports no later than March 1
- Set 5-year allocations
- Set the long-term sustainable yield at approximately 22,700 acre-feet per year (AFY)
- Used the period of 1985 to 1990 to establish the historical use allocated to senior irrigation rights, with priorities prior to or equal to October 1, 1965

- Junior irrigation water rights with priorities junior to October 1, 1965 are assigned the remaining amount of the sustainable yield of 22,700 AF; about 44 percent of the seniors' allocations

The Chief Engineer may evaluate the information collected at 5-year intervals and make adjustments to the corrective controls if needed to achieve the goals of the IGUCA (Walnut Creek IGUCA).

Nebraska

Nebraska has a joint permitting process for surface water and groundwater, with the Nebraska Department of Natural Resources (DNR) permitting the use of surface water using the Doctrine of Prior Appropriation for regulating surface water rights. Groundwater is permitted by local Natural Resource Districts (NRDs) and the use of groundwater is controlled by the NRDs with annual pumping allocations established for irrigation wells in a specific NRD. This joint permitting process led to some conflicts resulting from interstate litigation on the Republican River Compact and from other basins being over appropriated. In 2004, Legislative Bill (LB) 962 was adopted by the Nebraska Legislature and reflects the recognition that the state's water resources and use required more complex management. The result is an Integrated Management Process (IMP) that called for a proactive approach to management of the state's hydraulically connected groundwater and surface water, providing for the economic viability, social and environmental health, safety, and welfare of the river basin (Water Matters November 2009).

Under LB962, the DNR was required to make an over-appropriated determination for any basin meeting specific criteria. The criteria include being subject to an interstate cooperative agreement between three or more states, declaration by DNR of a moratorium on the issuance of new surface water appropriations in the basin, and a request by DNR that each NRD with jurisdiction in the affected basin either 1) close or continue in effect a previously adopted closure of all or part of a basin to the issuance of additional water well permits, or 2) temporarily suspend or continue in effect a temporary suspension on the drilling of new water wells in the area. All of these criteria had to occur prior to July 16, 2004 to be in effect (Water Matters November 2009).

LB962 also required DNR to evaluate all basins annually and designate a basin fully appropriated when the current uses of surface water and groundwater cause, or will in the reasonably foreseeable future cause, the surface water supply to be insufficient to sustain the beneficial purposes for which natural flow, storage, or instream flow appropriations were granted. A basin may also be deemed fully appropriated if the reduction in streamflow will cause noncompliance with an interstate compact or decree, other formal state contracts or agreements, or applicable state or federal laws. Once a basin is preliminarily determined to be fully appropriated, DNR places a stay on the construction of all new water wells with the basin (Water Matters November 2009).

When a basin is over appropriated or fully appropriated, the IMP is implemented. This includes establishing a stakeholder group to consult with the DNR and NRDs providing feedback and ideas. Goals and objectives are developed to give the IMP direction. An IMP may include both regulatory and non-regulatory action items. A fully appropriated determination does necessarily mean that existing users need to be regulated. An over appropriated area or basin is required to develop an incremental plan to balance water uses and supplies for an ultimate return to a fully appropriated level of uses.

An important component to the IMP is developing an understanding of the Basin Water Supply (BWS) and the uses of that supply. The BWS is the streamflow that would occur without the depletions caused by water uses in the basin. The BWS may need to be adjusted for obligations that require a portion of the streamflow to flow downstream. These obligations could be due to an interstate river compact or a river recovery plan resulting from the Endangered Species Act (ESA). The remaining water supply, referred to as the Available Water Supply (AWS), is compared with depletions from existing uses to determine if a reduction in water use is necessary to balance depletions with the AWS. The IMP will develop goals and objectives and specific regulatory controls to carry them out (Water Matters March 2010).

Oregon

Oregon has implemented conjunctive management of hydraulically connected groundwater and surface water in order to protect senior water rights and minimum streamflows. The Oregon Department of Water Resources (ODWR) has promulgated rules to implement the conjunctive management regulations and is published as the Oregon Administrative Rules (OARs). The Division 9 Rules are titled "Groundwater Interference with Surface Water" and apply to proposed and existing wells (OARs, Water Resources Department, Division 9 Rules).

The Division 9 Rules apply to hydraulically connected groundwater and surface water where there is the potential for substantial interference with surface water supplies. The ODWR must make the determination that the groundwater is hydraulically connected. All wells within one-quarter mile of a stream are presumed to be hydraulically connected.

All wells that produce water from a hydraulically connected aquifer shall be assumed to have the potential to cause substantial interference with the surface water source, if the existing or proposed groundwater appropriation is within one of the following categories:

1. The point of appropriation is within a horizontal distance less than one-quarter mile from the stream; or

2. The rate of appropriation is greater than 5 cubic feet per second (cfs) if the point of appropriation is less than 1 mile from the stream; or

3. The rate of appropriation is greater than 1 percent of the pertinent adopted minimum perennial streamflow or instream water right with a senior priority date, or if the discharge that is equaled or exceeded 80 percent of the time and the point of appropriation is less than 1 mile from the stream; or

4. The groundwater pumping, if continued for a period of 30 days, would result in a stream depletion greater than 25 percent of the rate of appropriation, if the point of appropriation is less than 1 mile from the stream.

According to Barry Norris, Acting Director of Water Rights Division, ODWR, the above rules were developed by a rules advisory committee that was made up of various interest groups. The rules are therefore not necessarily scientifically based. Mr. Norris further stated that there are areas in Oregon where ODWR routinely regulates junior priority wells in favor of surface water rights or instream flows every summer (Norris 2010a).

Oregon has initiated a study in the Umatilla River basin to identify recharge areas where water can be diverted and recharged into the underlying aquifer to offset the impacts of existing well pumping. The water is diverted in the non-irrigation season or periods of high streamflow when there is no demand for the water. The stream accretions from the recharge would be used to offset the stream depletions from well pumping and thereby minimize the amount well regulation that would be needed to protect senior water rights (Norris 2010b).

Colorado

Colorado was one of the earlier states to implement conjunctive management of hydraulically connected groundwater and surface water. The purpose of the initial conjunctive management was to protect senior surface water rights while maximizing beneficial use of water. This has expanded over time to include artificial recharge of alluvial aquifers to offset the stream and aquifer depletions caused by well pumping.

Colorado rewrote its water laws in 1969 to address complaints by senior surface water rights that uncontrolled irrigation well development in the dry period of 1950 to 1963 had caused stream depletions that were reducing the supply to senior surface water rights on two major streams in eastern Colorado. These included the South Platte River with over 1,000,000 acres irrigated by surface and groundwater, and the Arkansas River with over 350,000 acres irrigated by surface water and groundwater.

The Water Rights Determination and Administration Act of 1969 (Article 92 of Title 37 of the Colorado Revised Statutes) required for the first time that all tributary wells (wells that pump groundwater hydraulically connected to a stream or its alluvial aquifer) file for adjudication of the well in the Division Water Court (created by the Act) by July 1, 1972. The well would be assigned a priority based on the date of construction and placed into an integrated tabulation of all tributary water rights both surface water and groundwater. Surface water rights have been continuously adjudicated since the late 1880s and the

adjudicated well would be integrated with these water rights. Since most streams in Colorado are over appropriated as a result of demands (calls) by senior surface water rights dating to the later part of the 1800s, wells constructed in the 1950s and 1960s would be very junior and not in priority, except in high stream flow conditions during the peak of the snowmelt runoff season or during periods of high precipitation.

The Act required the State Engineer, who is also the Director of the DWR, to administer the wells once adjudicated and to promulgate rules for the administration of the wells with the recognition of the value of the wells to maximize the beneficial use of water but also honoring the Doctrine of Prior Appropriation.

The Act created a new term in Colorado water law, Plan for Augmentation, that was intended to assist groundwater users and the State Engineer with a mechanism to allow junior alluvial wells to pump. A plan for augmentation is defined as a "a detailed program which may be temporary or perpetual in duration, to increase the supply of water available for beneficial use in a basin by the development of new or alternate points of diversion, by a pooling of water resources, by water exchange projects, by providing substitute supplies of water, by the development of new sources of water, or by any other appropriate means" (CRS 37-92-103 (9)). The plans for augmentation that have been adjudicated include wells pumping as alternate points of diversion to senior surface water rights, the release of reservoir water to offset depletions caused by well pumping, the recharge of alluvial aquifers using surface water available at times of no call (demand) to provide a streamflow accretion credit to offset well pumping depletions, the use of waters imported from another basin including return flows from an initial use such as municipal, and other creative plans.

The key purpose of a plan for augmentation is to provide water at times the well depletion is affecting a stream when the priority of the well is junior to the call. This is intended to overcome the argument of well owners that curtailment of the well pumping did not necessarily provide immediate relief to a senior call. In Colorado, a well cannot pump in an over-appropriated basin unless a plan for augmentation is in place to offset delayed depletions that will occur in the future at times when a call is on. If there is no call senior to a well's priority, augmentation is not required. The State Engineer allows an exception for a well within 100 feet of the stream that does not have a delayed depletion. This is considered the same as a surface water diversion that can be administered in priority, and a plan for augmentation is not required (Simpson 2006).

In the 1970s, the State Engineer advocated the use of existing canals on the South Platte River to divert water at times of no call and outside the irrigation season into recharge basins constructed for this purpose. Currently over 200,000 AF of water is recharged in an average runoff year, and much less in a drought year. This recharged groundwater provides stream accretions that are credited to various organizations implementing the recharge programs and are used to offset well depletions in various plans for augmentation (Simpson 2006).

In the Arkansas River basin, recharge projects are not feasible since there is a year-round demand for water related to either senior water rights or the Arkansas River Compact approved in 1948. The Compact results in a demand for water with a priority of 1948 outside of the irrigation season.

During the severe drought of 2000 to 2006 in Colorado, some plans for augmentation were not able to operate due to a lack of adequate water for augmentation because the call period on the South Platte River increased from about 4 months per year to year-round. This basically increased the amount of water needed by a factor of 3 and several plans ceased to operate. As a result, about 2,000 irrigation wells were shut down by the State Engineer in 2006 and about 100,000 acres dried up. These wells have not been able to operate since that time due to the inability of irrigation interests to acquire reasonably priced augmentation water. This has in large part been caused by increased competition for water supplies in the basin resulting from rapid growth of the Front Range population (Simpson 2006).

Utah

The State of Utah has included in its State Water Plan a section on "Conjunctive Management of Surface and Groundwater in Utah." This section is a comprehensive treatment of conjunctive management of water, with emphasis on ASR. The elements of conjunctive water management identified in the plan are:

- Use more surface water and less groundwater when surface water is available during wet periods. (Wet periods include annual spring snowmelt runoff and consecutive years of above normal precipitation.)
- Store unused surface water above ground and underground during dry periods.
- Take water out of surface and groundwater storage during dry periods. (Dry periods include annual summer months and consecutive years of below-normal precipitation.)
- Use more groundwater during dry periods when insufficient surface water is available in streams and reservoirs.

The report states that although conjunctive management projects do not always involve storage of excess surface water underground, intentionally recharging aquifers when water is available and recovering it when needed is a common and critical element of most conjunctive management projects (Utah State Water Plan 2005).

The Utah State Engineer's Office has taken actions to address areas of declining groundwater levels and has developed Groundwater Management Plans for 12 designated areas of the state. The intent of these plans is to protect existing water rights, provide for maximum beneficial use of water resources, and address other issues unique to a particular groundwater basin. The Groundwater Management Plan typically includes

comparisons of the estimated natural recharge into the groundwater basin to natural discharge and human withdrawals out of the basin. Groundwater basins with approved water rights that exceed the amount of natural recharge physically available are considered over-appropriated and are closed to new appropriations. About 27 percent of Utah is closed to new appropriations. The closed area is along the Wasatch Front, the area of high population in Utah (Utah State Water Plan 2005).

ASR projects most commonly include the use of spreading basins in the primary recharge areas above the target aquifer and later withdrawing the water from locations in the aquifer influenced by the recharge. The best locations for surface water spreading include river deltas and at the mouth of the canyons near a water source of sufficient size. ASR projects are subject to the regulatory requirements of the Groundwater Recharge and Recovery Act adopted in 1991. The act requires the proponents of a project to obtain permits for recharge of water and permits for the recovery of the water (Utah State Water Plan 2005).

California

California is somewhat similar to Nebraska in that at the state agency level, only the allocation and use of surface water is regulated by the state. In California, this is accomplished by the State Water Resources Control Board (SWRCB), which is within the California Environmental Protection Agency. The SWRCB's role is to ensure the highest reasonable quality for waters of the state while allocating those waters to achieve optimum balance of beneficial uses.

Groundwater management and regulation, including permitting of water wells, is a local function carried out by counties, municipalities, or water districts. Efforts to regulate groundwater at the state level have been discouraged by the Legislature several times in recent history.

However, the California State Water Plan does describe how conjunctive management of water resources can be accomplished and the role the state can play in this effort. In Chapter 8, "Conjunctive Management and Groundwater Storage," California State Water Plan (Update 2009), California Department of Water Resources (CDWR),conjunctive management is defined as the coordinated and planned use and management of both surface water and groundwater resources to maximize the availability and reliability of water supplies in a region to meet various management objectives. One of the roles and goals of the state through the CDWR is to strive for sustainable and reliable groundwater supplies throughout the state. Groundwater plays an important role in meeting the water needs of its water users by providing over 35 percent of the water demand or about 15 million AF of pumping per year. Conjunctive management is emerging as one of the major water resources management tools to achieve this goal.

An example provided is the recharge of an aquifer with surface water when additional surface supplies are available and affordable. A sustainable conjunctive management program consists of several components that include investigating the groundwater

aquifer characteristics, estimating surface water and groundwater responses, and appropriate monitoring of groundwater level and quality. The state's role includes providing funding through grants and loans as well as technical assistance (California State Water Plan, Update 2009, Chapter 8).

At the end of Chapter 8, fourteen recommendations are provided to improve conjunctive management and groundwater storage in California that will not be restated in this report but should be reviewed for applicability to future Oklahoma conjunctive water management policy and actions.

Summary

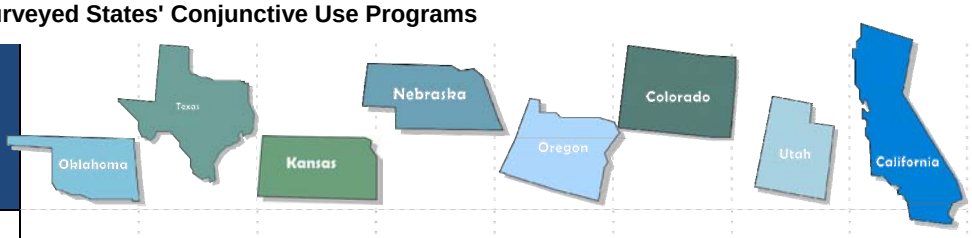
As can be seen from the discussion above for the eight states, conjunctive management of surface water and hydraulically connected groundwater varies significantly, ranging from minimal implementation to very active programs. Conjunctive management is a relatively recent activity often resulting from problems or conflicts becoming evident as uses of the water resources in a river basin start to experience limitations or conflicts resulting from some of the following:

- Declining streamflow as a result of groundwater uses causing depletions
- Declining groundwater levels resulting from excessive pumping
- Complaints by those with vested water rights or permits that junior diverters are causing them injury (e.g., senior surface water rights impacted by groundwater pumping)
- Interstate litigation between states over the administration of an interstate river compact
- Demands for instream flows to address the needs of endangered species dependent on the streamflow and imposed as a result of the federal ESA
- Desires for instream flows to provide for the needs of the environment or recreation

Often it has been specific legislation as identified for Oklahoma (SB288, 2003), Colorado (Water Rights Determination and Administration Act, 1969) and Nebraska (LB962, 2004) that resulted in a conjunctive water management program. The fact that the legislature of a state determines conjunctive management to be an important public water policy makes it even more enforceable by the state water agencies given the responsibility to implement the legislation.

Table 1 provides a brief synopsis of some of the key features of conjunctive management in the surveyed states.

Table 1—Comparison of Surveyed States' Conjunctive Use Programs

Conjunctive Management Criteria by State	
Conjunctive Management is not implemented in majority of state or is limited to areas with close proximity to a stream	● ● ● ●
Conjunctive Management is implemented in majority of state	● ● ●
Groundwater and Surface Water are permitted under separate laws	● ● ● ●
Groundwater and Surface Water are permitted under the same laws	● ● ● ● ●
State agency has authority to regulate wells for protection of Senior Surface Water Rights	● ● ● ●
Aquifer storage and recovery is encouraged and implemented	● ● ●
Conjunctive Management includes efforts to provide for sustainability of water resources in the basin	● ●

As Oklahoma considers potential future conjunctive water management activities, it will be important to have not only the support of water users but also the Legislature as programs are implemented. Future dialogue could include discussion of options for conjunctive management that include status quo methods and protocol, site-specific approaches such as those taken for the Arbuckle-Simpson aquifer (SB288), and statewide approaches. Key issues will include the continued protection of property rights while providing reliable water supplies to Oklahoma's water users.

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Appendix A
Alternate Definitions of Conjunctive Management

Some examples of various definitions are provided below:

- "Conjunctive water use usually involves institutional agreements where an existing groundwater user will curtail extractions during wet years in favor of a surface water supply—thereby allowing the aquifer to naturally replenish" (California Water Plan).
- "Conjunctive water management is the use of multiple water resources (surface water and groundwater) within a basin so that at the time of irrigation, adequate water of acceptable quality is available at the farm" (Jehangir et al. 2002).
- "Conjunctive water management involves the coordinated use of ground and surface water supplies. It aims to enhance overall water supplies and guard against drought" (Blomquist et al. 2001).
- "Conjunctive management is "the coordinated and combined use of surface water and ground water to better manage water supplies in order to meet growing needs" (Utah Division of Water Resources 2005).
- "In Texas, the concept of conjunctive use was defined by the Legislature as 'the combined use of groundwater and surface water sources that optimizes the beneficial characteristics of each source'" (Gershon 2003).
- "In Idaho, conjunctive management is defined as the 'legal and hydrologic integration of administration of the diversion and use of water under water rights from surface and ground water sources, including areas having a common ground water supply'" (Idaho Administrative Code).
- "Conjunctive use involves the withdrawal of both ground water and surface water. Conjunctive-use optimization modeling is a technique that can be used to determine maximum withdrawal rates from both surface water and ground water while meeting constraints with respect to water levels and streamflow" (Czarnecki et al. 2003).
- "Conjunctive management aims to coordinate ground-and surface waters in order to obtain the maximum economic benefits from both resources" (Glennon 2003).