LONE WOLF GROUNDWATER CONSERVATION DISTRICT

MANAGEMENT PLAN 2014-2019

Adopted: August 12, 2014

131 W. 5th
P.O. Box 1001
Colorado City, Texas 79512
Phone: (325) 728-2027
Fax: (325) 728-3046
Email: sueyoung@lwgcd.org
www.lonewolfgwcd.org

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LONE WOLF GROUNDWATER CONSERVATION DISTRICT

MISSION STATEMENT

The Mission of the Lone Wolf Groundwater Conservation District is to encourage conservation and the efficient, beneficial use of groundwater through monitoring and protecting the resource while upholding private property rights.

TIME PERIOD FOR THIS PLAN

This plan becomes effective upon approval of the District's Board of Directors and approval by the Texas Water Development Board. The plan remains in effect for five years after the date of certification by the Texas Water Development Board, or until a revised or amended plan is approved and certified.

STATEMENT OF GUIDING PRINCIPLES

The District recognizes that its groundwater resources are of utmost importance to the economy and environment, first to the residents of the District and then to the region. Also recognized is the importance of understanding the aquifers and aquifer characteristics for proper management of these resources. In addition, the integrity and ownership of groundwater play an important role in the management of this precious resource. One of the primary goals of the District is to preserve the integrity of the groundwater in the District from all potential contamination sources. This is accomplished as the District sets objectives to provide for the conservation, preservation, protection, recharge, prevention of waste and pollution, and efficient use of water including:

- Acquiring, understanding and beneficially employing scientific data on the District's aquifers and their hydrogeologic qualities and identifying the extent and location of water supplies within the District, for the purpose of developing sound management procedures;
- Protecting the private property rights of landowners of groundwater by ensuring that such landowners continue to have the opportunity to use the groundwater underlying their land;
- Promulgating rules for permitting and regulation of spacing of wells and transportation of groundwater resources in the District to protect the quantity and quality of the resource;
- Educating the public and managing for the conservation and beneficial use of the water;

- Educating the public and managing the prevention of pollution of groundwater resources;
- Cooperating and coordinating with other groundwater conservation districts with which the District shares aquifer resources.

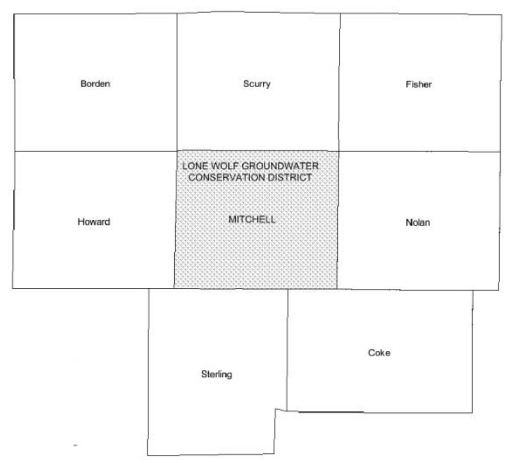
These objectives are best achieved through guidance from the locally elected board members who understand the local conditions and can manage the resource for the benefit of the citizens of the District and region.

Since a basic understanding of the aquifers and their hydrogeologic properties, as well as a quantification of resources, is the foundation from which to build prudent planning measures, this management plan is intended as a tool to focus the thoughts and actions of those given the responsibility for the execution of District activities.

GENERAL DESCRIPTION OF THE DISTRICT

History

The Lone Wolf Groundwater Conservation District was initially authorized to operate with "temporary" status during the 76th Texas Legislature with the passage of Senate Bill 1911. Subsequent actions of the 77th Texas Legislature removed the temporary status and allowed for the creation of the Lone Wolf Groundwater Conservation District. House Bill 2529 and Senate Bill 2 formally authorized the creation of the District. The voters of Mitchell County approved the District on February 2, 2002.



Location of the Lone Wolf Groundwater Conservation District.

Location and Extent

The Lone Wolf Groundwater Conservation District is located in West Texas and consists solely of Mitchell County. The District covers 576,000 acres or 900 square miles. The Colorado River runs through the county giving the county seat its name of Colorado City.

The County's and District's economy are mainly derived from agriculture and oil production. Cotton and wheat, along with cattle and goat raising, make up the majority of the agricultural income. Mitchell County is presently developing wind energy projects, which shall be a future economic staple for the area.

The boundaries of the District follow those of the County. The County is home to approximately 9,000 people and consists of three towns: Colorado City, Loraine and Westbrook.

Topography and Drainage

The District lies within the Colorado River Basin and the Great Plains. The topography of the area ranges from flat to rolling hills, but becomes rugged in the south portion of the County, especially in the vicinity of the Colorado River and major creeks. Farms and ranches dominate the area. Drainage from both sides of the county, east and west, flows towards the Colorado River which splits the county in half. Tributaries in the area are intermittent and few springs exist.

REGIONAL COOPERATION AND COORDINATION

The District is a member of the West Texas Regional Groundwater Alliance (WTRGA). This regional alliance consists of seventeen (17) locally created and locally funded districts that encompass approximately eighteen (18.2) million acres or twenty eight thousand three hundred sixty eight (28,368) square miles of West Texas (Fig 2). To put this in perspective, this area is larger than many individual states including Rhode Island (1,045 sq mi), Delaware (1,954 sq mi), Puerto Rico (3,425 sq mi), Connecticut (4,845 sq mi), Hawaii (6,423 sq mi), New Jersey (7,417 sq mi), Massachusetts (7,840 sq mi), New Hampshire (8,968 sq mi), Vermont (9,250 sq mi), Maryland (9,774 sq mi), and West Virginia (24, 230 sq mi). This West Texas region is as diverse as the State of Texas. Due to the diversity of this region, each member district provides its own unique programs to best serve its constituents.

In May of 1988, four (4) groundwater districts; Coke County UWCD, Glasscock County UWCD, Irion County WCD, and Sterling County UWCD adopted the original Cooperative Agreement. As new districts were created, they too adopted the Cooperative Agreement. In the fall of 1996, the original Cooperative Agreement was redrafted and the West Texas Regional Groundwater Alliance was created. The current member districts and the year they joined the Alliance are:

Territory in the West Texas Regional Alliance.

Coke County UWCD (1988)	Crockett County GCD (1992)	Glasscock GCD (1988)
Hickory UWCD # 1 (1997)	Hill Country UWCD (2005)	Irion County WCD (1988)
Kimble GCD (2004)	Lipan-Kickapoo WCD (1989)	Lone Wolf GCD (2002)
Menard County UWD (2000)	Middle Pecos GCD (2005)	Permian Basin UWCD (2006)
Plateau UWC & SD (1991)	Santa Rita UWCD (1990)	Sterling County UWCD (1988)
Sutton County UWCD (1991)	Wes-Tex GCD (2005)	

This Alliance was created because the local districts have a common objective to facilitate the conservation, preservation, and beneficial use of water and related resources. Local districts monitor the water-related activities of the State's largest industries such as farming & ranching, oil & gas and municipalities. The Alliance provides coordination essential to the activities of these member districts to monitor these activities and to accomplish their objectives.

The District is active in the Region F Water Planning Group. The group meetings provide input in developing and adopting the Regional Water Plans. The District will continue to be actively involved in future planning processes.

The District is a member of Groundwater Management Area 7, which covers all or part of thirty-three counties and includes twenty-one groundwater conservation districts. These Districts manage groundwater at the local level. The District actively participates in meetings and discussions to determine a feasible future desired condition of its aquifer.

GROUNDWATER RESOURCES

The data provided for this section of the management plan, unless otherwise noted, is obtained from a study conducted by Arcadis Geraghty and Miller for Mitchell County in October 1998. The study was conducted primarily to determine an alternate resource for the public water supply since the surface water resources were quickly evaporating due to drought. The study consisted of researching and reviewing available information (including published literature, reports, files, data, etc) which contain information pertinent to evaluating the groundwater resources available in the county.

Although the Dockum aquifer underlies more than 40 counties in West Texas, its low water-yielding ability and generally inferior quality results in its categorization as a minor aquifer.

The boundaries of the Lone Wolf Groundwater Conservation District are coextensive with the boundaries of Mitchell County, Texas, covering 583,562 acres. The towns of Colorado City, Loraine and Westbrook are the main population centers in Mitchell County, Texas. The City of Colorado City currently obtains its water supply from water wells located near Loraine with a backup water supply from Lake Colorado City and Lake Champion. Loraine obtains its water supply from water wells located within the city of Loraine. The City of Westbrook purchases its water from Mitchell County Utilities with wells located to the east of Colorado City.

Geology

The geologic rock formations of fresh water-bearing significance in Mitchell County consist of strata of Permian age, the Dockum Group of Triassic age, the Trinity and Fredricksburg Groups of Cretaceous age, the Ogallala Formation of Tertiary age and alluvium of Quaternary age. All of these strata outcrop in Mitchell County. Of paramount importance are the Santa Rosa Formation of the Dockum Group and the sands of the Trinity Group which constitute the principal source of groundwater in the area.

Historically, the uppermost Dockum shale rocks were thought to be correlative with the Chinle Formation found in New Mexico and Arizona. The sandstones below the Chinle were called the Santa Rosa and Trujillo Formations water bearing units and correlated with sandstones found in northeastern New Mexico. The Santa Rosa typically is composed of an upper sandstone unit, a middle shale member, and lower conglomerate sandstone. This division of the Triassic geology has commonly been used in West Texas and was the terminology followed in a report on the groundwater resources in Mitchell County prepared by Victor Shamburger and published by the Texas Water Development Board in June 1967. Although recent studies contest the historic Triassic correlations and nomenclatures and advance proposals for new divisions to the Triassic section found in Mitchell County, the Arcadis G&M report chose to base its findings from the TWDB 1967 report as it is apparent the stated debate will remain ongoing for quite some time.

Permian Strata
Strata of Permian age underlie much of the area but outcrop on the surface in the southeastern part of Mitchell County. The Permian strata consist mainly of red beds which are dense red silt shale with gray-green inclusions interbedded with tight reddish-brown, fine-grained laminated sandstones and occasional gypsum or anhydrite beds. The Permian beds dip westward at a slope of about 25 to 30 feet per mile, steepening considerably in the western part of Mitchell County.

Dockum Group (Santa Rosa and Chinle Foundations)
Strata of the Dockum Group occur on the surface or subsurface in much of Mitchell County. The Dockum Group is generally subdivided into the Santa Rosa Sandstone, the Tecovas Formation, the Trujillo Sandstone and the Cooper Canyon Formation by Lehman. The Cooper Canyon Formation is generally absent in the area except in the extreme western part of Mitchell County. The Cooper Canyon Formation is predominately red clay and shale with thin, ventricular, sandstone interbeds and it overlies the Trujillo Sandstone in the areas where the Cooper Canyon occurs. The Cooper Canyon Formation is generally unimportant as a source of water except for livestock because it yields only small quantities of water which are usually highly mineralized.

The Trujillo Sandstone is a cross-bedded unit composed of sandstones and conglomerates. The base of the unit (top of the Tecovas Formation) is marked by erosional unconformity. The Trujillo may be as much as 100 feet or more in thickness.
The Tecovas shale underlies the Trujillo and is composed of mostly dark gray mudstones and shales. The thickness of the unit may be as much as 45 to 50 feet in some areas.

The Santa Rosa Sandstone occurs beneath the Tecovas and it underlies unconformity on older Permian rocks. It consists of a basal conglomerate overlain by alternating beds of red and gray micaceous shale, clay and sand. The thickness of the formation ranges from a few feet to as much as 45 to 50 feet or more in other areas based on the work done by Lehman and Lucas. The thickness of the entire Dockum Group ranges from a few feet to over 300 feet in the area northeast of Colorado City.

Cretaceous Rocks (Trinity and Fredericksburg Groups)
The Cretaceous rocks which occur in the area are of Lower Cretaceous age and belong to the Trinity and Fredericksburg Groups. These rocks outcrop in southwestern and central Nolan County and underlie Tertiary Ogallala deposits in northwestern Nolan County. Cretaceous rocks are completely absent in Mitchell County, except for the extreme eastern part of the county.

Sands of the Trinity Group consist of moderate to loosely consolidated, white to purplish, fine to medium-grained quartz sand with occasional lenses of quartz gravel at the base of the unit. The thickness of the Trinity sands ranges from 60 to approximately 100 feet. The Trinity sand overlies the Dockum Group (Santa Rosa Formation) in Western Nolan County but it lies directly on Permian strata farther to the east.

The Fredericksburg Group consists of up to 220 feet of calcareous sediments which overlie the Trinity Group in Nolan County. These rocks are of little importance as a source of groundwater in the area.

Tertiary Ogallala Formation
Ogallala sediments of Tertiary age occur in the northwestern part of Nolan County (around Roscoe), the northeastern part of Mitchell County and in west central and northwestern Mitchell County. Near Roscoe, the Ogallala sediments consist of up to 50 feet of caliche, sand and gravel interbedded with light-colored clay. In this area, the Ogallala sediments are generally above the regional water table and are not a source of groundwater. However, they appear to constitute an effective avenue for recharge to the underlying Santa Rosa Formation and Trinity sand.

In the western part of Mitchell County, the Ogallala consists of up to 100 feet of unconsolidated buff-brown sand with a zone of coarse gravel at the base of the formation. In this area, the Ogallala sediments yield small quantities of usable water of variable quality to domestic and livestock wells.

Hydrology
The water-bearing formation of primary interest in Mitchell County is the Santa Rosa Formation which consists of basal gravel and sand of Triassic age overlain by alternating beds of red and gray micaceous shale, clay and sand (which comprises the Tecovas Formation and the Trujillo Sandstone based on Lehman's nomenclature). These strata occur on the surface over most of the county. The Permian rocks only yield small quantities of water to wells and are generally regarded as the base of the fresh water occurrence in the area. In the western part of the county, the Ogallala sediments yield small quantities of usable water of variable quality to domestic and livestock wells. The Permian beds dip westward at an approximate slope of 25 to 30 feet per mile for most of the county, but the dip steepens considerably in the western part of the county.

The literature indicates that the basal gravel and sand of the Santa Rosa Sandstone is highly productive and provides most of the water to wells in the area. In the area north and northeast of Colorado City, the upper part of the Dockum Group (probably the Trujillo Sandstone) is saturated and makes a significant contribution to well yields in the area. However, these upper sands apparently have a different water level than the lower Santa Rosa and generally contain water of inferior quality to that found in the basal sand and gravel.

Although the Santa Rosa/Trujillo Aquifer is very productive over most of the area, the literature indicates that the groundwater quality in the aquifer west of the Colorado River is poor and is not suitable for public consumption. In view of this, the remainder of this report focuses primarily on the Santa Rosa/Trujillo Aquifer and the upper productive sands of the Dockum Group in the area east of the river. The thickness of the Dockum Group as a whole in this area may be as much as 300 feet, but the saturated thickness is only approximately 50% or less of the total thickness. Reported yields for water supply wells in this area are up to 1,000 gallons per minute (gpm).

Santa Rosa/Trujillo Aquifer Water Table

Groundwater in the Santa Rosa/Trujillo Aquifer and the overlying rocks of the Dockum Group that are saturated (Trujillo Sandstone) occurs under either slightly artesian conditions or water table conditions. Pumping tests conducted on several wells completed in the Santa Rosa/Trujillo Aquifer and/or the Trujillo Sandstone in the area indicate that, under static condition, the water in the aquifer may be artesian, but with pumping and lowering of the water table below confining strata, water table conditions are produced.

Recharge to the aquifer results from infiltration and percolation of precipitation on the outcrop areas (including the overlying Ogallala and alluvium formations where they occur). The area west of Loraine (where the surface is fairly sandy) is highly conducive to recharge. Significant recharge also occurs along the creeks in the area where alluvium occurs on the surface along the stream channel. The amount of recharge to the Santa Rosa and the Trujillo Sandstone in this area has not been determined. A rough estimate of recharge in this area is approximately 0.5 inches per year which amounts to approximately 26.7 acre-feet per section of land.

The altitude as shown in TWDB maps of the water table in the Santa Rosa/Trujillo Aquifer and or the Trujillo Sandstone for the period of 1960-1961 shows that the direction of groundwater movement in the aquifer was to the west toward the Colorado River where significant discharge to the river occurred. West of the river, the direction of groundwater movement was to the east toward the river.

The static water levels in most (or all) of the Santa Rosa/Trujillo water wells in the area were as high as or higher in the mid-1990s than they were back in the early 1960s. This is reflected by the hydrographs of State observation wells which have historical records spanning the period from the early-1960s to the mid-1990s. Several of the hydrographs show that the water table/piezometric surface in the Santa Rosa/Trujillo Aquifer/Trujillo

Sandstone responds quite rapidly and significantly to heavy pumping or cessation in pumping of water wells.

The fact that the water table in this area is at or above the levels in the early 1960s indicates a substantial cessation of groundwater withdrawal from the aquifer for irrigation purposes during that time. The elevation of the water table appears to be approximately 20 feet higher in the mid 1990s than in 1960-61. However due to the sustained drought conditions during the late 1990s, groundwater usage in Mitchell County increased dramatically with irrigation and municipal use. As part of this plan, the District will monitor the groundwater levels regularly to determine the continued effects of increased pumping.

Groundwater Reserves

The gross saturated thickness of the Santa Rosa/Trujillo sediments in the eastern part of Mitchell County range from less than 60 feet in the southern part of the area to over 200 feet in the north. In the areas situated north, northeast and east of Colorado City, the thickness of Santa Rosa/Trujillo sediments ranged from 140 feet to over 200 feet in 1960-61. Accounting for the additional 20 feet in the water table by the mid-1990s, the gross saturation of the aquifer in this area in the mid 1990s ranged from approximately 160 feet to over 220 feet.

An estimate of the amount of groundwater reserves in storage in the aquifer can be made knowing the saturated thickness of Santa Rosa/Trujillo sediments and the effective porosity of the sediments. The effective porosity of the aquifer represents the void space from which water can be drained by gravity expressed as a percentage of the total volume of sediments. No values of the effective porosity for the Santa Rosa/Trujillo Aquifer have been reported in literature. However, based on Arcadis Geraghty and Miller’s experience in working with this and other aquifers in West Texas, a conservative value of 10 percent is assumed for the effective porosity of the aquifer. This value was used to estimate the amount of reserves in the aquifer.

Based on the range of gross saturated thickness of the aquifer discussed above for the areas north, northeast and east of Colorado City (160 feet to over 220 feet), the assumed effective porosity of the sediments of 10% and a recovery factor of 70%, the volume of recoverable groundwater presently in place in the aquifer is estimated to range from approximately 7,168 acre-feet per section to over 9,856 acre-feet per section depending on the location of the property. This represents groundwater reserves present in the aquifer that can be produced by pumping, and it does not include any recharge to the aquifer or exterior drainage from adjoining properties that may be captured once a well field is developed and production begins.

These estimates for groundwater reserves in the aquifer include the apparent poorer quality water that may exist in the upper part of the aquifer which may not be suitable for municipal purposes and may have to be sealed off during construction of water supply wells. The saturated thickness of this upper productive zone is not known with any degree of certainty and would need to be addressed in any subsequent exploratory work to verify the aquifer reserves, quality and productivity.

Groundwater Quality in the Santa Rosa/Trujillo Aquifer

State observation wells completed in the Dockum Group aquifer for which chemical analysis data were available in 1967 and more recent water quality data obtained from the TNRIS are available for a limited number of these observation wells. Data from these observation wells indicate the quality of the groundwater in the Santa Rosa/Trujillo Aquifer is considerably more mineralized in the western part of the county than in the eastern part of the county. Generally speaking, west of the Colorado River the groundwater quality in the aquifer is poor and is unsuitable for municipal purposes. However, east of the river, the water quality in the aquifer is less mineralized and is generally suitable for municipal purposes (with some exceptions). More recent water quality data, where available, confirm this conclusion. For example, State observation well 28-40-608 (located about 10 miles northwest of Colorado City) contained chloride, sulfate and total dissolved solids (TDS) of 560 milligrams per liter (mg/L), 337 mg/L and 1,891 mg/L, respectively, in 1963. In 1986, the chloride, sulfate and TDS concentration in this well were 519 mg/L, 386 mg/L and 1,893 mg/L, respectively. By contrast, State observation well 29-35-702 (located about eight miles east of Colorado City in Loraine) contained chloride, sulfate and TDS of 34 mg/L, 73 mg/L and 418 mg/L, respectively, for these same constituents in 1995. This also indicates that the groundwater quality in this well had not changed appreciably over the indicated time period. In fact, the quality in well 29-35-702 actually improved over the period.

Another important observation concerning the quality of groundwater in the Santa Rosa/Trujillo aquifer is the fact that the quality in the upper sands (Trujillo Sandstone) appears to be inferior to the quality in the deeper basal sands and gravels (Santa Rosa Sandstone). This appears to be true even for wells located east of the Colorado River.

Based on the available chemical quality data, it appears that wells completed in the lower (basal) sands or gravels (the Santa Rosa/Trujillo Aquifer) contain groundwater which would meet the TCEQ standards for municipal water supplies in terms of the chloride, sulfate and TDS content. These standards are 300 mg/L, 300 mg/L and 1,000 mg/L respectively, for these constituents.

The concentrations of nitrate in the groundwater are another important factor in determining the suitability of a water supply for municipal purposes. The MCL for nitrates in public water supplies (as established by the EPA) is 10 mg/L of nitrogen (or 45 mg/L as nitrates). Above this level, adverse health effects can result. The groundwater quality in the Santa Rosa/Trujillo Aquifer in the area east of Colorado City appears to be generally acceptable for municipal purposes from the standpoint of the nitrate content of the water. However, several wells in the area do exhibit elevated nitrate concentrations above the MCL of 45 mg/L. For example, State Well 29-27-902 had nitrates of 81 mg/L in 1978 which increased to 109.9 mg/L in 1986. Well 29-34-515 had nitrate of 66 mg/L in 1963, well 29-34-801 had nitrate levels of 98 in 1946 and well 29-35-108 had nitrate levels of 320 in 1963. No recent nitrates data are available for these wells. The source could be septic systems or areas where nitrate-rich fertilizers are stored. Additional exploration would be necessary to identify and delineate the nature and extent of this problem.

Hydraulic Properties of the Santa Rosa/Trujillo Aquifer and Aquifer Productivity

The results of pumping tests conducted by the Texas Water Development Board in the 1960s on several water wells in the area completed in the Santa Rosa/Trujillo Aquifer were used to estimate the transmissivity and storage coefficient of the aquifer. The transmissivity of the aquifer is defined as the rate at which water flows through a vertical strip of the full saturated thickness of the aquifer one foot wide and under a unit hydraulic gradient. It is a measure of the ability of the aquifer to transmit water. High values indicate greater transmitting capabilities of the aquifer. The storage coefficient is defined as the volume of water released from storage or taken into storage per unit of surface area of the aquifer per unit change in head in the aquifer. For water table aquifers, the storage coefficient is the same as the specific yield (or effective porosity). As discussed earlier, in this area the Santa Rosa/Trujillo Aquifer appears to exhibit slightly artesian conditions under static conditions due to the stratified nature of the aquifer. However, when the aquifer is pumped and the water level lowered below confining strata, water table conditions may be produced. The specific yield (effective porosity) of an aquifer is the volume of water which can be drained by gravity from a unit volume of the aquifer expressed as a fraction or percentage of the unit volume.

The transmissivity values obtained from the pumping tests conducted by the Texas Water Development Board ranged from 5,868 gallons per day (gpd/ft) to 12,300 gpd/ft and averaged 8,845 gpd/ft. Because the tested wells were located over a wide area (east of Colorado City), this range of transmissivity values appears to be representative of the Santa Rosa/Trujillo Aquifer in this area.

The storage coefficient values from the pumping tests ranged from 0.00008 to 0.00044 which are typical of aquifers under artesian conditions. With sustained pumping of the aquifer and lowering of the water table below confining strata, water table conditions are expected to be produced. Storage coefficients (or specific yields) in the range of 0.01 to 0.35 are typical of aquifers under water table conditions.

Reported yields for Santa Rosa/Trujillo water supply wells in the north, northeast and east of Colorado City are up to 1,000 gpm. However, well yields and the productivity of the aquifer will vary across the area and depend on factors such as the lithology of the formation and the gross saturated thickness of the aquifer. The design of the wells also has a significant impact on the yield of the well. Therefore, it would be imperative to conduct exploration and testing to better assess these factors and to determine the productivity of the aquifer and well yields in specific areas of interest.

ADDITIONAL NATURAL OR ARTIFICIAL RECHARGE

Each year, annual precipitation in and around the district results in a recharge of the aquifer of approximately 19,469 acre-feet into the lower Dockum Aquifer. [1] According to GAM Run 13-015 an estimated 1,357 acre-feet flow into the district within the lower Dockum Aquifer while about 434 acre-feet flow out of the district. An additional 194 acre-feet of water flows from upper aquifers into the lower portion of the Dockum.[2] However, more can be done to help the recharge rate.

Brush Control

The Lone Wolf Groundwater Conservation District supports brush control as a management practice to maintain and improve groundwater supplies in the District and region. The District, in fact, wrote a grant for the Mitchell and Nolan Soil and Water Conservation Districts in 2002 for a brush control program along the 41,000 acre Champion Creek Watershed. The $1.3 million grant was funded in the fall of 2002.. The District will continue to work with the local SWCD and NRCS offices to support new and ongoing brush control management projects.

The Texas Water Resources Institute, according to the 2001 Region F Water Plan, estimates that one acre-foot of water is lost annually for every 10 acres of brush. Much of the brush consists of mesquite, salt cedar and juniper. As these plants were introduced into the area they spread from the riverbanks to the plains replacing native grasslands. Some of the potential concerns associated with brush are increased erosion, competition for water with grasses, and reduced runoff infiltration.

Recharge Enhancement

Recharge enhancement is the process in which surface water is intentionally directed to areas where permeable soils or fractured rock allow rapid infiltration of the surface water into the subsurface to increase localized groundwater recharge. This includes any man-made structure that would slow down or hold surface water to increase the probability of groundwater recharge.

To determine possible sites for recharge, Region F utilized the geographic information system (GIS) to map the region. Mitchell County is identified as being mostly moderate to some favorable conditions for recharge enhancement. However, topography, drainages, soil properties and the extent and hydraulic characteristics of aquifer outcrops on a local scale would need to be studied before a site could be selected. Consideration should also be given to the potential reduction of surface runoff and how that affects existing surface water reservoirs. Further study is needed to determine the quantity of increased groundwater supplies from enhanced recharge structures and the potential impacts to surface water rights.

Weather Modification to Enhance Yields

Weather modification is defined as an attempt to increase the efficiency of a cloud to return more of the water drawn into the cloud as precipitation. Hail suppression and rainfall enhancement are common forms of weather modification. Early forms of weather modification began in Texas in the 1880s by firing cannons to induce convective cloud formation. Efforts to enhance rainfall in Texas continue to this day. Most efforts to increase rainfall take place in the spring and summer and are halted during the winter months.

A common agent for cloud seeding is Silver iodide, AgI, which is released from flares located on a plane. Silver iodide enhances ice crystal concentrations in clouds, encouraging larger drops to form thereby increasing the likelihood that precipitation will reach the ground. Environmental concerns have been raised with regard to using a heavy metal as a seeding agent, but research conducted along the Oklahoma border indicated only trace amounts, much smaller than allowed by law, of silver in livestock grazing or in soil downwind.

The Colorado River Municipal Water District (CRMWD) began weather modification efforts in 1970. The intent of the rainfall enhancement program is to increase runoff to reservoirs located in the District. The CRMWD has a permit to operate in a 14-county area along the Colorado River, including Mitchell County where the Lone Wolf GCD is located.

The effects of weather modification are difficult to measure. To accurately estimate the benefit of weather modification requires an approximation of how much rainfall would have occurred naturally without weather modification. Research has suggested increases of 15 percent or more of precipitation in areas included in weather modification. Local experiences have shown increases of 27 percent in rainfall. Other methods of measuring the effects of rainfall enhancement, such as dry land farm production, have shown positive benefits of weather modification. Dry land farming has increased in regions participating in rainfall enhancement.

MANAGEMENT OF GROUNDWATER SUPPLIES

Preservation and protection of groundwater quality and quantity has been the guiding principle of the District since its creation while striving to maintain the economic viability of all groundwater user groups, public and private. In consideration of the economic and cultural activities occurring within the District, the District will continue to identify and engage in such activities and practices, that if implemented, would result in preservation and protection of the groundwater. An observation network has been established and maintained for monitoring changing storage conditions of groundwater supplies within the District. The District will continue to make regular assessments of groundwater supply and storage conditions and make them available to the public. Additional monitor wells, both water quality and water level, are being added to the well monitor program, along with expansion of programs including the rainfall monitoring program.

The District has adopted rules to regulate groundwater withdrawals by means of spacing regulations and well density (number of wells per section). The District will amend these rules, within the limitations imposed by Chapter 36 of the Texas Water Code, as necessary to regulate groundwater withdrawals by means of additional spacing and/or production limits. District rules also address permitting and registration of wells, waste, well drilling and completion of wells, as well as capping and plugging of unused or abandoned wells. These rules are intended to provide equitable conservation and preservation of the groundwater resources.

The District may deny a drilling permit in accordance with the provisions of the District rules. The relevant factors to be considered in granting, denying, or limiting a permit include:

1) the purpose of the District rules, including but not limited to, preserving and protecting the quality and quantity of the aquifer resources, and protecting existing uses;
2) the equitable conservation and preservation of the resource; and
3) the economic hardship resulting from denial or limitation of a permit.

In pursuit of the District's mission of preserving and protecting the resource, the District will enforce the terms and conditions of permits and the rules of the District by injunction, mandatory injunction, or other appropriate remedies in a court of competent jurisdiction as provided by Chapter 36.102, Texas Water Code.

The District is aware of the importance of brackish groundwater as a potential future water supply. Therefore, the District takes steps within its authority to protect brackish groundwater resources, including participating in proceedings at the Texas Railroad Commission regarding injection wells or other permitted activities that could put either fresh water or brackish water resources at risk. With advances in desalination technology, water that is not economically usable today may prove to be an important resource in the future, and the District believes expending resources to preserve that brackish water in its current state and prevent any third party pollution of same is in the best interests of the public, landowners, the District, the area, and the state.

The District also recognizes the importance of public education to encourage efficient use, promote conservation, prevent waste, and preserve the integrity of groundwater. District personnel will seek opportunities to educate the public on water conservation issues and other matters relevant to the protection of groundwater resources through public meetings, newspaper articles, newsletters, speaking engagements, and other means that may become available.

By implementing more public education programs specifically aimed at irrigation conservation, rainwater harvesting and additional brush control methods, the District anticipates additional groundwater being available to offset future needs.

ACTIONS, PROCEDURES, PERFORMANCE AND AVOIDANCE FOR PLAN IMPLEMENTATION

The District will implement the provisions of this plan and will utilize the provisions of this plan as a guide for determining the direction and/or priority for District activities. All operations of the District will be consistent with the provisions of this plan.

The District adopted rules in 1999 and amended the rules in 2000, 2001 and 2003, and will continue to amend the rules as necessary. Rules adopted or amended by the District shall be pursuant to TWC Chapter 36 and the provisions of this plan. The promulgation and enforcement of the rules will be based on the best scientific and technical evidence available.

The District shall treat all citizens with equality. For good cause, the District, in its discretion and after notice and hearing if required, may grant an exception to the District rules. In so doing, the Board shall consider the potential for adverse effects on adjacent owners and aquifer conditions. The exercise of said discretion by the Board shall not be construed as limiting the power of the Board.

All activities of the District will be undertaken in cooperation and coordinated with the appropriate state, regional and local water management entities.

TECHNICAL DISTRICT INFORMATION REQUIRED BY TEXAS ADMINISTRATIVE CODE

Estimate of the modeled available groundwater in the District based on the desired future conditions. Texas Water Code §36.001 defines modeled available groundwater as “the amount of water that the executive administrator determines may be produced on an average annual basis to achieve a desired future condition established under Section 36.108”.

The joint planning process set forth in Texas Water Code §36.108 must be collectively conducted by all groundwater conservation districts within the same GMA. The District is a member of GMA 7. GMA 7 adopted a DFC Dockum Aquifer on July 29, 2010. The adopted DFC was then forwarded to the TWDB for the development of the MAG calculations. The submittal package for the DFC can be found at:
http://www.twdb.state.tx.us/groundwater/docs/DFC/GMA7_DFC_Adopted_2010-0729.pdf

The Desired Future Condition for the Lower Dockum Aquifer, based on GAM Run 10-001 (Appendix A), is for a total drawdown not to exceed 4 feet in Mitchell County, all of which is within the Lone Wolf Groundwater Conservation District.

Estimated Modeled Available Groundwater for the Dockum Aquifer in Mitchell County is 14,018 acre-feet per year in years 2010, 2020, 2030, 2040 2050 and 2060 per GAM Run 10-040 MAG Version 2, Table 1 (Appendix B).

Estimate of the annual amount of groundwater being used within the District on an annual basis: Please refer to Appendix C: Estimated Historical Water Use and 2012 State Water Plan Datasets – page 3.

Estimate of the annual amount of recharge from precipitation to the Dockum Aquifer: 19,469 acre feet. (Appendix D: GAM Run 13-015: Lone Wolf Groundwater Conservation District Management Plan – Table 1).

Estimate of the volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams and rivers: 6,858 acre feet. (Appendix D: GAM Run 13-015: Lone Wolf Groundwater Conservation District Management Plan – Table 1).

Estimate of the annual volume of flow into the District within the Dockum Aquifer: 1,357 acre feet. (Appendix D: GAM Run 13-015: Lone Wolf Groundwater Conservation District Management Plan – Table 1).

Estimate of the annual volume of flow out of the District within the Dockum Aquifer: 434 acre feet (Appendix D: GAM Run 13-015: Lone Wolf Groundwater Conservation District Management Plan – Table 1).

Estimate of the net annual volume of flow from the overlying units of the Dockum Aquifer: 194 acre feet: (Appendix D: GAM Run 13-015: Lone Wolf Groundwater Conservation District Management Plan – Table 1).

Estimate of the projected annual surface water supply within the District: 396 acre feet (Appendix C: Estimated Historical Water Use and 2012 State Water Plan Datasets – page 4).

Estimate of the projected total annual demand for water within the District: Please refer to Appendix C: Estimated Historical Water Use and 2912 State Water Plan Datasets – page 5.

Estimate of the projected annual water supply needs: Please refer to Appendix C: Estimated Historical Water Use and 2012 State Water Plan Datasets – page 6.

Water management strategies: Please refer to Appendix C: Estimated Historical Water Use and 2012 State Water Plan Datasets – page 7.

Methodology for Tracking Progress

The methodology that the District will use to track its progress on an annual basis, in achieving all of its management goals will be as follows:

> The District manager will prepare and present an annual report to the Board of Directors on District performance in regards to achieving management goals and objectives for the previous fiscal year, during the first meeting of each new fiscal year. The report will include the number of instances each activity was engaged in during the year.

The annual report will be maintained on file at the District office and will apply to all management goals contained in this plan.

GOALS, MANAGEMENT OBJECTIVES AND PERFORMANCE STANDARDS

The Management Plan Goals and Objectives of the Lone Wolf Groundwater Conservation District are as follows:

Goal
1.0 ***Providing the Most Efficient Use of Groundwater.***

Management Objective
1.1 Gather well production data and intended use (irrigation, domestic, etc) on all new wells permitted in the District each year. Information gathered will be compiled and entered into the District's database. Annual reports detailing the number of wells drilled, production data and intended use of the wells will be maintained at the District office.

Performance Standard
1.1.1 Data gathered and reports generated monthly and annually detailing the number and type of wells drilled.

Management Objective
1.2 The Lone Wolf Groundwater Conservation District has developed and enforces a set of rules outlining, among other things, the District's policies and water well spacing requirements. The Board will review the rules of the District for possible updates and revisions at least every odd numbered year. Minutes of the meeting will be maintained at the District office.

Performance Standard
1.2.1 Written rules maintained at the District office. Rules reviewed for possible updates at least every other year.

Management Objective
1.3 Each year the District will provide informative speakers to schools, civic groups, social clubs and organizations for presentations to inform a minimum of 20 citizens on the activities and programs, the geology and

hydrology of groundwater and the principles of water conservation relating to the best management practices for the efficient use of groundwater.

Performance Standard

1.3.2 Number of citizens in attendance at District presentations concerning the principles of water conservation relating to the best management practices for the efficient use of groundwater each year.

Goal

2.0 ***Controlling and Preventing Waste of Groundwater***

Management Objective

2.1 Each year the District will take water quality samples from at least two wells in order to monitor water quality trends and prevent the waste of groundwater by contamination.

Performance Standard

2.1.1 Number of wells sampled for water quality analysis by the District to monitor water quality trends each year.

Management Objective

2.2 Investigate all wasteful practices reported to the District. All reports of wasteful practices will be documented and investigated to ensure compliance with and enforcement of state and local groundwater laws and rules.

Performance Standard

2.2.1 Prompt investigation of all reported wasteful or detrimental activities relating to groundwater.

Management Objective

2.3 All wells drilled within the District will be registered or permitted.

Performance Standard

2.3.1 Number of wells drilled.

<u>Goal</u>
3.0 ***Controlling and Preventing <u>S</u>ubsidence***

The goal is not applicable.

<u>Goal</u>
4.0 ***Addressing Conjunctive Surface Water Management Issues***

The goal is not applicable.

<u>Goal</u>
5.0 ***Addressing Natural Resource Issues that Impact the Use and Availability of Groundwater and Are Impacted by the Use of Groundwater***

<u>Management Objective</u>

5.1 The District will promote at least once per year by way of press releases, community awareness programs, advertisements or a combination thereof the importance of plugging and/or capping all wells not in use. District staff will maintain a file indicating the methods of promotion used each year.

<u>Performance Standard</u>

5.1.1 Annually publicize the importance of plugging or capping wells.

<u>Goal</u>
6.0 ***Addressing Drought Conditions***

Texas Water Development Board drought page: <u>http://twdb.texas.gov/data/drought/</u>

<u>Management Objective</u>

6.1 The District has developed and maintains a drought contingency plan that includes recommended rationing and conservation techniques.

<u>Performance Standard</u>

6.1.1 At least annual review of Drought Contingency Plan.

<u>Management Objective</u>

6.2 Monthly review of applicable data including the Palmer Drought Severity Index (PDSI) by Texas Climatic Divisions to determine status of drought conditions and, if necessary, report to the Board on need to implement drought contingency plan.

Performance Standard

6.2.1 Each year complete and distribute to the Board an Annual Report on drought conditions in preceding year.

Management Objective

6.3 Monthly the District will monitor the Palmer Drought Severity Index (PDSI) by Texas Climatic Divisions. If PDSI indicates that the District will experience severe drought conditions, the District will notify all public water suppliers within the District.

Performance Standard

6.3.1 The District staff will monitor the PDSI and report findings and actions to the District Board on a monthly basis.

Goal

7.0 ***Addressing Conservation***

Management Objective

7.1 The District has developed and maintains a water level monitoring program that includes at least 30 water wells throughout the District. The District will gather water levels at least twice per year on each of the designated wells to determine the effects of pumping and weather conditions on the aquifer. Data files are maintained at the District office. Annual reports are presented to the Board on the status of the water level monitoring program.

Performance Standard

7.1.1 The number of water wells monitored for levels each year. Annual reports submitted to the Board.

Management Objective

7.2 District staff writes or sponsors at least four media releases per year on various issues relating to conservation. These articles are sent to local media outlets for publication. The District maintains a file detailing all newspaper articles and radio and television coverage on conservation issues.

<u>Performance Standard</u>
7.2.1 The number of media releases sent to local media outlets.

<u>Goal</u>
8.0 ***Addressing Recharge Enhancement***

The goal is not applicable.

<u>Goal</u>
9.0 ***Addressing Rainwater Harvesting***

<u>Management Objective</u>
<u>9.1</u>
The District provides literature for the public, as well as public seminars, regarding rainwater harvesting systems. The District has provided barrels for the seminars and subsequent instruction.

<u>Performance Standard</u>
9.1.1 Number of systems installed each year.

<u>Goal</u>
10.0 ***Addressing Precipitation Enhancement***

The goal is not applicable.

<u>Goal</u>
11.0 ***Addressing Brush Control***

The goal is not applicable.

<u>Goal</u>
12.1 ***Addressing in a Quantitative Manner the Desired Future Conditions of the Groundwater Resources***

<u>Management Objective</u>
12.1 The District will continue to monitor its drought conditions as related to the District Drought Contingency Plan.

Performance Standard

12.1.1 Monthly monitoring of Palmer Drought Index

Management Objective

12.2 The water well monitoring program will allow the District to closely monitor the static and draw down levels of the water table across the entire District.

Performance Standard

12.2.1 With historic water levels available, the District will monitor seasonal and long term water level declines and act accordingly.

Management Objective

12.3 The District maintains a Rainfall Cooperator Program that measures rainfall across the County and reported quarterly.

Performance Standard

12.3.1 Accumulative report of all cooperators available to public and reported to Board yearly.

APPENDICES

Appendix
A

GAM Run 10-001

by Mr. Wade Oliver

Texas Water Development Board
Groundwater Availability Modeling Section
(512) 463-3132
June 21, 2010

Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by employees under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on June 21, 2010.

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EXECUTIVE SUMMARY:

The recently modified groundwater model for the Dockum Aquifer was used to estimate drawdown from 2010 and 2060 using annual pumping values requested by Groundwater Management Area 7 for Nolan and Mitchell counties. This request included 14,018 acre-feet per year of pumping in Mitchell County and 5,750 acre-feet per year of pumping in Nolan County.

For comparison, the annual pumping for this "base" scenario was adjusted up and down between roughly half (40 percent) and twice (190 percent) the base value to provide insight into how the drawdown results change under different pumping scenarios.

Results indicate that average drawdown in Mitchell County after 51 years (2010 to 2060) is significantly less than the drawdown for Nolan County. For the baseline run, drawdown in Mitchell County is approximately 3 feet while drawdown in Nolan County is 39 feet. This difference is primarily because the Dockum Aquifer in Mitchell County is predominantly outcrop while it is mostly subcrop in Nolan County. The Dockum Aquifer also covers a much smaller area of Nolan County than Mitchell County, which leaves less area over which to spread the requested pumping.

For the runs with pumping adjusted between 40 percent and 190 percent of the base scenario, drawdown after 51 years are 1 to 7 feet for Mitchell County and 12 to 84 feet for Nolan County.

REQUESTOR:

Ms. Caroline Runge of Menard County Underground Water District on behalf of Groundwater Management Area 7.

DESCRIPTION OF REQUEST:

Ms. Runge requested a groundwater availability model run of the Dockum Aquifer with base pumping of 14,018 acre-feet per year in Mitchell County and 5,750 acre-feet per year in Nolan County. She then requested that we adjust this base pumping up and down in order to provide drawdown results under various pumping scenarios. The Dockum Aquifer and associated groundwater management areas are shown in Figure 1.

METHODS:

The recently modified groundwater model of the Dockum Aquifer (Oliver and Hutchison, 2010) was used to simulate future conditions as specified in the request. This model is a modification to the groundwater availability model documented in Ewing and others (2008) and was completed in order to more effectively simulate predictive conditions. The pumping between 2010 and 2060 in Mitchell and Nolan counties was specified by members of Groundwater Management Area 7. In portions of Groundwater Management Area 7 outside of Mitchell and Nolan counties, pumping was held at the levels present for the last stress period of the historical-calibration portion of the model (1997).

After the above model run (referred to in this report as the "base" scenario), the pumping for each county was systematically adjusted up and down to show how drawdown through time changes under different pumping scenarios. More details on pumping in the model are given in the Pumping section below.

The historical-calibration period of the model ends in 1997 while the predictive simulation documented here begins in 2010. To estimate the appropriate level of pumping between 1998 and 2009, the interim period leading up to the predictive simulation, a preliminary analysis of water levels in a few selected wells in Groundwater Management Area 7 was performed. As shown in Appendix A, these hydrographs do not indicate significant trends in water levels that indicate large changes in pumping during this time period. For this reason, the pumping levels and distribution for the last year of the historical-calibration portion of the model were considered to be appropriate for the interim period. Pumping was, therefore, held constant at 1997 levels between 1998 and 2009.

PARAMETERS AND ASSUMPTIONS:

The parameters and assumptions for the model run using the modified groundwater model for the Dockum Aquifer are described below:

- We used the modified groundwater model for the Dockum Aquifer described in Oliver and Hutchison (2008). This model is an modification to the previously developed groundwater availability model for the Dockum Aquifer described in Ewing and others (2008) in order to more effectively simulate predictive conditions. See Oliver and Hutchison (2010) and Ewing and others (2008) for assumptions and limitations of the model.

- The model includes two active layers which represent the upper and lower portions of the Dockum Aquifer. Layer 2 represents the upper portion of the Dockum Aquifer. Layer 3 represents the lower portion of the Dockum Aquifer. Layer 1, which is active in version 1.01 of the model documented in Ewing and others (2008), was inactivated in the modified model as described in Oliver and Hutchison (2010).

- The mean absolute error (a measure of the difference between simulated and measured water levels during model calibration) for the lower portion of the Dockum Aquifer between 1980 and 1997 is 53 feet. This represents 2.5 percent of the hydraulic head drop across the model area.

- The MODFLOW General-Head Boundary package was used to simulate flow between the Dockum Aquifer and overlying aquifers. The water levels in the overlying aquifers were applied as described in Oliver and Hutchison (2010) using Groundwater Availability Model Run 09-001 (Smith, 2009) for the northern portion of the Ogallala Aquifer and Groundwater Availability Model Run 09-023 (Oliver, 2010b) for the southern portion of the Ogallala Aquifer.

- Cells were assigned to individual counties and groundwater conservation districts as shown in the September 14, 2009 version of the model grid for the Dockum Aquifer. Because this model grid predates the development of the modified model, care was taken to ensure that only those fields in the model grid that were valid for the modified model were used for analyzing model results.
- The recharge used for the model run represents average recharge as described in Ewing and others (2008).
- Pumping used for the predictive simulations was specified to match the requested rate by members of Groundwater Management Area 7. Details on this pumpage are given below.

Pumping

The pumping between 2010 and 2060 for the base scenario was requested by members of Groundwater Management Area 7. To meet this request, pumping was uniformly increased from the 1997 level uniformly over all model cells that contained pumping in 1997 (the last stress period of the historical-calibration portion of the model).

With the exception of Groundwater Management Area 1, the pumping in areas outside Groundwater Management Area 7 was held constant at 1997 levels through the predictive period. Pumping in Groundwater Management Area 1 was also adjusted, at their request, to match a specified drawdown rate of 1-foot per year. Results for Groundwater Management Area 1 are presented in GAM Run 09-014 (Oliver, 2010a).

As mentioned in the Methods section above, the base pumping scenario was also adjusted up and down in order to provide insight into the relationship between pumping and drawdown in the Dockum Aquifer. The pumping input to the model was multiplied by factors to increase (factors of 1.3, 1.6 and 1.9) or decrease (factors of 0.8, 0.6, and 0.4) the pumping over the model as a whole. These values were chosen to provide a range of pumping values between roughly half and twice the base scenario above. The relationships generated are presented in the Results section below.

RESULTS:

As described above, the pumping distribution for the last year of the historical-calibration portion of the model was held constant between 1998 and 2009 and then set to levels to meet the requested pumping between 2010 and 2060. The average drawdown for each decade between 2010 and 2060 for the base scenario is shown in tables 1 and 2 for each county, groundwater conservation district, and groundwater management area for the upper and lower portions of the Dockum Aquifer, respectively. Table 2 also includes pumping output from the model which accounts for pumping lost due to cells going inactive. A model cell goes inactive when the water level in a cell drops below the bottom of the aquifer. In this situation, pumping can no longer occur. Table 1 does not include pumping because no pumping occurs in the upper portion of the Dockum Aquifer in the model.

As shown in Figure 1, the upper portion of the Dockum Aquifer within Groundwater Management Area 7 is limited to Ector and Midland counties. Water level drawdowns over the 51-year predictive period for these counties are 6 and 29 feet, respectively (Table 1).

Table 2 shows pumping and average drawdown for the lower portion of the Dockum Aquifer for the base scenario. Drawdown in Groundwater Management Area 7 as a whole increases steadily, but slowly, to about 5 feet after 51 years. This rate varies by county, however. For Mitchell and Nolan counties, the two counties with requested pumping, drawdown after 51 years is 3 and 39 feet, respectively. The primary reason for this difference is that the Dockum Aquifer outcrops over a large area of Mitchell County while there is less outcrop area in Nolan County. In the outcrop areas, a decline in the water level means that the aquifer is being dewatered. This is in contrast to the subcrop, where a decline in water level is a result of a reduction in pressure. Another factor is that the Dockum Aquifer covers a smaller area of Nolan County than Mitchell County.

As described in the Pumping section above, the base pumping distribution was adjusted up and down to provide insight into how the aquifer responds under different levels of pumping. Tables similar to tables 1 and 2, but showing pumping and drawdown results based on these pumping adjustments are shown in Appendix B. In addition, Figure 2 shows the drawdown in the lower portion of the Dockum Aquifer in Mitchell County through time for the various pumping scenarios. For the model run with 40 percent of the base scenario pumping, drawdown in Mitchell County is approximately 1 foot after 51 years. For the model run with 190 percent of the base scenario pumping, drawdown in Mitchell County is approximately 7 feet after 51 years.

Figure 3 shows the drawdown in Nolan County through time in the lower portion of the Dockum Aquifer for the various pumping scenarios. For the model run with 40 percent of the base scenario pumping, drawdown in Nolan County is approximately 12 feet after 51 years. For the model run with 190 percent of the base scenario pumping, drawdown in Nolan County is approximately 84 feet after 51 years.

To better illustrate how the model responds through time during the base run, Appendix C contains charts for each of the major water budget terms for each year of the predictive model run. Note that these charts only reflect the lower portion of the Dockum Aquifer within Groundwater Management Area 7. Appendix D contains water budget tables for each county, groundwater conservation district, and groundwater management area for the last stress period of the model run. The components of the water budget are described below:

- Recharge— areally distributed recharge due to precipitation falling on the outcrop areas of the aquifer. Recharge is always shown as "Inflow" into the water budget. Recharge is modeled using the MODFLOW Recharge package.

- Pumping—water produced from wells in the aquifer. This component is always shown as "Outflow" from the water budget. Pumping is modeled using the MODFLOW Well package.

- Change in Storage—changes in the water stored in the aquifer. This component of the budget is often seen as water both going into and out of the aquifer because water levels may decline in some areas (water is being removed from storage) and rise in others (water is being added to storage).

- Overlying Aquifers—water that flows into (or out of) the aquifer due to interaction with overlying units. Interaction with overlying aquifers is modeled using the MODFLOW General-Head Boundary package. For areas overlain by the Ogallala Aquifer, the water level input to the general-head boundary package comes from predictive GAM runs 09-001 and 09-023 using the models for the northern and southern portions of the Ogallala Aquifer, respectively (Smith, 2009; Oliver, 2010b).

- Springs and Evapotranspiration—water that naturally discharges from the aquifer when water levels rise above the elevation of the spring or when it is close enough to the surface to evaporate or be taken up by plants. This component is always shown as "Outflow," or discharge, in the water budget. Spring and evapotranspiration outflows are simulated collectively in the model using the MODFLOW Drain package.

- Stream Interaction—water that flows between streams and the aquifer. The direction and amount of flow depends on the relationship between the water levels in the stream and the aquifer. Where the water level in the stream is higher than the water level in the aquifer, water flows into the aquifer and is shown as "Inflow" in the budget. Where the water level in the stream is lower than the water level in the aquifer, water flows out of the aquifer and is shown as "Outflow" in the budget. Streams are modeled using the MODFLOW Stream package.

- Lateral flow—describes lateral flow within the aquifer between one area and an adjacent area (for example, lateral flow into and out of a groundwater management area).

- Vertical flow or leakage (upper or lower)—describes the vertical flow, or leakage, between two aquifers, or, in the case of this model, between the upper and lower portions of the Dockum Aquifer. This flow is controlled by the water levels in each unit and aquifer properties that define the amount of leakage that can occur. "Upper" refers to interaction between an aquifer and the aquifer overlying it. "Lower" refers to interaction between an aquifer and the aquifer below it. For this model, vertical flow between the upper and lower portions of the Dockum Aquifer is reported separately from interaction of the Dockum Aquifer with the overlying aquifers described above (which is, strictly speaking, also vertical flow).

Figure C-1 in Appendix C shows the recharge through time. Recharge is constant through time for both the historical period of the model to which it was calibrated (not shown) and the predictive period. Recharge into the Dockum Aquifer in Groundwater Management Area 7 is approximately 47,000 acre-feet per year.

Figure C-2 shows pumping through time for the base scenario. Beginning in 2010, the pumping requested by Groundwater Management Area 7 is applied, totaling about 23,800 acre-feet per year. Most of this (over 80 percent) occurs in Mitchell and Nolan counties (Table D-1 in Appendix D).

Figure C-3 shows the Net Change in Storage in the modified groundwater model. Note that the amount of water removed from storage increases dramatically in 2010 due to the increase in pumping shown in Figure C-2. The rate that water is removed from storage annually then slowly declines through the remainder of the simulation period as the aquifer slowly adjusts to the new levels of pumping.

Figure C-4 shows the net inflow from overlying aquifers to the lower portion of the Dockum Aquifer in Groundwater Management Area 7. Inflow from the overlying aquifers is relatively steady through the period, with only small declines. These declines are likely due to reductions in the water level in the overlying Ogallala Aquifer in Ector, Midland, and Glasscock counties.

Figure C-5 shows the outflow to springs and by evapotranspiration. Outflows decline through time beginning in 2010 due to declining water levels in the Dockum Aquifer. Figure C-6, showing net outflow to streams, exhibits a very similar response as the springs and evapotranspiration shown in Figure C-5 for the same reason.

Figure C-7 shows the net lateral flow between Groundwater Management Area 7 and adjacent areas. Notice that throughout the predictive period flow is always a net outflow, but declines in magnitude as water levels in Groundwater Management Area 7 decline relative to surrounding areas.

Figure C-8 shows the magnitude and direction of vertical flow between the upper and lower portions of the Dockum Aquifer. Through the predictive period there is a net downward flow from the upper portion of the Dockum Aquifer to the lower portion. However, this rate declines through time for most of the predictive period corresponding to a drop in the inflow from the overlying Ogallala Aquifer in Ector and Midland counties.

It is important to acknowledge the limitations of the precision of the sub-regional water budgets that is associated with the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary (for example, a county) is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located.

REFERENCES AND ASSOCIATED MODEL RUNS:

Ewing, J.E., Jones, T.L., Yan, T., Vreugdenhil, A.M., Fryar, D.G., Pickens, J.F., Gordon, K., Nicot, J.P., Scanlon, B.R., Ashworth, J.B., Beach, J., 2008, Groundwater Availability Model for the Dockum Aquifer – Final Report: contract report to the Texas Water Development Board, 510 p.

Oliver, W., Hutchison, W.R., 2010, Modification and recalibration of the Groundwater Availability Model of the Dockum Aquifer: Texas Water Development Board, 114 p.

Oliver, W., 2010a, GAM Run 09-014: Texas Water Development Board, GAM Run 09-014 Draft Report, 44 p.

Oliver, W., 2010b, GAM Run 09-023: Texas Water Development Board, GAM Run 09-023 Draft Report, 30 p.

Smith, R., 2009, GAM Run 09-001: Texas Water Development Board, GAM Run 09-001 Draft Report, 28 p.

Table 1. Average drawdown for the upper portion of the Dockum Aquifer by decade for each county and groundwater management area (GMA). Drawdown is in feet. Groundwater conservation districts are not shown because none exist for the upper portion of the Dockum Aquifer in Groundwater Management Area 7.

Base Scenario: Upper Dockum	Base					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
County						
Ector	0	2	4	6	6	6
Midland	1	8	15	21	26	29
GMA						
Out-of-State	0	0	1	1	1	1
GMA 1	0	3	7	12	16	19
GMA 2	1	15	27	35	40	42
GMA 3	0	0	0	0	1	1
GMA 7	0	5	9	13	15	16

Table 2. Pumping and average drawdown for the lower portion of the Dockum Aquifer by decade for each county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. The abbreviation for Underground Water Conservation District is UWCD and Water Conservation District is WCD.

Base Scenario: Lower Dockum	**Pumping**						**Average Drawdown**					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County												
Coke	0	0	0	0	0	0	0	0	0	0	0	0
Crockett	2	2	2	2	2	2	0	2	2	3	3	3
Ector	528	528	528	528	528	528	0	1	3	4	5	5
Glasscock	0	0	0	0	0	0	0	0	1	1	2	2
Irion	0	0	0	0	0	0	0	1	2	2	2	2
Midland	0	0	0	0	0	0	0	3	7	11	14	16
Mitchell	14,018	14,018	14,018	14,018	14,018	14,018	0	1	2	3	3	3
Nolan	5,750	5,750	5,750	5,750	5,750	5,750	23	29	32	35	37	39
Pecos	777	777	777	777	777	777	0	0	0	0	0	0
Reagan	2,064	2,064	2,064	2,064	2,064	2,064	1	4	5	6	6	7
Scurry	1,209	1,209	1,209	1,209	1,209	1,209	0	0	0	0	0	0
Sterling	10	10	10	10	10	10	0	0	0	1	1	1
Tom Green	0	0	0	0	0	0	0	2	2	3	3	3
Upton	219	219	219	219	219	219	0	2	2	3	3	4
GCD												
Coke County UWCD	0	0	0	0	0	0	0	0	0	0	0	0
Crockett County GCD	2	2	2	2	2	2	0	2	2	3	3	3
Glasscock GCD	1,027	1,027	1,027	1,027	1,027	1,027	0	1	1	2	2	3
Irion County WCD	0	0	0	0	0	0	0	1	2	2	2	2
Lone Wolf GCD	14,018	14,018	14,018	14,018	14,018	14,018	0	1	2	3	3	3
Middle Pecos GCD	777	777	777	777	777	777	0	0	0	0	0	0
Santa Rita UWCD	1,037	1,037	1,037	1,037	1,037	1,037	1	4	5	6	6	7
Sterling County UWCD	10	10	10	10	10	10	0	0	0	1	1	1
Wes-Tex GCD	5,750	5,750	5,750	5,750	5,750	5,750	23	29	32	35	37	39
GMA												
Out-of-State	7,793	7,793	7,793	7,793	7,793	7,793	0	1	1	2	2	3
GMA 1	13,419	19,177	26,940	40,099	64,566	107,175	1	11	21	31	41	51
GMA 2	9,598	9,598	9,598	9,598	9,598	9,598	1	10	20	29	34	37
GMA 3	4,231	4,231	4,231	4,231	4,231	4,231	0	0	0	0	0	0
GMA 6	69	69	69	69	69	69	0	1	2	2	3	4
GMA 7	23,802	23,802	23,802	23,802	23,802	23,802	1	2	3	4	5	5

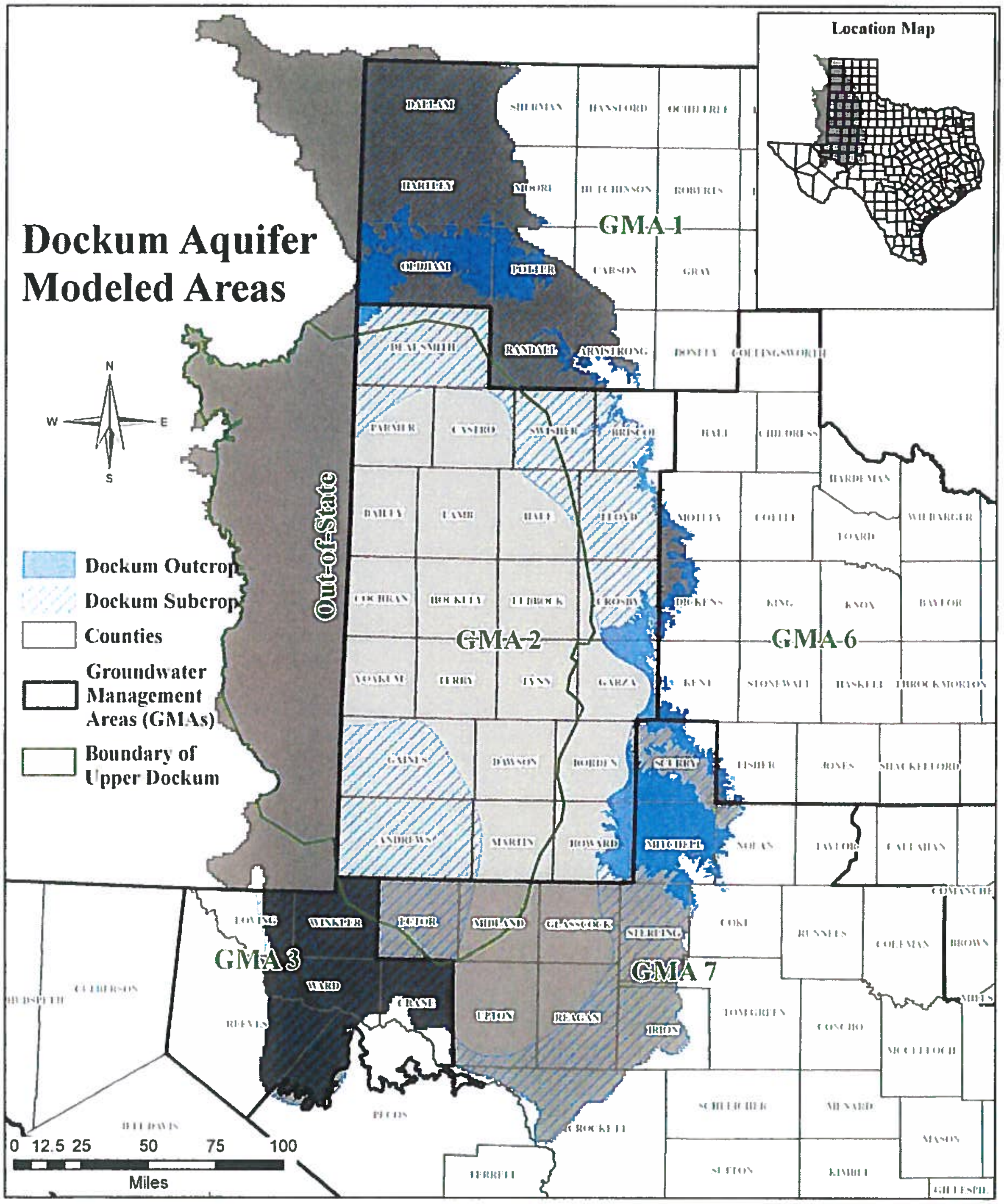


Figure 1. Location map showing model grid cells representing the Dockum Aquifer, groundwater management areas, the official Dockum Aquifer boundary, and the boundary of the upper portion of the Dockum Aquifer.

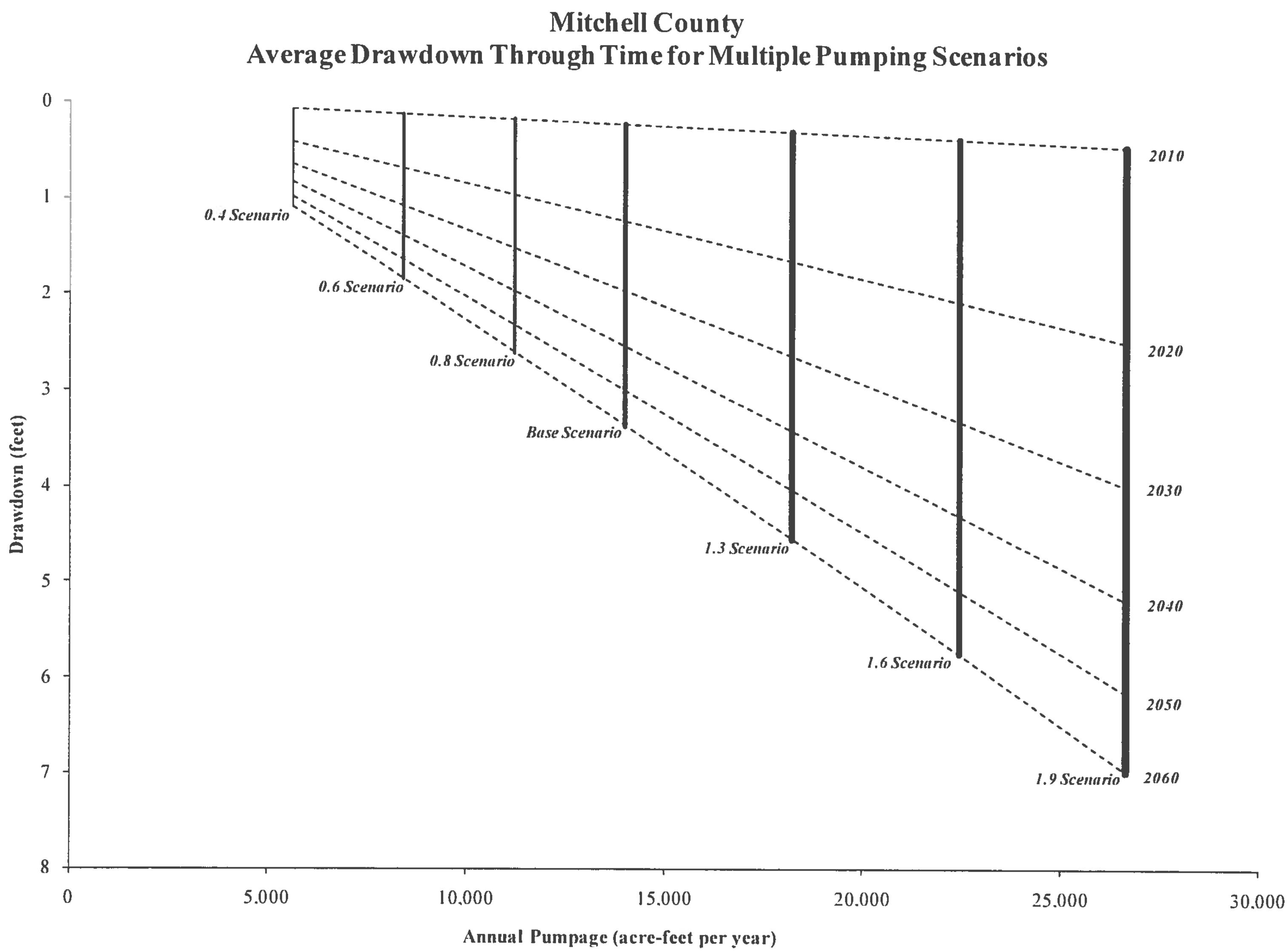


Figure 2. Average drawdown for the lower portion of the Dockum Aquifer in Mitchell County through time for multiple pumping scenarios.

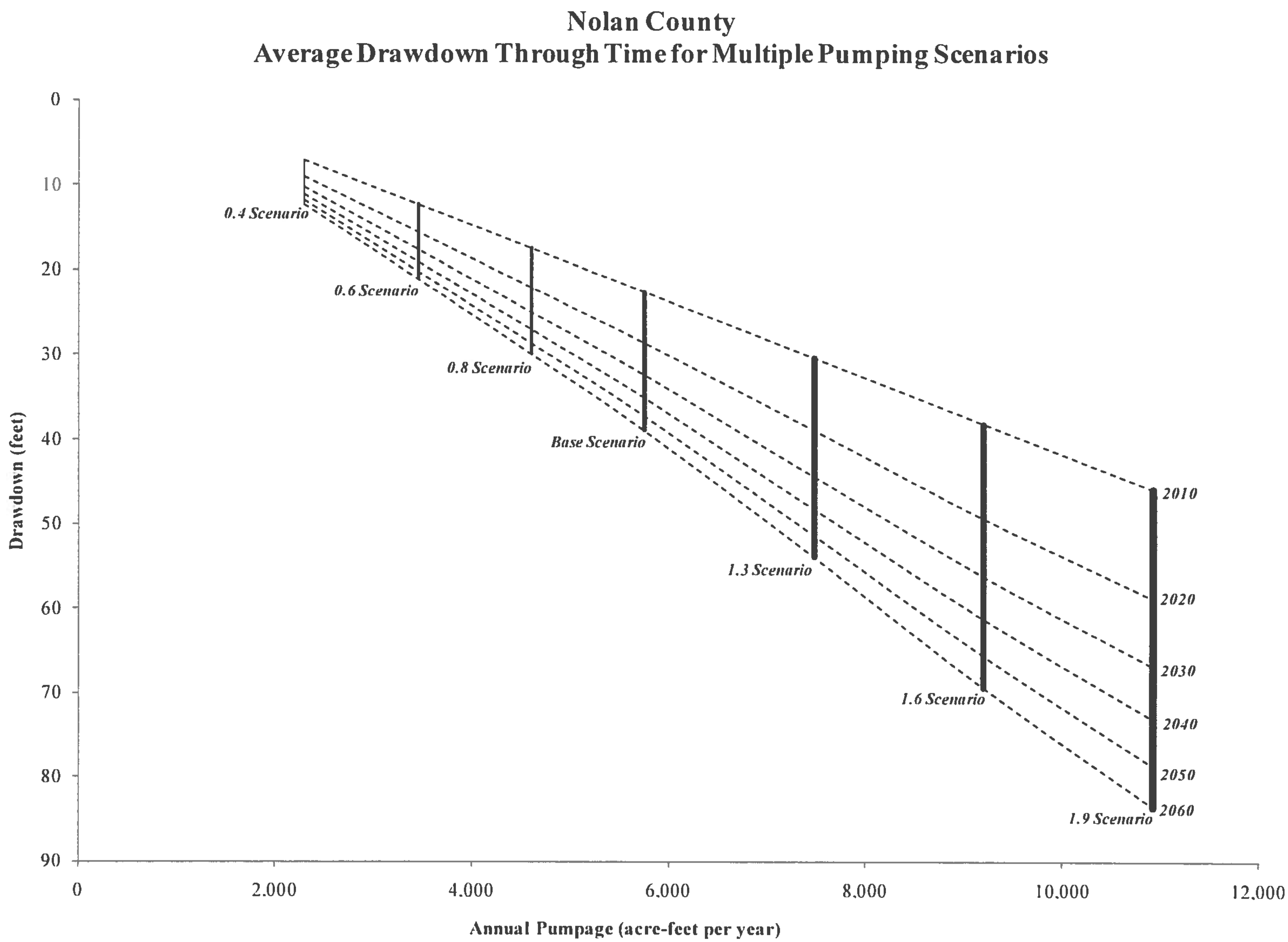


Figure 3. Average drawdown for the lower portion of the Dockum Aquifer in Nolan County through time for multiple pumping scenarios.

Appendix A

Selected hydrographs between 1980 and 2009 for the Dockum Aquifer in Groundwater Management Area 7

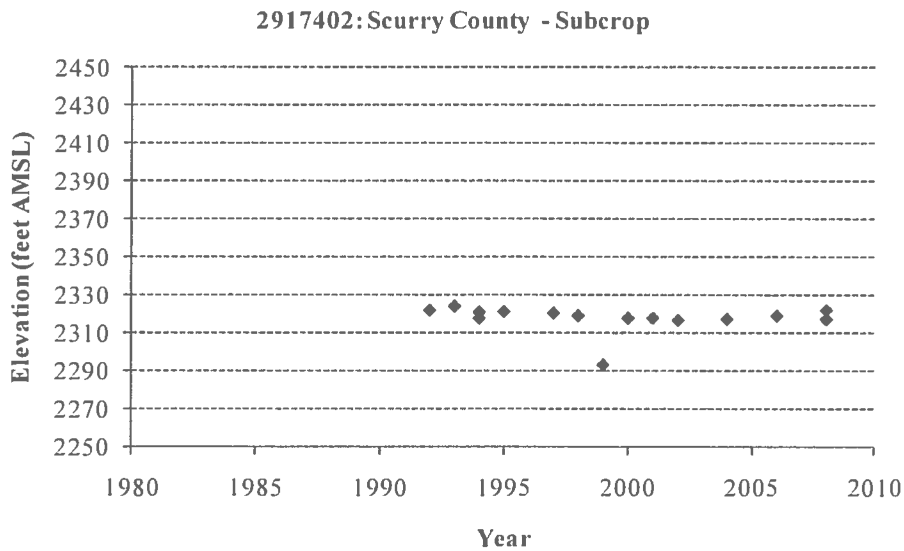


Figure A-1. Hydrograph of state well 2917402 located in the subcrop portion of the Dockum Aquifer in Scurry County.

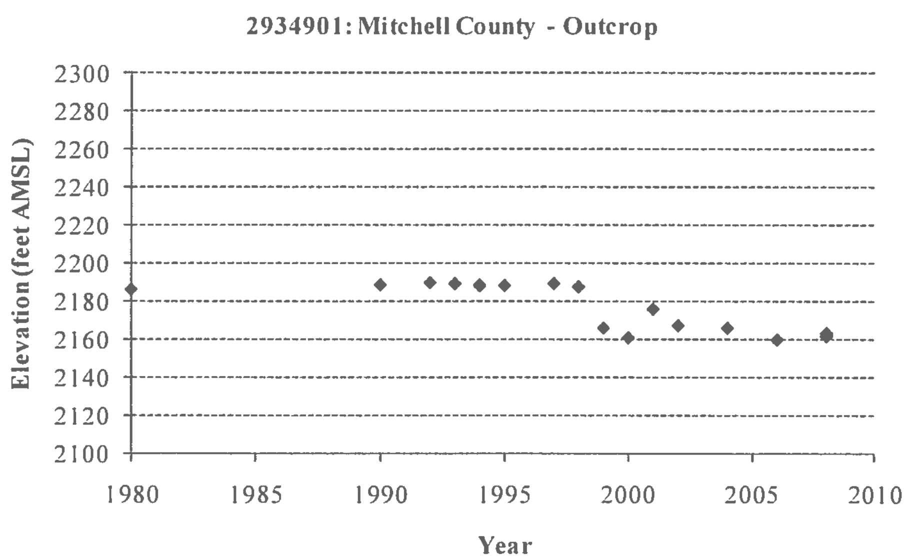


Figure A-2. Hydrograph of state well 2934901 located in the outcrop portion of the Dockum Aquifer in Mitchell County.

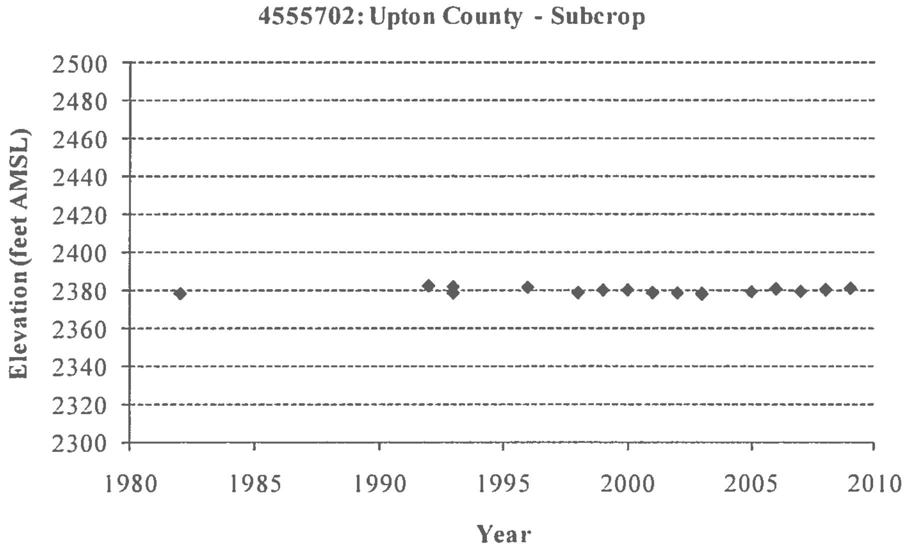


Figure A-3. Hydrograph of state well 4555702 located in the subcrop portion of the Dockum Aquifer in Upton County.

Appendix B

Pumping and drawdown for each pumping scenario by decade

Table B-1. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping decreased to 40 percent of the base scenario by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. The abbreviation for Underground Water Conservation District is UWCD and Water Conservation District is WCD. Negative values indicate a water level rise.

Pumping 40 Percent of Base Scenario	Pumping						Average Drawdown					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County												
Coke	0	0	0	0	0	0	0	0	0	0	0	0
Crockett	1	1	1	1	1	1	0	-5	-7	-8	-8	-8
Ector	211	211	211	211	211	211	0	1	2	3	5	5
Glasscock	0	0	0	0	0	0	-1	-3	-3	-3	-2	-2
Irion	0	0	0	0	0	0	0	0	-1	-2	-2	-2
Midland	0	0	0	0	0	0	0	2	6	10	13	15
Mitchell	5,607	5,607	5,607	5,607	5,607	5,607	0	0	1	1	1	1
Nolan	2,300	2,300	2,300	2,300	2,300	2,300	7	9	10	11	12	12
Pecos	311	311	311	311	311	311	-1	-2	-2	-2	-2	-2
Reagan	826	826	826	826	826	826	-3	-18	-23	-25	-25	-25
Scurry	484	484	484	484	484	484	0	0	0	0	0	0
Sterling	4	4	4	4	4	4	0	0	-1	-1	-1	-1
Tom Green	0	0	0	0	0	0	0	-1	-3	-4	-4	-4
Upton	88	88	88	88	88	88	0	-3	-4	-5	-5	-5
GCD												
Coke County UWCD	0	0	0	0	0	0	0	0	0	0	0	0
Crockett County GCD	1	1	1	1	1	1	0	-5	-7	-8	-8	-8
Glasscock GCD	411	411	411	411	411	411	-2	-7	-8	-8	-8	-7
Irion County WCD	0	0	0	0	0	0	0	0	-1	-2	-2	-2
Lone Wolf GCD	5,607	5,607	5,607	5,607	5,607	5,607	0	0	1	1	1	1
Middle Pecos GCD	311	311	311	311	311	311	-1	-2	-2	-2	-2	-2
Santa Rita UWCD	415	415	415	415	415	415	-2	-15	-20	-22	-22	-23
Sterling County UWCD	4	4	4	4	4	4	0	0	-1	-1	-1	-1
Wes-Tex GCD	2,300	2,300	2,300	2,300	2,300	2,300	7	9	10	11	12	12
GMA												
Out-of-State	3,117	3,117	3,117	3,117	3,117	3,117	-1	-2	-2	-2	-1	-1
GMA 1	5,368	7,673	10,782	16,048	25,835	42,878	-3	2	11	19	28	37
GMA 2	3,839	3,839	3,839	3,839	3,839	3,839	0	9	19	27	32	35
GMA 3	1,692	1,692	1,692	1,692	1,692	1,692	-1	-2	-2	-2	-2	-2
GMA 6	28	28	28	28	28	28	0	0	1	1	2	2
GMA 7	9,521	9,521	9,521	9,521	9,521	9,521	0	-3	-3	-3	-3	-3

Table B-2. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping decreased to 60 percent of the base scenario by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. The abbreviation for Underground Water Conservation District is UWCD and Water Conservation District is WCD. Negative values indicate a water level rise.

Pumping 60 Percent of Base Scenario	Pumping						Average Drawdown					
	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
County												
Coke	0	0	0	0	0	0	0	0	0	0	0	0
Crockett	1	1	1	1	1	1	0	-3	-4	-4	-4	-4
Ector	317	317	317	317	317	317	0	1	2	4	5	5
Glasscock	0	0	0	0	0	0	0	-2	-2	-1	-1	-1
Irion	0	0	0	0	0	0	0	0	0	0	-1	-1
Midland	0	0	0	0	0	0	0	3	6	10	13	16
Mitchell	8,411	8,411	8,411	8,411	8,411	8,411	0	1	1	1	2	2
Nolan	3,450	3,450	3,450	3,450	3,450	3,450	12	16	18	19	20	21
Pecos	466	466	466	466	466	466	-1	-1	-1	-1	-1	-1
Reagan	1,238	1,238	1,238	1,238	1,238	1,238	-2	-11	-13	-14	-15	-15
Scurry	725	725	725	725	725	725	0	0	0	0	0	0
Sterling	6	6	6	6	6	6	0	0	0	0	0	0
Tom Green	0	0	0	0	0	0	0	0	-1	-2	-2	-2
Upton	131	131	131	131	131	131	0	-1	-2	-2	-2	-2
GCD												
Coke County UWCD	0	0	0	0	0	0	0	0	0	0	0	0
Crockett County GCD	1	1	1	1	1	1	0	-3	-4	-4	-4	-4
Glasscock GCD	616	616	616	616	616	616	-1	-4	-5	-5	-4	-4
Irion County WCD	0	0	0	0	0	0	0	0	0	-1	-1	-1
Lone Wolf GCD	8,411	8,411	8,411	8,411	8.411	8,411	0	1	1	1	2	2
Middle Pecos GCD	466	466	466	466	466	466	-1	-1	-1	-1	-1	-1
Santa Rita UWCD	622	622	622	622	622	622	-1	-9	-12	-12	-13	-13
Sterling County UWCD	6	6	6	6	6	6	0	0	0	0	0	0
Wes-Tex GCD	3,450	3,450	3,450	3,450	3,450	3,450	12	16	18	19	20	21
GMA												
Out-of-State	4,676	4,676	4,676	4,676	4,676	4,676	0	-1	-1	0	0	0
GMA 1	8,052	11,510	16,169	24,065	38,745	64,311	-2	6	15	24	33	43
GMA 2	5,759	5,759	5,759	5,759	5,759	5,759	1	9	19	27	33	36
GMA 3	2,538	2,538	2,538	2,538	2,538	2,538	0	-1	-1	-1	-1	-1
GMA 6	41	41	41	41	41	41	0	0	1	2	2	3
GMA 7	14,281	14,281	14,281	14,281	14,281	14,281	0	-1	-1	-1	0	0

Table B-3. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping decreased to 80 percent of the base scenario by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. The abbreviation for Underground Water Conservation District is UWCD and Water Conservation District is WCD. Negative values indicate a water level rise.

Pumping 80 Percent of Base Scenario	Pumping						Average Drawdown					
	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
County												
Coke	0	0	0	0	0	0	0	0	0	0	0	0
Crockett	2	2	2	2	2	2	0	0	-1	-1	-1	-1
Ector	422	422	422	422	422	422	0	1	2	4	5	5
Glasscock	0	0	0	0	0	0	0	-1	0	0	0	1
Irion	0	0	0	0	0	0	0	1	1	1	1	1
Midland	0	0	0	0	0	0	0	3	7	10	14	16
Mitchell	11,214	11,214	11,214	11,214	11,214	11,214	0	1	2	2	2	3
Nolan	4,600	4,600	4,600	4,600	4,600	4,600	18	22	25	27	29	30
Pecos	622	622	622	622	622	622	0	-1	-1	-1	-1	-1
Reagan	1,651	1,651	1,651	1,651	1,651	1,651	-1	-3	-4	-4	-4	-4
Scurry	967	967	967	967	967	967	0	0	0	0	0	0
Sterling	8	8	8	8	8	8	0	0	0	0	0	0
Tom Green	0	0	0	0	0	0	0	1	1	0	0	0
Upton	175	175	175	175	175	175	0	0	0	1	1	1
GCD												
Coke County UWCD	0	0	0	0	0	0	0	0	0	0	0	0
Crockett County GCD	2	2	2	2	2	2	0	0	-1	-1	-1	-1
Glasscock GCD	822	822	822	822	822	822	0	-2	-2	-1	-1	-1
Irion County WCD	0	0	0	0	0	0	0	1	1	1	1	1
Lone Wolf GCD	11,214	11,214	11,214	11,214	11,214	11,214	0	1	2	2	2	3
Middle Pecos GCD	622	622	622	622	622	622	0	-1	-1	-1	-1	-1
Santa Rita UWCD	830	830	830	830	830	830	0	-3	-3	-3	-3	-3
Sterling County UWCD	8	8	8	8	8	8	0	0	0	0	0	0
Wes-Tex GCD	4,600	4,600	4,600	4,600	4,600	4,600	18	22	25	27	29	30
GMA												
Out-of-State	6,234	6,234	6,234	6,234	6,234	6,234	0	0	0	1	1	2
GMA 1	10,735	15,344	21,555	32,082	51,655	85,743	0	9	18	28	38	48
GMA 2	7,678	7,678	7,678	7,678	7,678	7,678	1	10	20	28	34	37
GMA 3	3,385	3,385	3,385	3,385	3,385	3,385	0	0	-1	-1	-1	-1
GMA 6	55	55	55	55	55	55	0	1	1	2	3	3
GMA 7	19,042	19,042	19,042	19,042	19,042	19,042	0	0	1	1	2	2

Table B-4. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping increased to 130 percent of the base scenario by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. The abbreviation for Underground Water Conservation District is UWCD and Water Conservation District is WCD.

Pumping 130 Percent of Base Scenario	Pumping						Average Drawdown					
	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
County												
Coke	0	0	0	0	0	0	0	0	0	0	0	0
Crockett	3	3	3	3	3	3	1	7	10	11	12	12
Ector	686	686	686	686	686	686	0	1	3	5	6	6
Glasscock	0	0	0	0	0	0	0	1	2	2	3	3
Irion	0	0	0	0	0	0	0	5	7	8	9	9
Midland	0	0	0	0	0	0	0	3	7	11	14	17
Mitchell	18,223	18,223	18,223	18,223	18,223	18,223	0	2	3	3	4	5
Nolan	7,475	7,475	7,475	7,475	7,475	7,475	31	39	44	48	51	54
Pecos	1,010	1,010	1,010	1,010	1,010	1,010	1	1	1	1	1	1
Reagan	2,683	2,683	2,683	2,683	2,683	2,683	3	20	26	28	29	30
Scurry	1,572	1,572	1,572	1,572	1,572	1,572	0	0	0	1	1	1
Sterling	13	13	13	13	13	13	0	1	1	1	2	2
Tom Green	0	0	0	0	0	0	0	4	7	8	8	8
Upton	285	285	285	285	285	285	0	4	6	7	8	9
GCD												
Coke County UWCD	0	0	0	0	0	0	0	0	0	0	0	0
Crockett County GCD	3	3	3	3	3	3	1	7	10	11	12	12
Glasscock GCD	1,145	1,145	1,145	1,145	1,145	1,145	1	3	4	5	5	6
Irion County WCD	0	0	0	0	0	0	0	5	7	8	9	9
Lone Wolf GCD	18,223	18,223	18,223	18,223	18,223	18,223	0	2	3	3	4	5
Middle Pecos GCD	1,010	1,010	1,010	1,010	1,010	1,010	1	1	1	1	1	1
Santa Rita UWCD	1,539	1,539	1,539	1,539	1,539	1,539	3	20	26	28	29	30
Sterling County UWCD	13	13	13	13	13	13	0	1	1	1	2	2
Wes-Tex GCD	7,475	7,475	7,475	7,475	7,475	7,475	31	39	44	48	51	54
GMA												
Out-of-State	10,131	10,131	10,131	10,131	10,131	10,131	0	3	4	4	5	5
GMA 1	17,440	24,926	35,018	52,125	83,931	139,324	2	14	25	35	45	55
GMA 2	12,478	12,478	12,478	12,478	12,478	12,478	1	11	21	30	35	38
GMA 3	5,492	5,492	5,492	5,492	5,492	5,492	1	1	1	1	1	1
GMA 6	90	90	90	90	90	90	0	1	2	3	4	4
GMA 7	30,950	30,950	30,950	30,950	30,950	30,950	1	5	7	9	10	10

Table B-5. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping increased to 160 percent of the base scenario by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. The abbreviation for Underground Water Conservation District is UWCD and Water Conservation District is WCD.

Pumping 160 Percent of Base Scenario	**Pumping**						**Average Drawdown**					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
County												
Coke	0	0	0	0	0	0	0	0	0	0	0	1
Crockett	3	3	3	3	3	3	1	12	17	19	20	21
Ector	845	845	845	845	845	845	0	2	4	5	6	7
Glasscock	0	0	0	0	0	0	0	2	3	4	4	4
Irion	0	0	0	0	0	0	1	9	13	15	15	16
Midland	0	0	0	0	0	0	0	3	7	11	15	17
Mitchell	22,428	22,428	22,428	22,428	22,428	22,428	0	2	3	4	5	6
Nolan	9,200	9,200	9,200	9,200	9,200	9,200	38	50	56	61	66	69
Pecos	1,243	1,243	1,243	1,243	1,243	1,243	1	2	2	2	2	2
Reagan	3,302	3,302	3,302	3,302	3,302	3,302	6	36	46	50	52	53
Scurry	1,934	1,934	1,934	1,934	1,934	1,934	0	0	1	1	1	1
Sterling	16	16	16	16	16	16	0	1	2	2	2	3
Tom Green	0	0	0	0	0	0	1	7	11	13	13	14
Upton	350	350	350	350	350	350	1	6	9	11	12	13
GCD												
Coke County UWCD	0	0	0	0	0	0	0	0	0	0	0	1
Crockett County GCD	3	3	3	3	3	3	1	12	17	19	20	21
Glasscock GCD	1,262	1,262	1,262	1,262	1,262	1,262	1	6	7	8	9	9
Irion County WCD	0	0	0	0	0	0	1	9	13	15	15	16
Lone Wolf GCD	22,428	22,428	22,428	22,428	22,428	22,428	0	2	3	4	5	6
Middle Pecos GCD	1,243	1,243	1,243	1,243	1,243	1,243	1	2	2	2	2	2
Santa Rita UWCD	2,040	2,040	2,040	2,040	2,040	2,040	6	36	46	50	52	53
Sterling County UWCD	16	16	16	16	16	16	0	1	2	2	2	3
Wes-Tex GCD	9,200	9,200	9,200	9,200	9,200	9,200	38	50	56	61	66	69
GMA												
Out-of-State	12,468	12,468	12,468	12,468	12,468	12,468	1	5	6	7	8	8
GMA 1	21,462	30,675	43,096	64,151	103,297	171,472	4	18	28	39	49	58
GMA 2	15,358	15,358	15,358	15,358	15,358	15,358	1	12	22	31	36	39
GMA 3	6,754	6,754	6,754	6,754	6,754	6,754	1	2	2	2	3	3
GMA 6	110	110	110	110	110	110	0	2	3	3	4	5
GMA 7	38,097	38,097	38,097	38,097	38,097	38,097	2	9	12	14	15	16

Table B-6. Average drawdown in the lower portion of the Dockum Aquifer resulting from pumping increased to 190 percent of the base scenario by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is in acre-feet per year. Drawdown is in feet. The abbreviation for Underground Water Conservation District is UWCD and Water Conservation District is WCD.

Pumping 190 Percent of Base Scenario	Pumping						Average Drawdown					
	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
County												
Coke	0	0	0	0	0	0	0	0	0	0	1	1
Crockett	4	4	4	4	4	4	1	17	24	27	29	30
Ector	1,003	1,003	1,003	1,003	1,003	1,003	0	2	4	6	7	7
Glasscock	0	0	0	0	0	0	1	3	4	5	5	6
Irion	0	0	0	0	0	0	1	12	18	21	22	22
Midland	0	0	0	0	0	0	0	4	8	12	15	18
Mitchell	26,633	26,633	26,633	26,633	26,633	26,633	0	3	4	5	6	7
Nolan	10,925	10,925	10,925	10,925	10,925	10,925	46	59	67	73	79	84
Pecos	1,476	1,476	1,476	1,476	1,476	1,476	2	3	3	3	3	3
Reagan	3,921	3,921	3,921	3,921	3,921	3,921	9	52	66	72	75	76
Scurry	2,297	2,297	2,297	2,297	2,297	2,297	0	1	1	1	1	1
Sterling	19	19	19	19	19	19	0	2	3	3	3	3
Tom Green	0	0	0	0	0	0	1	10	15	18	19	19
Upton	416	416	416	416	416	416	1	8	12	15	17	18
GCD												
Coke County UWCD	0	0	0	0	0	0	0	0	0	0	1	1
Crockett County GCD	4	4	4	4	4	4	1	17	24	27	29	30
Glasscock GCD	1,379	1,379	1,379	1,379	1,379	1,379	2	8	10	11	12	13
Irion County WCD	0	0	0	0	0	0	1	13	19	21	22	23
Lone Wolf GCD	26,633	26,633	26,633	26,633	26,633	26,633	0	3	4	5	6	7
Middle Pecos GCD	1,476	1,476	1,476	1,476	1,476	1,476	2	3	3	3	3	3
Santa Rita UWCD	2,542	2,542	2,542	2,542	2,542	2,542	9	52	66	72	75	76
Sterling County UWCD	19	19	19	19	19	19	0	2	3	3	3	3
Wes-Tex GCD	10,925	10,925	10,925	10,925	10,925	10,925	46	59	67	73	79	84
GMA												
Out-of-State	14,806	14,806	14,806	14,806	14,806	14,806	1	7	9	10	10	11
GMA 1	25,483	36,424	51,173	76,177	122,663	203,620	5	20	31	41	52	60
GMA 2	18,239	18,239	18,239	18,239	18,239	18,239	1	12	23	31	37	40
GMA 3	8,016	8,016	8,016	8,016	8,016	8,016	2	3	3	4	4	4
GMA 6	131	131	131	131	131	131	1	2	3	4	5	6
GMA 7	45,244	45,244	45,244	45,244	45,244	45,244	2	12	16	19	20	21

Table B-7. Average drawdown in the upper portion of the Dockum Aquifer resulting from changes to the base pumping scenario. Results are shown by decade by county, groundwater conservation district (GCD), and groundwater management area (GMA). Pumping is not shown because no pumping exists in the upper portion of the Dockum Aquifer in the model. Drawdown is in feet. The abbreviation for Underground Water Conservation District is UWCD and Water Conservation District is WCD. Negative values indicate a water level rise.

Base Scenario:	40 Percent of Base Pumping						60 Percent of Base Pumping						80 Percent of Base Pumping					
Upper Dockum	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
County																		
Ector	0	2	4	5	6	6	0	2	4	6	6	6	0	2	4	6	6	6
Midland	1	8	15	21	25	28	1	8	15	21	26	29	1	8	15	21	26	29
GMA																		
Out-of-State	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
GMA 1	0	2	4	7	10	13	0	2	5	8	12	16	0	3	6	10	14	18
GMA 2	1	15	26	34	39	40	1	15	27	35	39	41	1	15	27	35	39	41
GMA 3	0	-1	-1	-1	-1	-1	0	0	-1	-1	0	0	0	0	0	0	0	0
GMA 7	0	5	9	12	14	16	0	5	9	12	15	16	0	5	9	12	15	16

Table B-7. Continued.

Base Scenario:	130 Percent of Base Pumping						160 Percent of Base Pumping						190 Percent of Base Pumping					
Upper Dockum	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060	2010	2020	2030	2040	2050	2060
County																		
Ector	0	2	4	6	6	6	0	3	5	6	7	7	0	3	5	7	7	7
Midland	1	8	15	21	26	29	1	8	15	22	26	29	1	8	15	22	26	29
GMA																		
Out-of-State	0	1	1	1	1	1	0	1	2	2	2	2	0	2	2	2	3	3
GMA 1	1	5	9	14	18	21	1	6	11	16	19	22	1	8	13	17	20	23
GMA 2	1	16	27	36	40	42	2	16	28	36	41	43	2	16	28	36	41	43
GMA 3	0	1	2	2	2	2	1	3	3	3	3	4	1	4	4	5	5	5
GMA 7	0	5	9	13	15	16	0	5	9	13	15	16	0	5	9	13	15	17

Appendix C

Water budgets for each stress period of the predictive model run

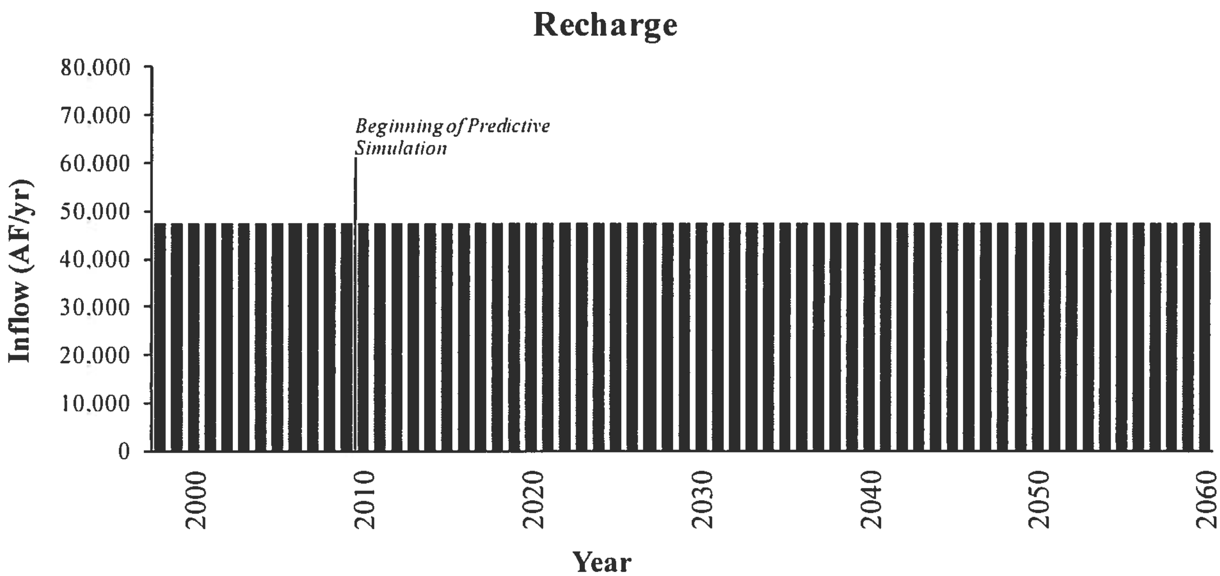


Figure C-1. Net recharge to the Dockum Aquifer by year in the model for Groundwater Management Area 7. AF/yr is acre-feet per year.

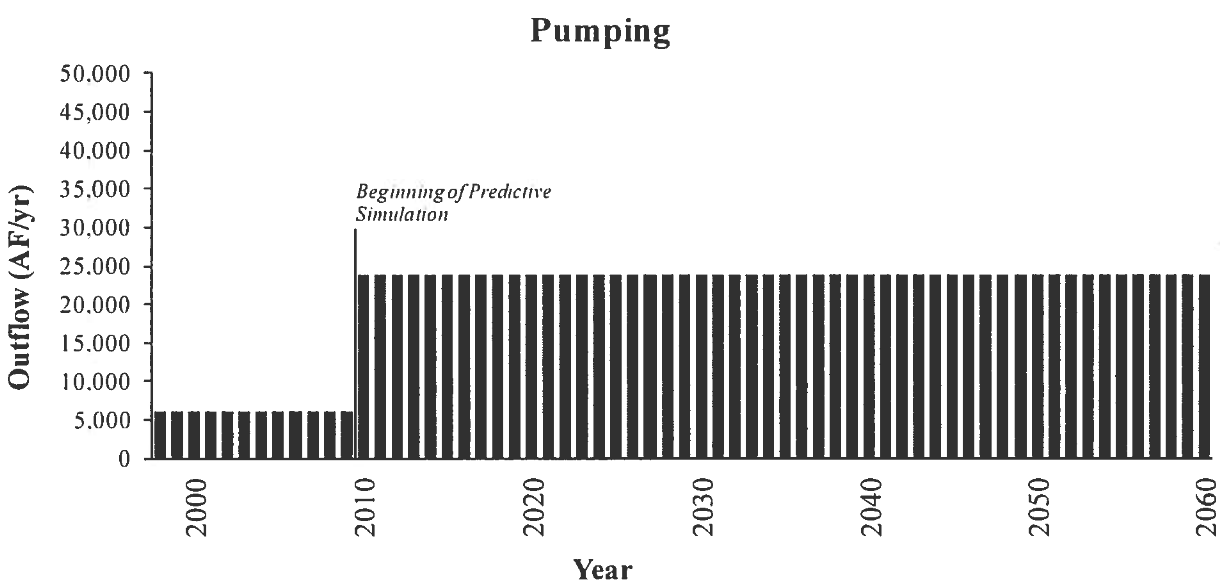


Figure C-2. Pumping output from the Dockum Aquifer by year in the model for Groundwater Management Area 7. AF/yr is acre-feet per year.

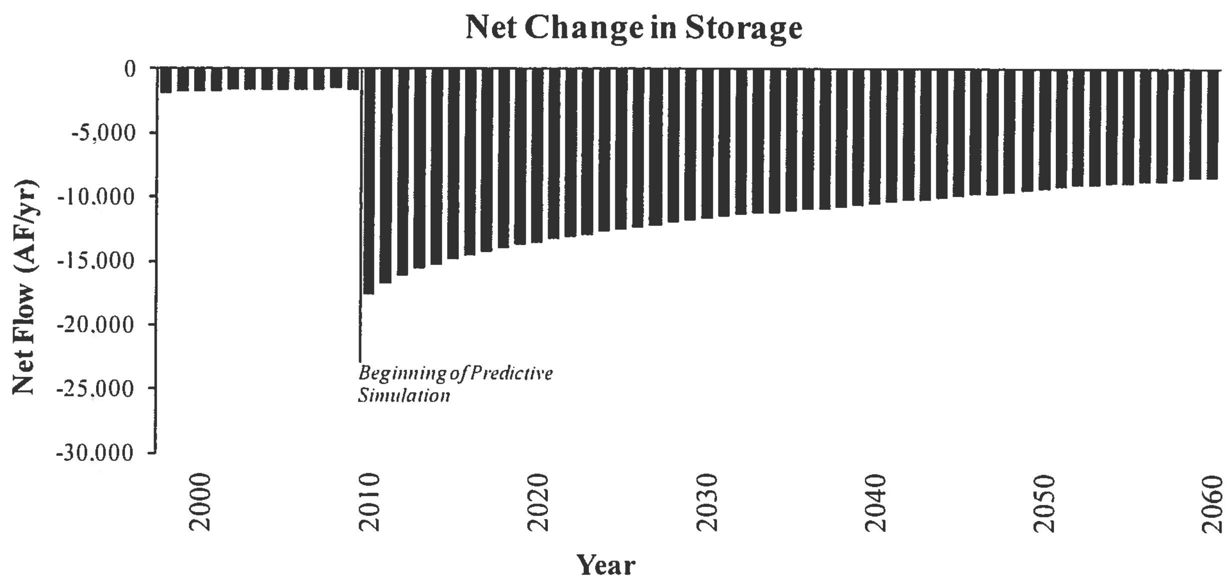


Figure C-3. Net change in storage (the volume of water stored in the aquifer) by year in the lower portion of the Dockum Aquifer for Groundwater Management Area 7. Negative values for the net change in storage indicate water level declines. AF/yr is acre-feet per year.

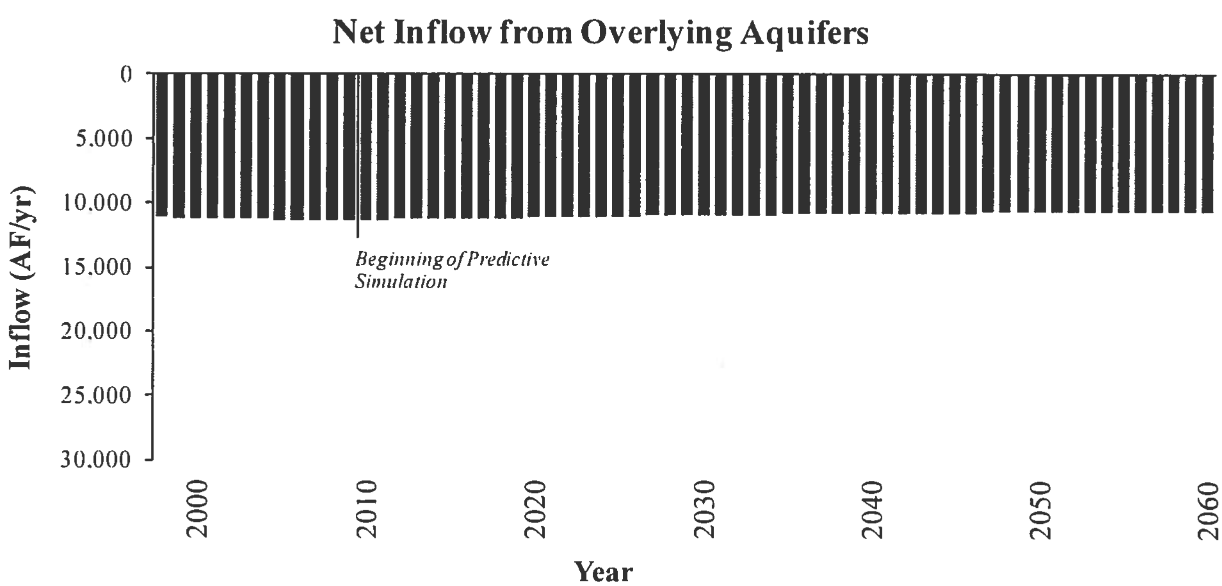


Figure C-4. Net inflow from overlying aquifers to the lower portion of the Dockum Aquifer in Groundwater Management Area 7. AF/yr is acre-feet per year.

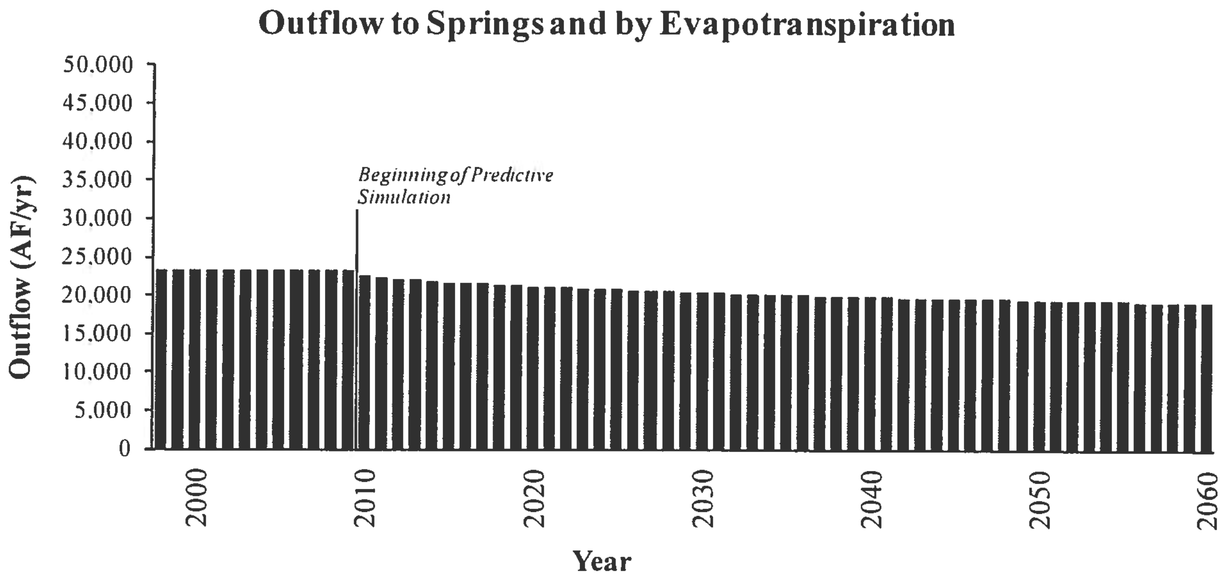


Figure C-5. Outflow from the Dockum Aquifer in Groundwater Management Area 7 to springs and by evapotranspiration. AF/yr is acre-feet per year.

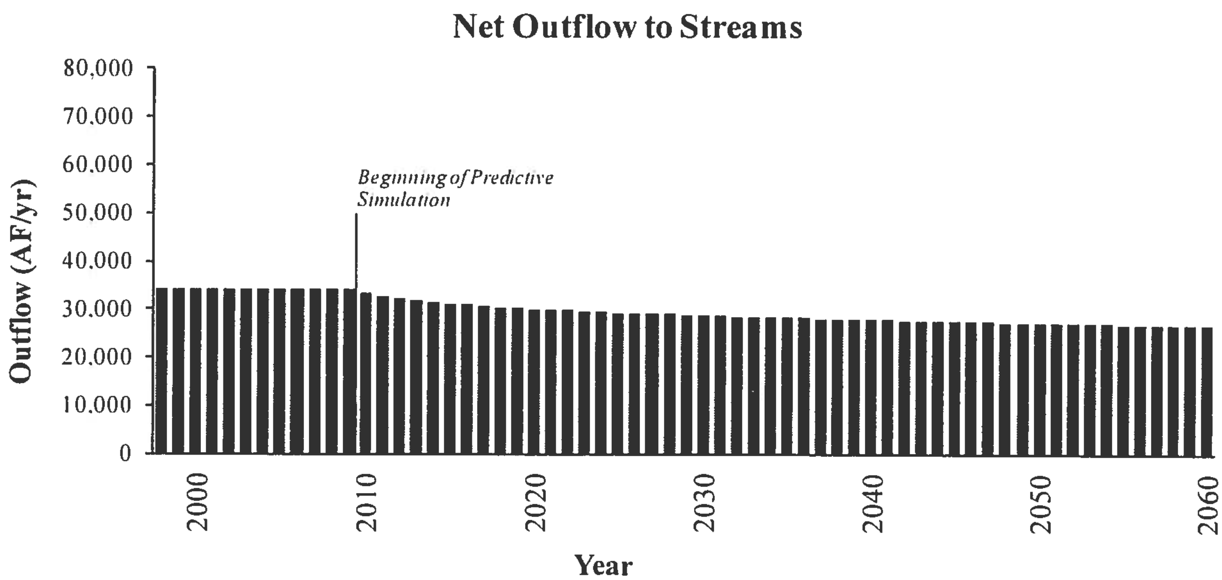


Figure C-6. Net outflow to streams from the Dockum Aquifer in Groundwater Management Area 7. AF/yr is acre-feet per year.

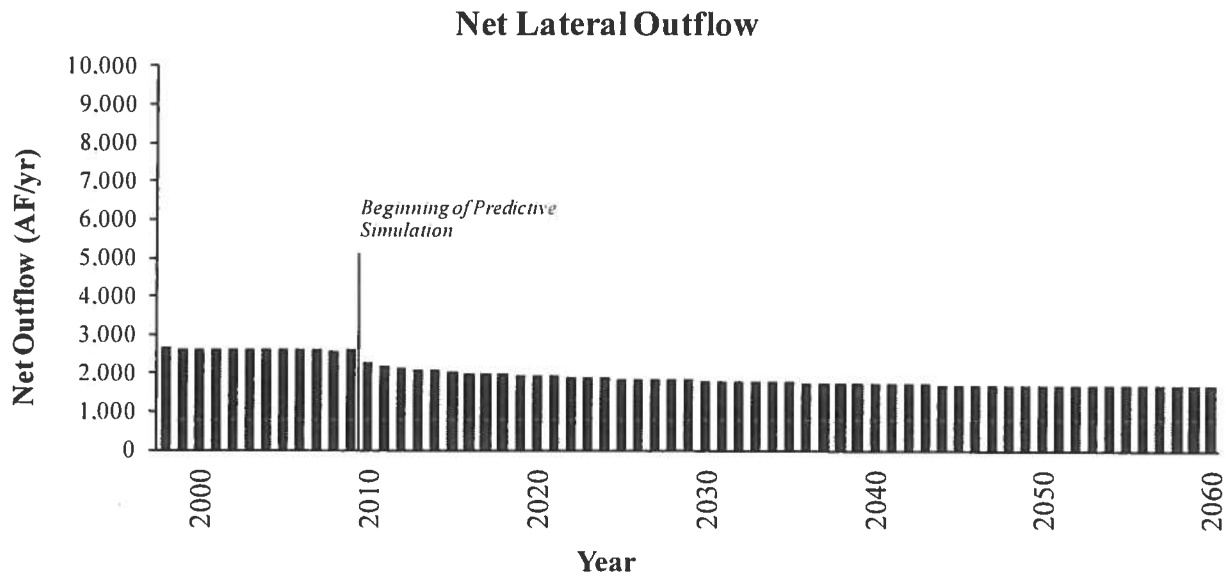


Figure C-7. Net lateral outflow to adjacent areas from the lower portion of the Dockum Aquifer in Groundwater Management Area 7. AF/yr is acre-feet per year.

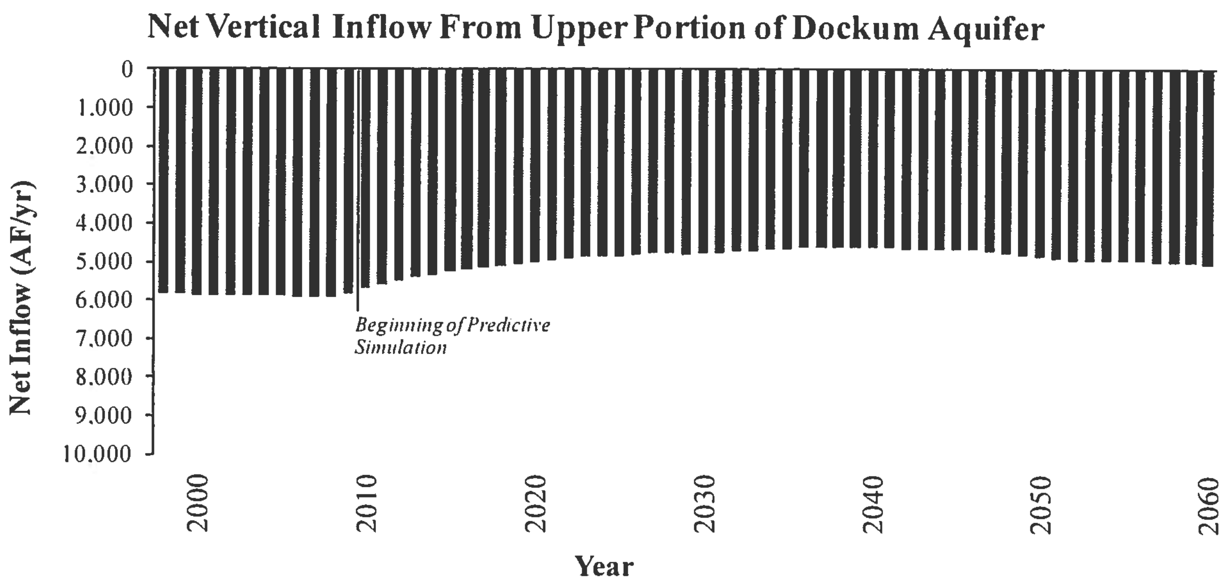


Figure C-8. Net vertical inflow from the upper portion of the Dockum Aquifer to the lower portion of the Dockum Aquifer in Groundwater Management Area 7. AF/yr is acre-feet per year.

Appendix D

Water budget tables by county, groundwater conservation district, and groundwater management area for 2060 in the predictive model run

Table D-1. Water budgets by county in Groundwater Management Area 7 for the last stress period of the groundwater model run (2060). All values are reported in acre-feet per year.

	Coke		Crockett		Ector		Glasscock		Irion		Midland		Mitchell	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Inflow														
Drains	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Overlying Aquifers	0	33	0	226	4,094	2,742	0	2,673	0	48	1,883	561	0	172
Recharge	0	105	0	0	0	0	0	0	0	0	0	0	0	19,472
Stream Interaction	0	0	0	0	0	0	0	0	0	0	0	0	0	5,924
Vertical Leakage Upper	-	0	-	0	-	4,074	-	0	-	0	-	1,891	-	0
Vertical Leakage Lower	0	-	0	-	529	-	0	-	0	-	379	-	0	-
Lateral Flow	0	49	0	103	56	196	0	4,725	0	104	68	2,148	0	21,834
Total Inflow	*0*	*187*	*0*	*329*	*4,679*	*7,012*	*0*	*7,398*	*0*	*152*	*2,330*	*4,600*	*0*	*47,402*
Outflow														
Wells	0	0	0	2	0	528	0	0	0	0	0	0	0	14,018
Springs and Evapotranspiration	0	0	0	0	0	0	0	0	0	0	0	0	0	9,686
Overlying Aquifers	0	2	0	306	694	0	0	3	0	149	575	27	0	0
Stream Interaction	0	0	0	0	0	0	0	0	0	0	0	0	0	26,796
Vertical Leakage Upper	0	0	0	0	0	529	0	0	0	0	0	379	0	0
Vertical Leakage Lower	0	-	0	-	4,074	-	0	-	0	-	1,891	-	0	-
Lateral Flow	0	190	0	22	96	6,098	0	8,535	0	3	17	5,783	0	67
Total Outflow	*0*	*192*	*0*	*330*	*4,864*	*7,155*	*0*	*8,538*	*0*	*152*	*2,483*	*6,189*	*0*	*50,567*
Inflow - Outflow	**0**	**-5**	**0**	**-1**	**-185**	**-143**	**0**	**-1,140**	**0**	**0**	**-153**	**-1,589**	**0**	**-3,165**
Storage Change	**0**	**-5**	**0**	**-1**	**-184**	**-143**	**0**	**-1,139**	**0**	**0**	**-153**	**-1,587**	**0**	**-3,168**
Model Error	**0**	**0**	**0**	**0**	**-1**	**0**	**0**	**-1**	**0**	**0**	**0**	**-2**	**0**	**3**
Model Error (percent)	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.03**	**0.00**	**0.01**

Table D-1. Continued.

	Nolan		Pecos		Reagan		Scurry		Sterling		Tom Green		Upton	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Inflow														
Drains	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Overlying Aquifers	0	0	0	2,659	0	758	0	0	0	1,859	0	9	0	1,632
Recharge	0	7,135	0	0	0	0	0	20,229	0	439	0	0	0	0
Stream Interaction	0	289	0	0	0	0	0	4,479	0	84	0	0	0	0
Vertical Leakage Upper	-	0	-	0	-	0	-	0	-	0	-	0	-	0
Vertical Leakage Lower	0	-	0	-	0	-	0	-	0	-	0	-	0	-
Lateral Flow	0	206	0	1,007	0	1,438	0	3,813	0	4,470	0	31	0	885
Total Inflow	*0*	*7,630*	*0*	*3,666*	*0*	*2,196*	*0*	*28,521*	*0*	*6,852*	*0*	*40*	*0*	*2,517*
Outflow														
Wells	0	5,750	0	777	0	2,064	0	1,209	0	10	0	0	0	219
Springs and Evapotranspiration	0	25	0	0	0	0	0	9,512	0	0	0	0	0	0
Overlying Aquifers	0	0	0	1,703	0	16	0	0	0	344	0	17	0	134
Stream Interaction	0	464	0	0	0	0	0	10,053	0	185	0	0	0	0
Vertical Leakage Upper	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vertical Leakage Lower	0	-	0	-	0	-	0	-	0	-	0	-	0	-
Lateral Flow	0	2,903	0	1,186	0	121	0	8,053	0	6,659	0	24	0	2,337
Total Outflow	*0*	*9,142*	*0*	*3,666*	*0*	*2,201*	*0*	*28,827*	*0*	*7,198*	*0*	*41*	*0*	*2,690*
Inflow - Outflow	**0**	**-1,512**	**0**	**0**	**0**	**-5**	**0**	**-306**	**0**	**-346**	**0**	**-1**	**0**	**-173**
Storage Change	0	**-1,512**	**0**	**0**	**0**	**-5**	**0**	**-306**	**0**	**-345**	**0**	**0**	**0**	**-173**
Model Error	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**-1**	**0**	**-1**	**0**	**0**
Model Error (percent)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**2.47**	**0.00**	**0.00**

Table D-2. Water budgets by groundwater conservation district (GCD) in Groundwater Management Area 7 for the last stress period of the groundwater model run (2060). All values are reported in acre-feet per year. The abbreviation for Underground Water Conservation District is UWCD and Water Conservation District is WCD.

	Coke County UWCD		Crockett County GCD		Glasscock GCD		Irion County WCD		Lone Wolf GCD	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Inflow										
Overlying Aquifers	0	33	0	226	0	2,778	0	51	0	172
Recharge	0	105	0	0	0	0	0	0	0	19,472
Stream Interaction	0	0	0	0	0	0	0	0	0	5,924
Vertical Leakage Upper	-	0	-	0	-	0	-	0	-	0
Vertical Leakage Lower	0	-	0	-	0	-	0	-	0	-
Lateral Flow	0	49	0	103	0	6,292	0	109	0	21,834
Total Inflow	*0*	*187*	*0*	*329*	*0*	*9,070*	*0*	*160*	*0*	*47,402*
Outflow										
Wells	0	0	0	2	0	1,027	0	0	0	14,018
Springs and Evapotranspiration	0	0	0	0	0	0	0	0	0	9,686
Overlying Aquifers	0	2	0	306	0	3	0	149	0	0
Stream Interaction	0	0	0	0	0	0	0	0	0	26,796
Vertical Leakage Upper	0	0	0	0	0	0	0	0	0	0
Vertical Leakage Lower	0	-	0	-	0	-	0	-	0	-
Lateral Flow	0	190	0	22	0	9,180	0	11	0	67
Total Outflow	*0*	*192*	*0*	*330*	*0*	*10,210*	*0*	*160*	*0*	*50,567*
Inflow - Outflow	**0**	**-5**	**0**	**-1**	**0**	**-1,140**	**0**	**0**	**0**	**-3,165**
Storage Change	**0**	**-5**	**0**	**-1**	**0**	**-1,139**	**0**	**0**	**0**	**-3,168**
Model Error	**0**	**0**	**0**	**0**	**0**	**-1**	**0**	**0**	**0**	**3**
Model Error (percent)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.01**

Table D-2. Continued.

	Middle Pecos GCD		Santa Rita UWCD		Sterling County UWCD		Wes-Tex GCD	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Inflow								
Overlying Aquifers	0	2,659	0	653	0	1,859	0	0
Recharge	0	0	0	0	0	439	0	7,135
Stream Interaction	0	0	0	0	0	84	0	289
Vertical Leakage Upper	-	0	-	0	-	0	-	0
Vertical Leakage Lower	0	-	0	-	0	-	0	-
Lateral Flow	0	1,007	0	1,919	0	4,471	0	206
Total Inflow	*0*	*3,666*	*0*	*2,572*	*0*	*6,853*	*0*	*7,630*
Outflow								
Wells	0	777	0	1,037	0	10	0	5,750
Springs and Evapotranspiration	0	0	0	0	0	0	0	25
Overlying Aquifers	0	1,703	0	16	0	347	0	0
Stream Interaction	0	0	0	0	0	185	0	464
Vertical Leakage Upper	0	0	0	0	0	0	0	0
Vertical Leakage Lower	0	-	0	-	0	-	0	-
Lateral Flow	0	1,186	0	1,524	0	6,656	0	2,903
Total Outflow	*0*	*3,666*	*0*	*2,577*	*0*	*7,198*	*0*	*9,142*
Inflow - Outflow	**0**	**0**	**0**	**-5**	**0**	**-345**	**0**	**-1,512**
Storage Change	**0**	0	**0**	**-4**	**0**	**-345**	**0**	**-1,512**
Model Error	0	**0**	**0**	**-1**	**0**	**0**	**0**	0
Model Error (percent)	**0.00**	**0.00**	**0.00**	**0.04**	**0.00**	**0.00**	**0.00**	**0.00**

Table D-3. Water budgets by groundwater management area (GMA) for the last stress period of the groundwater model run (2060). All values are reported in acre-feet per year.

	Out-of-State		GMA 1		GMA 2		GMA 3		GMA 6		GMA 7	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Inflow												
Overlying Aquifers	34,181	19,726	510	25,803	15,885	3,505	1,064	9,499	0	341	5,977	11,690
Recharge	44	1,142	0	8,834	26	21,783	0	0	0	7,974	0	47,369
Stream Interaction	0	78	0	4,279	535	20,406	0	0	0	1,022	0	10,776
Vertical Leakage Upper	-	14,768	-	662	-	20,597	-	1,268	-	0	-	5,965
Vertical Leakage Lower	4,434	-	0	-	8,187	-	280	-	0	-	908	-
Lateral Flow	23	1,032	45	18,898	2,329	13,025	153	7,900	0	2,983	106	15,532
Total Inflow	*38,682*	*36,746*	*555*	*58,476*	*26,962*	*79,316*	*1,497*	*18,667*	*0*	*12,320*	*6,991*	*91,332*
Outflow												
Wells	0	7,793	0	107,175	0	9,598	0	4,231	0	69	0	23,802
Springs and Evapotranspiration	0	2,107	0	6,491	0	26,506	0	0	0	3,541	0	19,166
Overlying Aquifers	21,994	5,473	6	3,544	17,505	1,269	324	12,883	0	27	1,269	1,128
Stream Interaction	0	1,941	0	16,628	0	40,262	0	0	0	7,248	0	37,498
Vertical Leakage Upper	0	4,434	0	0	0	8,187	0	280	0	0	0	908
Vertical Leakage Lower	14,768	-	662	-	20,597	-	1,268	-	0	-	5,965	-
Lateral Flow	2,292	20,258	19	1,464	251	17,003	0	1,505	0	1,925	95	17,215
Total Outflow	*39,054*	*42,006*	*687*	*135,302*	*38,353*	*102,825*	*1,592*	*18,899*	*0*	*12,810*	*7,329*	*99,717*
Inflow - Outflow	**-372**	**-5,260**	**-132**	**-76,826**	**-11,391**	**-23,509**	**-95**	**-232**	**0**	**-490**	**-338**	**-8,385**
Storage Change	**-363**	**-5,254**	**-132**	**-76,806**	**-11,386**	**-23,499**	**-95**	**-231**	**0**	**-491**	**-337**	**-8,385**
Model Error	**-9**	**-6**	**0**	**-20**	**-5**	**-10**	**0**	**-1**	**0**	**1**	**-1**	**0**
Model Error (percent)	**0.02**	**0.01**	**0.00**	**0.01**	**0.01**	**0.01**	**0.00**	**0.01**	**0.00**	**0.01**	**0.01**	**0.00**

Appendix
B

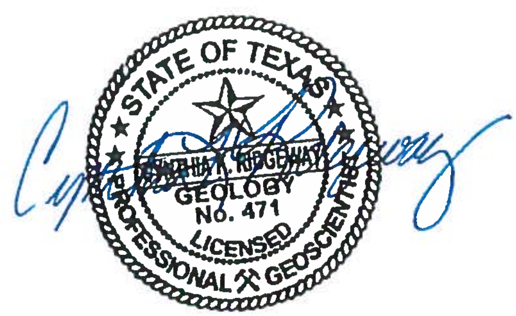
GAM Run 10-040 MAG Version 2

By Mohammad Masud Hassan, P.E.

Edited and finalized by Wade Oliver to reflect statutory changes
effective September 1, 2011

Updated to Version 2 by Shirley Wade to reflect refined modeled available groundwater estimates

Texas Water Development Board
Groundwater Availability Modeling Section
(512) 936-0883
June 22, 2012



Cynthia K. Ridgeway, the Manager of the Groundwater Availability Modeling Section, is responsible for oversight of work performed by employees under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on June 22, 2012.

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EXECUTIVE SUMMARY:

The modeled available groundwater for the Dockum Aquifer as a result of the desired future conditions adopted by the districts of Groundwater Management Area 7 is approximately 21,700 acre-feet per year. The estimates were extracted from the "base" scenario in Groundwater Availability Model Run 10-001, which meets the desired future conditions adopted by the districts of Groundwater Management Area 7. These desired future conditions are drawdown limits set for the upper and lower portions of the Dockum Aquifer in Ector, Midland, Mitchell, Nolan, Pecos, Scurry, and Upton counties. The Dockum Aquifer is deemed not relevant in the remaining counties in Groundwater Management Area 7.

The first version of this report showed modeled available groundwater for areas declared not relevant for joint planning purposes. In this report version we show modeled available groundwater only in areas specified as relevant by Groundwater Management Area 7 in their resolution.

REQUESTOR:

Mr. Allan J. Lange of the Lipan-Kickapoo Water Conservation District on behalf of Groundwater Management Area 7.

DESCRIPTION OF REQUEST:

In a letter dated August 13, 2010, Mr. Allan J. Lange provided the Texas Water Development Board (TWDB) with the desired future conditions of the Dockum Aquifer adopted by the districts of Groundwater Management Area 7. The desired future conditions for the Dockum Aquifer in Groundwater Management Area 7, as described in Resolution No. 07-29-10-1, are:

> *"Upper Dockum, as delineated in Figure 1 of TWDB GAM Run 10-001: net total drawdown not to exceed 29 feet in Midland County; and*
>
> *Lower Dockum Aquifer, as delineated in Figure 1 of TWDB GAM Run 10-001: net total drawdown not to exceed 4 feet in Ector, Mitchell, Pecos, Scurry, and Upton Counties (Lone Wolf GCD, Middle Pecos GCD); and*
>
> *Lower Dockum Aquifer as delineated in Figure 1 of TWDB GAM Run 10-001: Drawdown not to exceed a net total of 39 feet in Nolan County (West-Tex GCD); and*
>
> *The Dockum Aquifer is not relevant for joint planning purposes in all other areas of GMA 7."*

In response to receiving the adopted desired future conditions, the TWDB has estimated the modeled available groundwater for the Dockum Aquifer in Groundwater Management Area 7.

METHODS:

The TWDB previously completed several predictive groundwater availability model simulations of the Dockum Aquifer to assist the districts of Groundwater Management Area 7 in defining desired future conditions. The location of Groundwater Management Area 7, the Dockum Aquifer, and the groundwater availability model cells that represent the aquifer are shown in Figure 1. As stated in Resolution No. 07-29-10-1, the groundwater management area considered Groundwater Availability Model (GAM) Run 10-001 (Oliver, 2010) when defining desired future conditions. Since each of the desired future conditions above is met in the "base" scenario in GAM Run 10-001, the estimated pumping for Groundwater Management Area 7 presented here was taken directly from that simulation. The pumping was then divided by county, regional water planning area, river basin, and groundwater conservation district.

PARAMETERS AND ASSUMPTIONS:

The parameters and assumptions for the model run using the groundwater availability model for the Dockum Aquifer are described below:

- The results presented in this report are taken from the "base" scenario in GAM Run 10-001 (Oliver, 2010). See GAM Run 10-001 for a full description of the methods, assumptions, and results for the groundwater availability model run.

- The modified groundwater availability model for the Dockum Aquifer described in Oliver and Hutchison (2008) was used for this analysis. This model is a modification of the previously developed groundwater availability model for the Dockum Aquifer described in Ewing and others (2008). This model was modified in order to more effectively simulate predictive conditions. See Oliver and Hutchison (2010) and Ewing and others (2008) for assumptions and limitations of the model.

- Layers 2 and 3 of the model represent the upper and lower portions of the Dockum Aquifer, respectively. Layer 1, which is active in version 1.01 of the model documented in Ewing and others (2008), was inactivated in the modified model as described in Oliver and Hutchison (2010).

- Cells were assigned to individual counties and groundwater conservation districts as shown in the September 14, 2009, version of the model grid for the Dockum Aquifer. Because this model grid predates the development of the modified model, care was taken to ensure that only those fields in the model grid that were valid for the modified model were used for analyzing model results.

Modeled Available Groundwater and Permitting

As defined in Chapter 36 of the Texas Water Code, "modeled available groundwater" is the estimated average amount of groundwater that may be produced annually to achieve a desired future condition. Groundwater conservation districts are required to consider modeled available groundwater, along with several other factors, when issuing permits in order to manage groundwater production to achieve the desired future condition(s). The other factors districts must consider include annual precipitation and production patterns, the estimated amount of pumping exempt from permitting, existing permits, and a reasonable estimate of actual groundwater production under existing permits. The estimated amount of pumping exempt from permitting, which the TWDB is required to develop after soliciting input from applicable groundwater conservation districts, will be provided in a separate report.

RESULTS:

The modeled available groundwater for the Dockum Aquifer in Groundwater Management Area 7 consistent with the desired future conditions is approximately 21,700 acre-feet per year. This has been divided by county, regional water planning area, and river basin for each decade between 2010 and 2060 for use in the regional water planning process (Table 1).

The modeled available groundwater is also summarized by county, regional water planning area, river basin, and groundwater conservation district as shown in tables 2, 3, 4, and 5, respectively.

LIMITATIONS:

The groundwater model used in developing estimates of modeled available groundwater is the best available scientific tool that can be used to estimate the pumping that will achieve the desired future conditions. Although the groundwater model used in this analysis is the best available scientific tool for this purpose, it, like all models, has limitations. In reviewing the use of models in environmental regulatory decision-making, the National Research Council (2007) noted:

> "Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects for a particular regulatory application. These characteristics make evaluation of a regulatory model more complex than solely a comparison of measurement data with model results."

A key aspect of using the groundwater model to develop estimates of modeled available groundwater is the need to make assumptions about the location in the aquifer where future pumping will occur. As actual pumping changes in the future, it will be necessary to evaluate the amount of that pumping as well as its location in the context of the assumptions associated with this analysis. Evaluating the amount and location of future pumping is as important as evaluating the changes in groundwater levels, spring flows, and other metrics that describe the condition of the groundwater resources in the area that relate to the adopted desired future condition(s).

Given these limitations, users of this information are cautioned that the modeled available groundwater numbers should not be considered a definitive, permanent description of the amount of groundwater that can be pumped to meet the adopted desired future condition. Because the application of the groundwater model was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations relating to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor future groundwater pumping as well as whether or not they are achieving their desired future conditions. Because of the limitations of the model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine the modeled available groundwater numbers given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future.

REFERENCES:

Ewing, J.E., Jones, T.L., Yan, T., Vreugdenhil, A.M., Fryar, D.G., Pickens, J.F., Gordon, K., Nicot, J.P., Scanlon, B.R., Ashworth, J.B., Beach, J., 2008, Groundwater Availability Model for the Dockum Aquifer – Final Report: contract report to the Texas Water Development Board, 510 p.

National Research Council, 2007, Models in Environmental Regulatory Decision Making. Committee on Models in the Regulatory Decision Process, National Academies Press, Washington D.C., 287 p.

Oliver, W., 2010, GAM Run 10-001: Texas Water Development Board, GAM Run 10-001 Report, 36 p.

Oliver, W., Hutchison, W.R., 2010, Modification and recalibration of the Groundwater Availability Model of the Dockum Aquifer: Texas Water Development Board, 114 p.

Smith, R., 2009, GAM Run 09-001: Texas Water Development Board, GAM Run 09-001 Draft Report, 28 p.

Table 1: Modeled available groundwater for the Dockum Aquifer in Groundwater Management Area 7. Results are in acre-feet per year and are divided by county, regional water planning area, and river basin.

County	Regional Water Planning	River Basin	Year 2010	2020	2030	2040	2050	2060
Ector	F	Colorado	13	13	13	13	13	13
		Rio Grande	515	515	515	515	515	515
Midland	F	Colorado	0	0	0	0	0	0
Mitchell	F	Colorado	14,018	14,018	14,018	14,018	14,018	14,018
Nolan	G	Brazos	2,824	2,824	2,824	2,824	2,824	2,824
		Colorado	2,926	2,926	2,926	2,926	2,926	2,926
Pecos	F	Rio Grande	3	3	3	3	3	3
Scurry	F	Brazos	306	306	306	306	306	306
		Colorado	903	903	903	903	903	903
Upton	F	Colorado	0	0	0	0	0	0
		Rio Grande	219	219	219	219	219	219
Total			**21,727**	**21,727**	**21,727**	**21,727**	**21,727**	**21,727**

Table 2: Modeled available groundwater for the Dockum Aquifer summarized by county in Groundwater Management Area 7 for each decade between 2010 and 2060. Results are in acre-feet per year.

County	Year					
	2010	2020	2030	2040	2050	2060
Ector	528	528	528	528	528	528
Midland	0	0	0	0	0	0
Mitchell	14,018	14,018	14,018	14,018	14,018	14,018
Nolan	5,750	5,750	5,750	5,750	5,750	5,750
Pecos	3	3	3	3	3	3
Scurry	1,209	1,209	1,209	1,209	1,209	1,209
Upton	219	219	219	219	219	219
Total	**21,727**	**21,727**	**21,727**	**21,727**	**21,727**	**21,727**

Table 3: Modeled available groundwater for the Dockum Aquifer summarized by regional water planning area in Groundwater Management Area 7 for each decade between 2010 and 2060. Results are in acre-feet per year.

Regional Water Planning Area	Year					
	2010	2020	2030	2040	2050	2060
F	15,977	15,977	15,977	15,977	15,977	15,977
G	5,750	5,750	5,750	5,750	5,750	5,750
Total	**21,727**	**21,727**	**21,727**	**21,727**	**21,727**	**21,727**

Table 4: Modeled available groundwater for the Dockum Aquifer summarized by river basin in Groundwater Management Area 7 for each decade between 2010 and 2060. Results are in acre-feet per year.

Basin	Year					
	2010	2020	2030	2040	2050	2060
Brazos	3,130	3,130	3,130	3,130	3,130	3,130
Colorade	17,860	17,860	17,860	17,860	17,860	17,860
Rio Grande	737	737	737	737	737	737
Total	**21,727**	**21,727**	**21,727**	**21,727**	**21,727**	**21,727**

Table 5: Modeled available groundwater for the Dockum Aquifer summarized by groundwater conservation district in Groundwater Management Area 7 for each decade between 2010 and 2060. Results are in acre-feet per year.

Groundwater Conservation District	Year					
	2010	2020	2030	2040	2050	2060
Lone Wolf	14,018	14,018	14,018	14,018	14,018	14,018
Middle Pecos	3	3	3	3	3	3
Wes-Tex	5,750	5,750	5,750	5,750	5,750	5,750
No District	1,956	1,956	1,956	1,956	1,956	1,956
Total	**21,727**	**21,727**	**21,727**	**21,727**	**21,727**	**21,727**

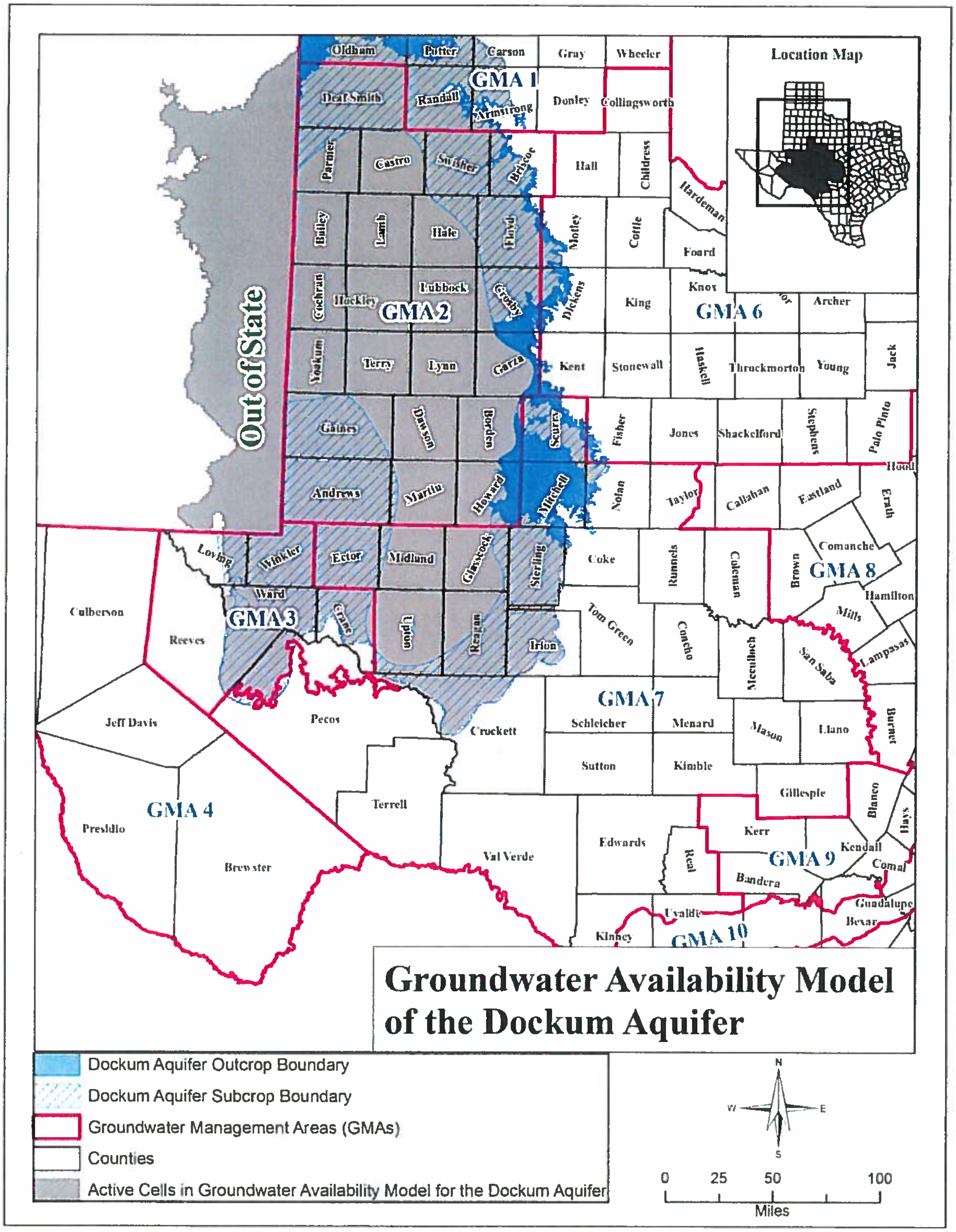

Figure 1: Map showing the areas covered by the groundwater model for the Dockum Aquifer.

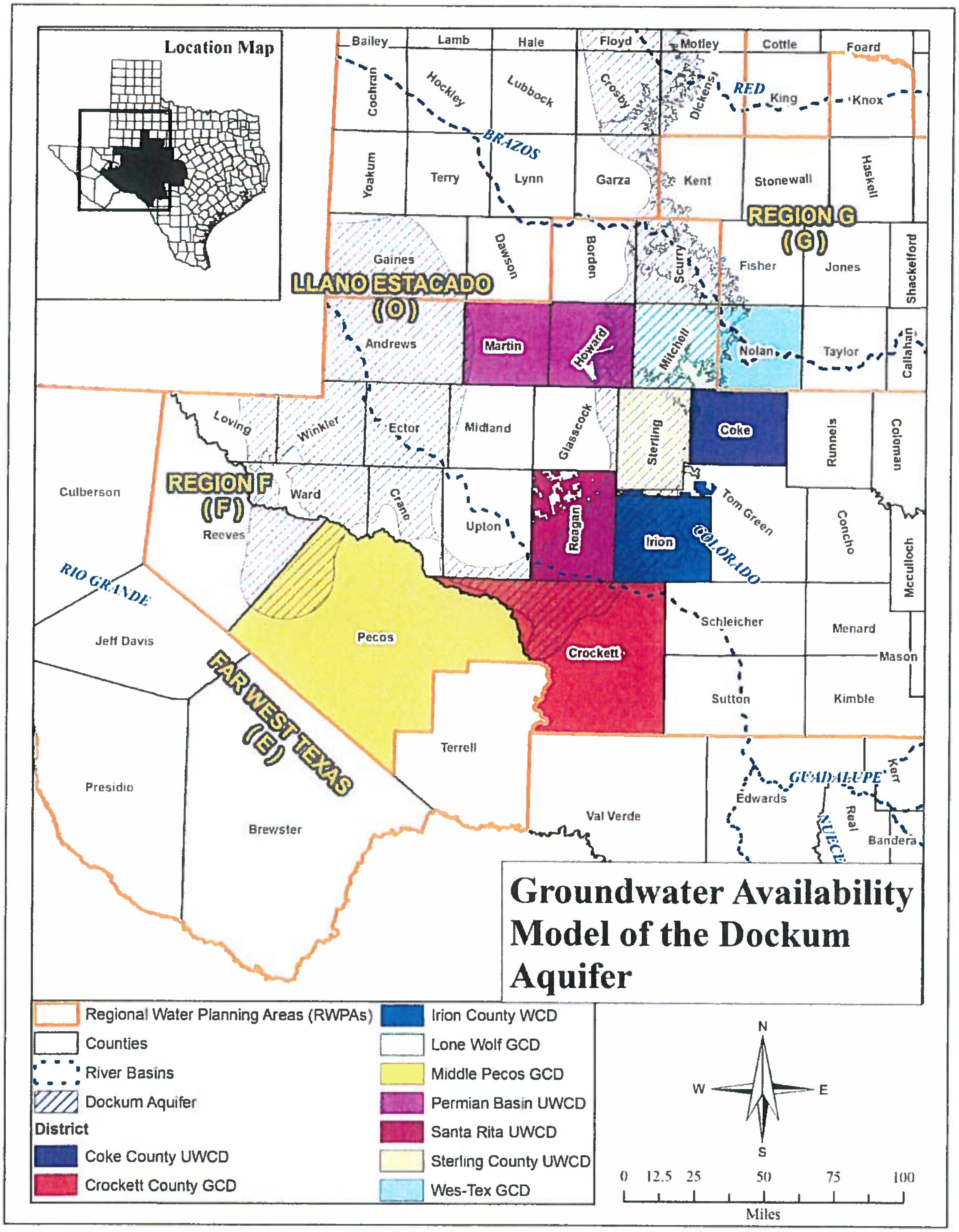

Figure 2: Map showing regional water planning areas (RWPAs), groundwater conservation districts (GCDs), counties, and river basins in Groundwater Management Area 7.

Appendix
C

Estimated Historical Water Use And 2012 State Water Plan Datasets:

Lone Wolf Groundwater Conservation District

by Stephen Allen
Texas Water Development Board
Groundwater Resources Division
Groundwater Technical Assistance Section
stephen.allen@twdb.texas.gov
(512) 463-7317
June 10, 2014

GROUNDWATER MANAGEMENT PLAN DATA:

This package of water data reports (part 1 of a 2-part package of information) is being provided to groundwater conservation districts to help them meet the requirements for approval of their five-year groundwater management plan. Each report in the package addresses a specific numbered requirement in the Texas Water Development Board's groundwater management plan checklist. The checklist can be viewed and downloaded from this web address:

http://www.twdb.texas.gov/groundwater/docs/GCD/GMPChecklist0113.pdf

The five reports included in part 1 are:

1. Estimated Historical Water Use (checklist Item 2)

   from the TWDB Historical Water Use Survey (WUS)
2. Projected Surface Water Supplies (checklist Item 6)
3. Projected Water Demands (checklist Item 7)
4. Projected Water Supply Needs (checklist Item 8)
5. Projected Water Management Strategies (checklist Item 9)

   reports 2-5 are from the 2012 Texas State Water Plan (SWP)

Part 2 of the 2-part package is the groundwater availability model (GAM) report. The District should have received, or will receive, this report from the Groundwater Availability Modeling Section. Questions about the GAM can be directed to Dr. Shirley Wade, shirley.wade@twdb.texas.gov, (512) 936-0883.

DISCLAIMER:

The data presented in this report represents the most up-to-date WUS and 2012 SWP data available as of 6/10/2014. Although it does not happen frequently, neither of these datasets are static so they are subject to change pending the availability of more accurate WUS data or an amendment to the 2012 SWP. District personnel must review these datasets and correct any discrepancies in order to ensure approval of their groundwater management plan.

The WUS dataset can be verified at this web address:

http://www.twdb.texas.gov/waterplanning/waterusesurvey/estimates/

The 2012 SWP dataset can be verified by contacting Sabrina Anderson (sabrina.anderson@twdb.texas.gov or 512-936-0886).

For additional questions regarding this data, please contact Stephen Allen (stephen.allen@twdb.texas.gov or 512-463-7317) or Rima Petrossian (rima.petrossian@twdb.texas.gov or 512-936-2420).

Estimated Historical Water Use
TWDB Historical Water Use Survey (WUS) Data

Groundwater and surface water historical use estimates are currently unavailable for calendar year 2012. TWDB staff anticipates the calculation and posting of these estimates at a later date.

MITCHELL COUNTY

All values are in acre-fee/year

Year	Source	Municipal	Manufacturing	Mining	Steam Electric	Irrigation	Livestock	Total
2011	GW	1,521	0	180	3	10,146	103	11,953
	SW	97	0	96	3,173	0	307	3,673
2010	GW	1,387	0	229	3	9,443	99	11,161
	SW	75	0	122	3,177	0	298	3,672
2009	GW	1,180	0	254	7	11,575	94	13,110
	SW	79	0	135	3,237	0	280	3,731
2008	GW	1,214	0	278	13	8,092	103	9,700
	SW	72	0	148	2,883	0	310	3,413
2007	GW	1,367	0	0	26	9,870	80	11,343
	SW	26	0	0	12	0	241	279
2006	GW	1,483	0	0	17	7,306	77	8,883
	SW	26	0	0	12	0	232	270
2005	GW	1,745	0	0	17	5,931	76	7,769
	SW	75	0	0	12	0	228	315
2004	GW	1,560	0	0	0	5,826	30	7,416
	SW	42	0	0	567	0	272	881
2003	GW	1,065	0	0	0	5,188	30	6,283
	SW	40	0	0	2,295	0	271	2,606
2002	GW	1,385	0	0	0	3,670	35	5,090
	SW	52	0	0	3,450	0	316	3,818
2001	GW	926	0	0	0	3,423	42	4,391
	SW	80	0	0	2,338	0	374	2,792
2000	GW	917	0	0	0	5,549	44	6,510
	SW	273	0	0	65	15	399	752

Projected Surface Water Supplies
TWDB 2012 State Water Plan Data

MITCHELL COUNTY

All values are in acre-feet/year

RWPG	WUG	WUG Basin	Source Name	2010	2020	2030	2040	2050	2060
F	COLORADO CITY	COLORADO	COLORADO CITY-CHAMPION LAKE/RESERVOIR SYSTEM	0	0	0	0	0	0
F	IRRIGATION	COLORADO	COLORADO RIVER COMBINED RUN-OF-RIVER IRRIGATION	15	15	15	15	15	15
F	LIVESTOCK	COLORADO	LIVESTOCK LOCAL SUPPLY	381	381	381	381	381	381
F	MINING	COLORADO	COLORADO RIVER RUN-OF-RIVER CRMWD DIVERTED WATER	0	0	0	0	0	0
F	STEAM ELECTRIC POWER	COLORADO	COLORADO CITY-CHAMPION LAKE/RESERVOIR SYSTEM	0	0	0	0	0	0
	Sum of Projected Surface Water Supplies (acre-feet/year)			**396**	**396**	**396**	**396**	**396**	**396**

Projected Water Demands
TWDB 2012 State Water Plan Data

Please note that the demand numbers presented here include the plumbing code savings found in the Regional and State Water Plans.

MITCHELL COUNTY

All values are in acre-feet/year

RWPG	WUG	WUG Basin	2010	2020	2030	2040	2050	2060
F	MINING	COLORADO	115	110	108	107	106	104
F	IRRIGATION	COLORADO	5,534	5,507	5,479	5,452	5,425	5,398
F	LIVESTOCK	COLORADO	449	449	449	449	449	449
F	STEAM ELECTRIC POWER	COLORADO	5,023	4,847	4,670	4,493	4,317	4,140
F	COLORADO CITY	COLORADO	997	980	949	914	879	826
F	LORAINE	COLORADO	85	82	79	75	71	67
F	COUNTY-OTHER	COLORADO	621	609	593	570	549	516
	Sum of Projected Water Demands (acre-feet/year)		**12,824**	**12,584**	**12,327**	**12,060**	**11,796**	**11,500**

Projected Water Supply Needs
TWDB 2012 State Water Plan Data

Negative values (in red) reflect a projected water supply need, positive values a surplus.

MITCHELL COUNTY

All values are in acre-feet/year

RWPG	WUG	WUG Basin	2010	2020	2030	2040	2050	2060
F	COLORADO CITY	COLORADO	0	19	52	90	129	187
F	COUNTY-OTHER	COLORADO	0	0	0	0	0	0
F	IRRIGATION	COLORADO	30	57	85	112	139	166
F	LIVESTOCK	COLORADO	0	0	0	0	0	0
F	LORAINE	COLORADO	25	28	31	35	39	43
F	MINING	COLORADO	26	31	33	34	35	37
F	STEAM ELECTRIC POWER	COLORADO	-5,023	-4,847	-4,670	-4,493	-4,317	-4,140
	Sum of Projected Water Supply Needs (acre-feet/year)		**-5,023**	**-4,847**	**-4,670**	**-4,493**	**-4,317**	**-4,140**

Projected Water Management Strategies
TWDB 2012 State Water Plan Data

MITCHELL COUNTY

WUG, Basin (RWPG)

All values are in acre-feet/year

Water Management Strategy	Source Name [Origin]	2010	2020	2030	2040	2050	2060
COLORADO CITY, COLORADO (F)							
DEVELOP DOCKUM AQUIFER SUPPLIES	DOCKUM AQUIFER [MITCHELL]	0	2,200	2,200	2,200	2,200	2,200
IRRIGATION, COLORADO (F)							
IRRIGATION CONSERVATION	CONSERVATION [MITCHELL]	0	865	1,729	1,729	1,729	1,729
WEATHER MODIFICATION	WEATHER MODIFICATION [MITCHELL]	0	0	0	0	0	0
STEAM ELECTRIC POWER, COLORADO (F)							
SUBORDINATION	COLORADO CITY-CHAMPION LAKE/RESERVOIR SYSTEM [RESERVOIR]	5,023	4,847	4,670	4,493	4,317	4,140
Sum of Projected Water Management Strategies (acre-feet/year)		**5,023**	**7,912**	**8,599**	**8,422**	**8,246**	**8,069**

Appendix D

GAM Run 13-015: Lone Wolf Groundwater Conservation District Management Plan

by Chelsea Seiter-Weatherford
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 936-0883
June 27, 2013

Cynthia K. Ridgeway is the Manager of the Groundwater Availability Modeling Section and is responsible for oversight of work performed by Chelsea Seiter-Weatherford under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on June 27, 2013.

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GAM RUN 13-015: LONE WOLF GROUNDWATER CONSERVATION DISTRICT MANAGEMENT PLAN

By Chelsea Seiter-Weatherford
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 936-0883
June 27, 2013

EXECUTIVE SUMMARY:

Texas State Water Code, Section 36.1071, Subsection (h), states that, in developing its groundwater management plan, a groundwater conservation district shall use groundwater availability modeling information provided by the executive administrator of the Texas Water Development Board (TWDB) in conjunction with any available site-specific information provided by the district for review and comment to the executive administrator. Information derived from groundwater availability models that shall be included in the groundwater management plan includes:

- the annual amount of recharge from precipitation to the groundwater resources within the district, if any;
- for each aquifer within the district, the annual volume of water that discharges from the aquifer to springs and any surface water bodies, including lakes, streams, and rivers; and
- the annual volume of flow into and out of the district within each aquifer and between aquifers in the district.

This report (Part 2 of a two-part package of information from the TWDB to Lone Wolf Groundwater Conservation District) fulfills the requirements noted above. Part 1 of the 2-part package is the Historical Water Use/State Water Plan data report. The district will receive this data report from the TWDB Groundwater Technical Assistance Section. Questions about the data report can be directed to Mr. Stephen Allen, Stephen.Allen@twdb.texas.gov, (512) 463-7317.

The groundwater management plan for the Lone Wolf Groundwater Conservation District should be adopted by the district on or before August 6, 2014 and submitted to the executive administrator of the TWDB on or before September 5, 2014. The current management plan for the Lone Wolf Groundwater Conservation District expires on November 4, 2014.

This report discusses the methods, assumptions, and results from model runs using the groundwater availability model for the Dockum Aquifer. Table 1 summarizes the groundwater availability model data required by the statute, and Figure 1 shows the area of the model from which the values in the table were extracted. This model run replaces the results of GAM Run 08-48 (Oliver, 2009). GAM Run 13-015 meets current standards set after the release of GAM Run 08-48 including use of the extent of the official aquifer boundaries within the district instead of the entire active area of the model within the district. In addition discharge from model cells representing springs was added to the discharge to surface water bodies. If after review of the figures, Lone Wolf Groundwater Conservation District determines that the district boundaries used in the assessment do not reflect current conditions, please notify the Texas Water Development Board immediately. Per statute TWDB is required to provide the districts with data from the official groundwater availability models; however, the TWDB has also approved, for planning purposes, an alternative model for the Dockum Aquifer. Please contact Cindy Ridgeway at (512)936-2386 or cindy.ridgeway@twdb.texas.gov if a comparison table using this alternative model is desired.

METHODS:

In accordance with the provisions of the Texas State Water Code, Section 36.1071, Subsection (h), the groundwater availability model for the Dockum Aquifer was run for this analysis. Lone Wolf Groundwater Conservation District water budgets were extracted for each year of the historical model periods using ZONEBUDGET Version 3.01 (Harbaugh, 2009). The average annual water budget values for recharge, surface water outflow, inflow to the district, outflow from the district, net inter-aquifer flow (upper), and net inter-aquifer flow (lower) for the portion of the aquifer located within the district is summarized in this report.

PARAMETERS AND ASSUMPTIONS:

Dockum Aquifer

- We used Version 1.01 of the groundwater availability model for the Dockum Aquifer. See Ewing and others (2008) for assumptions and limitations of the groundwater availability model for the Dockum Aquifer.
- This groundwater availability model includes three layers which generally represent the Ogallala, Edwards-Trinity (High Plains), Edwards-Trinity (Plateau), Pecos Valley, and Rita Blanca aquifers (Layer 1), the upper portion of the Dockum Aquifer (Layer2), and the lower portion of the Dockum Aquifer (Layer 3).
- The geologic units represented in Layer 1 of the groundwater availability model are only included in the model for the purpose of more accurately representing flow between these units and the Dockum Aquifer. This model is not intended to explicitly simulate flow in these overlying units (Ewing and others, 2008).
- The MODFLOW Drain package was used to simulate both evapotranspiration and springs. Only drain flow from model grid cells representing springs within the district were incorporated into the surface water outflow values shown in Table 1.
- Groundwater in the Dockum Aquifer ranges from fresh to brine in composition (Ewing and others, 2008). Groundwater with total dissolved solids of less than 1,000 milligrams per liter are considered fresh, total dissolved solids of 1,000 to 10,000 milligrams per liter are considered brackish, and total dissolved solids greater than 35,000 milligrams per liter are considered brines.
- The model was run with MODFLOW-2000 (Harbaugh and others, 2000).

RESULTS:

A groundwater budget summarizes the amount of water entering and leaving the aquifer according to the groundwater availability model. Selected groundwater budget components listed below were extracted from the model results for the aquifers located within the district and averaged over the duration of the calibration and verification portion of the model run in the district, as shown in Table 1.

- Precipitation recharge—The areally distributed recharge sourced from precipitation falling on the outcrop areas of the aquifers (where the aquifer is exposed at land surface) within the district.

- Surface water outflow—The total water discharging from the aquifer (outflow) to surface water features such as streams, reservoirs, and drains (springs).

- Flow into and out of district—The lateral flow within the aquifer between the district and adjacent counties.

- Flow between aquifers—The net vertical flow between aquifers or confining units. This flow is controlled by the relative water levels in each aquifer or confining unit and aquifer properties of each aquifer or confining unit that define the amount of leakage that occurs. "Inflow" to an aquifer from an overlying or underlying aquifer will always equal the "Outflow" from the other aquifer.

The information needed for the District's management plan is summarized in Table 1. It is important to note that sub-regional water budgets are not exact. This is due to the size of the model cells and the approach used to extract data from the model. To avoid double accounting, a model cell that straddles a political boundary, such as a district or county boundary, is assigned to one side of the boundary based on the location of the centroid of the model cell. For example, if a cell contains two counties, the cell is assigned to the county where the centroid of the cell is located (Figure 1).

TABLE 1: SUMMARIZED INFORMATION FOR THE DOCKUM AQUIFER THAT IS NEEDED FOR THE LONE WOLF GROUNDWATER CONSERVATION DISTRICT'S GROUNDWATER MANAGEMENT PLAN. ALL VALUES ARE REPORTED IN ACRE-FEET PER YEAR AND ROUNDED TO THE NEAREST 1 ACRE-FOOT.

Management Plan requirement	*Aquifer or confining unit*	*Dockum Aquifer*
Estimated annual amount of recharge from precipitation to the district	Dockum Aquifer	19,469
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Dockum Aquifer	6,858[1]
Estimated annual volume of flow into the district within each aquifer in the district	Dockum Aquifer	1,357
Estimated annual volume of flow out of the district within each aquifer in the district	Dockum Aquifer	434
Estimated net annual volume of flow between each aquifer in the district	From overlying units to the Dockum Aquifer	194

[1] Drains in spring cells were added to stream discharge from the model.

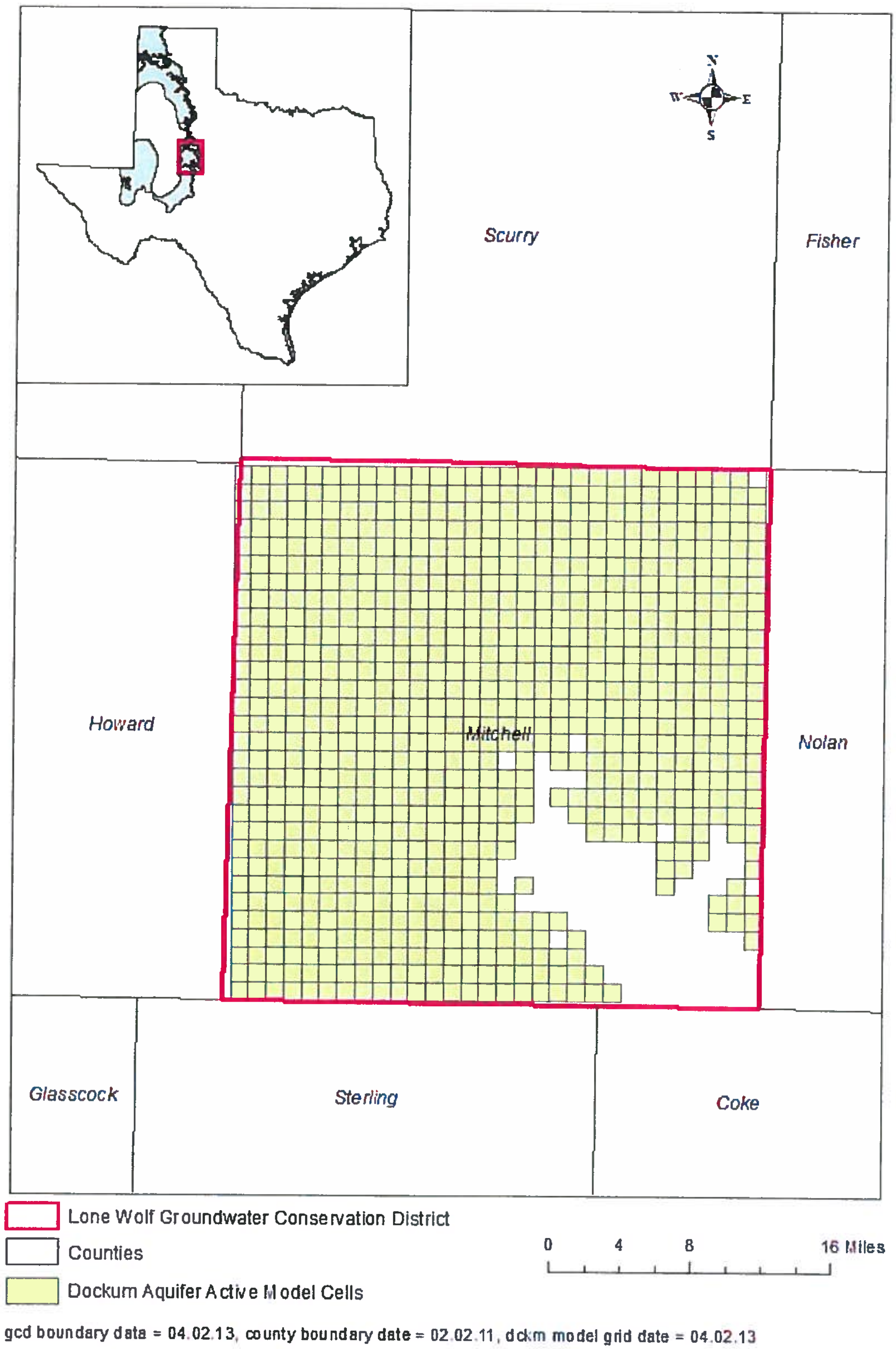

FIGURE 1: AREA OF THE GROUNDWATER AVAILABILITY MODEL FOR THE DOCKUM AQUIFER FROM WHICH THE INFORMATION IN TABLE 1 WAS EXTRACTED (THE DOCKUM AQUIFER EXTENT WITHIN THE DISTRICT BOUNDARY).

LIMITATIONS

The groundwater model(s) used in completing this analysis is the best available scientific tool that can be used to meet the stated objective(s). To the extent that this analysis will be used for planning purposes and/or regulatory purposes related to pumping in the past and into the future, it is important to recognize the assumptions and limitations associated with the use of the results. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

> *"Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects for a particular regulatory application. These characteristics make evaluation of a regulatory model more complex than solely a comparison of measurement data with model results."*

A key aspect of using the groundwater model to evaluate historic groundwater flow conditions includes the assumptions about the location in the aquifer where historic pumping was placed. Understanding the amount and location of historic pumping is as important as evaluating the volume of groundwater flow into and out of the district, between aquifers within the district (as applicable), interactions with surface water (as applicable), recharge to the aquifer system (as applicable), and other metrics that describe the impacts of that pumping. In addition, assumptions regarding precipitation, recharge, and interaction with streams are specific to particular historic time periods.

Because the application of the groundwater models was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations related to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor groundwater pumping and overall conditions of the aquifer. Because of the limitations of the groundwater model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future. Historic precipitation patterns also need to be placed in context as future climatic conditions, such as dry and wet year precipitation patterns, may differ and affect groundwater flow conditions.

REFERENCES:

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Appendix
E

LONE WOLF GROUNDWATER CONSERVATION DISTRICT
DROUGHT CONTINGENCY
AND
EMERGENCY WATER DEMAND MANAGEMENT PLAN

A. INTRODUCTION

The goal of this Plan is to cause a reduction in water use in response to drought or emergency conditions so that water availability can be preserved. Since emergency conditions can occur rapidly, responses must also be enacted quickly. This Plan has been prepared in advance considering conditions that will initiate and terminate the actions set forth herein.

The Lone Wolf Groundwater Conservation District Board of Directors (Board) will monitor usage patterns and public education efforts and will make recommendations on future conservation efforts, demand management procedures or any changes to this Plan. The Board will develop public awareness notices, information sheets, and other material that will serve as a constant reminder that water should be conserved at all times, not just during a drought or emergency. This Board will also review and evaluate any needed amendments or major changes to this Plan due to changes in the aquifer or other relevant circumstances. This review and evaluation will be done every other year unless conditions necessitate more frequent amendments.

The Plan will be implemented according to the three stages of rationing as imposed by the Board. Section C describes the conditions that will trigger these stages.

B. PUBLIC INVOLVEMENT

Opportunity for the public to provide input into the preparation of the Plan was provided by the Board by scheduling and providing public notice of a public meeting to accept input on the Plan. In the adoption of this Plan, the Board considered all comments from landowners.

C. TRIGGER CONDITIONS

The Board is responsible for monitoring water supply and demand conditions on a quarterly basis (or more frequently as conditions warrant) and shall determine when conditions warrant initiation or termination of each stage of the Plan. The Board will monitor drawdown reports, water supply and/or rainfall as needed to determine when trigger conditions are reached. The triggering conditions described below take into consideration: The vulnerability of the water source under drought of record conditions, the production, and distribution capacities of the aquifer and usage based upon historical patterns.

a. **Stage I- Mild Conditions**: Stage I water conservation measures may be implemented when the following condition exist:
   The Texas Palmer Drought Index shows that the area has reached a level of Mild Drought Conditions.

b. **Stage II- Moderate Conditions**: Stage II water conservation measures may be implemented when the following condition exist:

The Texas Palmer Drought Index shows that the area has reached a level of Moderate Drought Conditions.

c. **Stage III- Severe Conditions:** Stage III water conservation measures may be implemented when one or more of the following conditions exist:
   i. The Texas Palmer Drought Index shows that the area has reached a level of Severe Drought Conditions.
   ii. Natural or man-made contamination of the water supply source(s).
   iii. The declaration by the State or Federal Government of a state of disaster due to drought condition in a county or counties served by the District.
   iv. Other unforeseen events which could cause imminent health or safety risks to the public.

D. STAGE LEVELS OF WATER ALLOCATIONS

The stage levels of water conservation are to be placed in effect by the triggers in Section C. The District may institute monitoring and enforce penalties for violations of the Drought Plan for each of the Stages listed below. The water conservation measures are summarized below.

d. **Stage I- Mild Conditions**
   i. Alternate day, time of day or duration restriction for outside water usage allowed. (District will notify public water utilities and landowners which restrictions are in effect)
   ii. The public water utilities will reduce flushing operations.
   iii. Reduction of water use will be encouraged through local media notices or other methods.

e. **Stage II- Moderate Conditions**
   i. All outside water use is prohibited (except for a livestock or other exemption or variance granted under this section).
   ii. Public service announcements as conditions change via local media (TV, radio, newspapers, etc.).

f. **Stage III- Severe Conditions**
   i. All outside watering prohibited.
   ii. District shall continue enforcement and educational efforts.

E. INITIATION AND TERMINATION PROCEDURES

Once a trigger condition occurs, the District, or its designated responsible representative, shall, based on recommendations from the Board, decide upon the appropriate stage of conservation to be initiated. The initiation may be delayed if there is a reasonable possibility the aquifer's performance will not be compromised by the condition. If water conservation is to be instituted, notice will be made via public local media (TV, radio, newspapers, etc.).

The notice shall contain the following information:

a. The date water conservation shall begin,
b. The expected duration,

c. The stage (level) of water conservations to be employed, the penalty for violations of the water conservation program, and the affected area or areas.

If the water conservation program extends 30 days the Board President or General Manager shall present the reasons at the next scheduled Board Meeting and shall request the concurrence of the Board to extend the conservation period.

When the trigger condition no longer exists, the responsible official may terminate the water conservation provided that such an action is based on sound judgment. The end of conservation shall be given to landowners via local media (TV, radio, newspapers, etc.). A water conservation period may not exceed 60 days without extension by action of the Board.

F. PENALTIES FOR VIOLATIONS

a. **First Violation-** The Violator will be notified by written notice of their specific violation and their need to comply with district rules. The notice will show the amount of penalty to be assessed for continued violations.
b. **Second Violation-** The District may assess a penalty of up to $2,500.
c. **Subsequent Violations-** The District may assess a penalty of up to $10,000 for violations continuing after Second Violation. Each day a violation exists shall be considered a separate, subsequent violation. The District may also install a flow restricting devise in the violator's well to limit the amount of water that will pass through the well in a 24 hour period. The costs of this procedure will be for the actual work and equipment and shall be paid by the customer.

These provisions apply to all landowners/ operators within the District. Municipal water supplies are responsible for ensuring their customers comply with the provisions. Municipal water supplies shall be deemed to be the violator if a customer of the supplier violates this Plan.

G. EXEMPTIONS OR WAIVERS

The Board may, in writing, grant temporary variance for existing water uses otherwise prohibited under this Plan if it is determined that failure to grant such variance would cause an emergency condition adversely affecting the health or sanitation of the public or the person requesting such variance and if one or more of the following conditions are met:

a. Compliance with this Plan cannot be technically accomplished during the duration of the water supply shortage or other condition for which the Plan is in effect.
b. Alternative methods can be implemented which will achieve the same level of reeducation in water use.

Persons requesting an exemption from the provisions of this Ordinance shall file a petition for variance with the Board within 5 days after the Plan or particular drought response stage has been invoked or after a condition justifying the variance first occurs. All petitions for variances shall be reviewed by the Board and shall include the following:

a. Name and address of the petitioner(s).
b. Purpose of water use.

c. Specific provision(s) of the Plan from which the petitioner is requesting relief.
d. Detailed statement as to how the specific provision of the Plan adversely affects the petitioner or what damage or harm will occur to the petitioner or others if petitioner complies with this Plan.
e. Description of the relief requested.
f. Period of time for which the variance is sought.
g. Alternative water use restrictions or other measures the petitioner is taking or proposes to take to meet the intent of this Plan and the compliance date.
h. Other pertinent information, as requested by the Board.

Variances granted by the Board shall be subject to the following conditions, unless specifically waived or modified by the Board:

a. Variances granted shall include a timetable for compliance.
b. Variances granted shall expire when the water conservation is no longer in effect, unless the petitioner has failed to meet specified requirements. No variances allowed for a condition requiring water conservation will continue beyond the termination of water conservation under Section E. Any variances for subsequent water conservation must be repetitioned. The fact that a variance has been granted in response to a petition will have no relevance to the Board's decision on any subsequent petition.

No variance shall be retroactive or otherwise justify any violation of this Plan occurring prior to the issuance of the variance.

H. SEVERABILITY

If any one or more of the provisions contained in these rules are for any reason held to be invalid, illegal, or unenforceable in any respect, the invalidity, illegality, or unenforceability may not affect any other rules or provisions of these rules, and these rules must be construed as if such invalid, illegal or unenforceable rules or provision had never been contained in these rules.

I. IMPLEMENTATION

The Board established the DROUGHT CONTINGENCY AND EMERGENCY WATER DEMAND MANAGEMENT PLAN by Resolution. This Board will review the procedures in this Plan every other year or more frequently if necessary. Modifications may be required to accommodate system growth, changes in water use demand, available water supply, and/or other circumstances.

This Plan was adopted by the Lone Wolf Groundwater Conservation District Board at the properly noticed public hearing held on April 1, 2008.

Appendix F

LONE WOLF GROUNDWATERCONSERVATION DISTRICT

P.O. Box 1001
Colorado City, Texas 79512

RESOLUTION
LWGCD MANAGEMENT PLAN
2014 - 2024

WHEREAS, the Lone Wolf Groundwater Conservation District (District) was created by Acts of the 77th Texas Legislature (2001), H.B. 2529 in accordance with Article 16, Section 59 of the Constitution of Texas and Chapters 35 and 36 of the Texas Water Code, as amended; and

WHEREAS, the District is required by S. B. 1 through Chapter 36.1071 of the Texas Water Code to develop and adopt a Management Plan; and

WHEREAS, the District is required by S. B. 1 to review and readopt the plan with or without revisions at least once every five years and to submit the adopted Management Plan to the Executive Administrator of the Texas Water Development Board for review and approval; and

WHEREAS, the District's Management Plan shall be certified by the Executive Administrator once the plan is determined to be administratively complete; and

WHEREAS, the District Board of Directors has determined this Management Plan addresses the requirements of Chapter 36.1071.

NOW, THEREFORE, be it resolved, that the Board of Directors of the Lone Wolf Groundwater Conservation District, following notice and public hearing, hereby adopts this Management Plan; and

BE IT FURTHER RESOLVED, that this Management Plan shall become effective immediately upon adoption by the District.

Adopted this 12th day of August, 2014.

David Stubblefield
Board Chairman

Attest:

Bobby Lemons
Board Vice Chairman

Appendix G

Affidavit of Publication

BEFORE ME, the undersigned notary public, this day personally appeared

Sheila Plagens
(Name)

Publisher
(Title)

Colorado Record
(Name of Newspaper)

a newspaper having general circulation in

Mitchell

County, Texas, who being by me duly sworn, deposes and says that the foregoing attached notice was published in said newspaper on the following

date(s), to wit: August 14, 2014

Signed: Sheila Plagens
(Signature of Affiant)

SUBSCRIBED AND SWORN TO this the 14th day of Aug., 20 14.

Stephanie Perez
Notary Public in and for the State of Texas

Seal:

STEPHANIE PEREZ
Notary Public, State of Texas
My Commission Expires
MARCH 28, 2018

barran is contracted to work at

WATER DISTRICT
NOTICE OF PUBLIC HEARING
ON TAX RATE

The Lonewolf Groundwater Conservation District will hold a public meeting on a proposed tax rate for the tax year 2014 on September 9, 2014 at 7:00 a.m. at Lone Wolf Ground Water, 131 West 5th Street, Colorado City, TX, 79512. Your individual taxes may increase or decrease, depending on the change in the taxable value of your property in relation to the change in taxable value of all other property and the tax rate that is adopted.

For the proposal:	Kenney Gillespie, Bobby Lemons, David Stubblefield
Against the proposal:	
Present and not voting:	
Absent:	Woody Anderson, Tommy Morris

The following table compares taxes on an average residence homestead in this taxing unit last year to taxes proposed on the average residence homestead this year.

	Last Year	This Year
Total tax rate (per $100 of value)	$0.022240/$100 Adopted	$0.020135/$00 Proposed
Difference in rates per $100 of value	$.0002105	
Percentage increase / decrease in rates (+/-)	-2.30%	
Average appraised value	$44,410	$52,990
General exemption available (excluding senior citizen's or disabled person's exemptions)	$0	$0
Average taxable value	$44,410	$52,990
Tax on average residence homestead	$9.88	$10.67
Annual increase/decrease in taxes if proposed tax rate is adopted (+/-)	$.79	
and percentage of increase (+/-)	7.99%	

NOTICE OF TAXPAYERS' RIGHT TO ROLLBACK ELECTION

If taxes on the average residence homestead increase by more than eight percent, the qualified voters of the district by petition may require that an election be held to determine whether to reduce the operation and maintenance tax rate to the rollback tax rate under Section 49.23(d), Water Code.

Appendix
H

NOTICE OF MEETING OF THE LONE WOLF GROUNDWATER CONSERVATION DISTRICT BOARD OF DIRECTORS

A PUBLIC HEARING will convene at 7:00 a.m. on the 12th day of August, 2014, at the Lone Wolf Groundwater Conservation District office at 131 West 5th Street in Colorado City, Texas. The purpose of the hearing is to accept public comment on the draft 2014-2024 Management Plan.

The regular meeting of the Lone Wolf Groundwater Conservation District Board will be held immediately following the Public Hearing on the 12th day of August, 2014 at the Lone Wolf Groundwater Conservation District office at 131 West 5th Street in Colorado City, Texas, at which time the following subjects will be discussed with possible action:

FILED FOR RECORD

AUG 8 2014

AT 1:40 O'CLOCK P M
DEBBY CARLOCK
County Clerk, Mitchell County, Texas
By Sadame Deputy

1. Public Hearing
2. Approval of previous minutes
3. Ratify bills
4. Adopt 2014-2024 Management Plan
5. Injection wells
6. Well permits
7. Executive session pursuant to Texas Gov Code 551.071, consultation with attorney
8. Audit Report 2013
9. Budget Workshop
10. Establish tax rate and set public hearing
11. Palmer Drought Index
12. Public comment
13. Adjourn

By: Sue Young Date: 8/8/14
Sue Young, LWGCD General Manager

I, the undersigned, County Clerk, do hereby certify that the above notice of Meeting of the Lone Wolf Groundwater Conservation District is a true and correct copy of said Notice, and that I posted a true and correct copy of said Notice on the bulletin board at the Courthouse of Mitchell County on the 8th day of August, 2014 and said notice remained so posted continuously for at least seventy-two (72) hours immediately preceding the time of said meeting.

By: Sandra Adame Date: 8/8/14
County Clerk, Mitchell County, Texas

In compliance with Open Meeting laws, the Lone Wolf Groundwater Conservation District Board welcomes any interested party to attend the meetings. The board also welcomes any public comment with a limit of 5 minutes per person. Any person with ADA special needs should notify the board at least three days prior to the meeting so accommodations may be made.

At any time during the meeting and in compliance with the Texas Open Meetings Act, Chapter 551, Government Code, Vernon's Texas Codes, Annotated, the Lone Wolf Groundwater Conservation District Board may meet in executive session on any of the above agenda items for consultation concerning attorney-client matters (§551.071); deliberation regarding real property (§551.072); deliberation regarding prospective gift (§551.073); personnel matters (§551.074); and deliberation regarding security devices (§551.076). Any subject discussed in executive session may be subject to action during an open meeting.

Lone Wolf Groundwater Conservation District
Board of Directors
August 12, 2014

Present: Kenney Gillespie, Bobby Lemons and David Stubblefield; Sue Young and Darlene Moore

Chairman David Stubblefield called the public hearing to order at 7:08 a.m. There were no public comments and the hearing was adjourned at 7:10 a.m.

Chairman Stubblefield called the meeting to order at 7:10 a.m..

Bobby Lemons moved that the minutes of the previous meeting be approved as printed. Bobby Lemons seconded the motion, which passed.

Kenney Gillespie moved that the bills be approved as presented. Bobby Lemons seconded the motion and it passed.

Kenney Gillespie moved that the "Lone Wolf Groundwater Conservation District Management Plan 2014-2024" be approved as presented. A resolution to that effect was signed by Chairman Stubblefield and Vice Chairman Lemons. The resolution will accompany the Plan to the Water Development Board for the Director's approval.

There were four injection wells from Energen presented before the applications are sent to the Railroad Commission. Bobby Lemons moved and Kenney Gillespie seconded the motion that further action from the Board will not be necessary if they will case to 200 feet below production levels of the wells in that section. This motion passed. The Board's attorney will be contacted for assistance with this matter.

Kenney Gillespie moved that the wells for Alexander and Smith be granted. Bobby Lemons seconded the motion, which passed.

Bobby Lemons moved that the Independent Auditor's Report and Financial Statements for the year ending December 31, 2013 be accepted as printed. Kenney Gillespie seconded the motion and it passed.

Bobby Lemons moved that the tax rate for 2014 be $0.020135 and a public hearing will be held at the next regular meeting of the Board, September 9, 2014. Kenney Gillespie seconded the motion, which passed.

Bobby Lemons moved and Kenney Gillespie seconded the motion to adopt a budget of $268,948.00 for the year 2015. The motion passed.

The Palmer Drought Index was reviewed.

There being no further business, the meeting was adjourned at 8:30a.m.

Minutes prepared by:

____

Sue Young, General Manager

Minutes approved by:

____

David Stubblefield, President

____

Tommy Morris, Secretary

Appendix

I

Appendix
1

LONE WOLF GROUNDWATER CONSERVATION DISTRICT

August 12, 2014

Mike Hemphill
Mitchell County Utilities
5345 LCR 256
Colorado City, Texas 79512

Re: Lone Wolf Groundwater Conservation District Management Plan

The Lone Wolf Groundwater Conservation District has updated the District Management Plan for 2008 to 2013. The new Management Plan, dated 2014 to 2019, will replace the old Management Plan and brings the District up-to-date with current state laws. Under §36.1072, Texas Water Code, as amended, the District must review and revise its management plan every five years and submit it to the Texas Water Development Board for review and approval.

Under §36.1071, Texas Water Code, as amended, the District is required to coordinate with surface water entities in preparation of its management plan. In compliance with this chapter of the water code, the District is submitting to you a copy of the draft management plan for your review and comments.

Please review this management plan and submit any comments or suggestions to the District. If you have any questions or want additional information as you review this plan, please contact the District office at (325) 728-2027. We appreciate your attention and cooperation in reviewing this management plan.

Sincerely,

Sue Young

Sue Young
General Manager

enclosures

Lone Wolf Groundwater Conservation District

August 12, 2014

Mayor Jim Baum
City of Colorado City
P O Box 912
Colorado City, Texas 79512

Re: Lone Wolf Groundwater Conservation District Management Plan

The Lone Wolf Groundwater Conservation District has updated the District Management Plan for 2008 to 2013. The new Management Plan, dated 2014 to 2019, will replace the old Management Plan and brings the District up-to-date with current state laws. Under §36.1072, Texas Water Code, as amended, the District must review and revise its management plan every five years and submit it to the Texas Water Development Board for review and approval.

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Sincerely,

Sue Young

Sue Young
General Manager

enclosures

LONE WOLF GROUNDWATER CONSERVATION DISTRICT

August 12, 2014

City of Loraine
P O Box 7
Loraine, Texas 79532

Re: Lone Wolf Groundwater Conservation District Management Plan

The Lone Wolf Groundwater Conservation District has updated the District Management Plan for 2008 to 2013. The new Management Plan, dated 2014 to 2019, will replace the old Management Plan and brings the District up-to-date with current state laws. Under §36.1072, Texas Water Code, as amended, the District must review and revise its management plan every five years and submit it to the Texas Water Development Board for review and approval.

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Sincerely,

Sue Young

Sue Young
General Manager

enclosures

P O BOX 1001 131 WEST 5TH STREET COLORADO CITY, TX 79512
(325) 728-2027 FAX (325) 728-3046

LONE WOLF GROUNDWATER CONSERVATION DISTRICT

August 12, 2014

City of Westbrook
110 N. Hooper
Westbrook, Texas 79565

Re: Lone Wolf Groundwater Conservation District Management Plan

The Lone Wolf Groundwater Conservation District has updated the District Management Plan for 2008 to 2013. The new Management Plan, dated 2014 to 2019, will replace the old Management Plan and brings the District up-to-date with current state laws. Under §36.1072, Texas Water Code, as amended, the District must review and revise its management plan every five years and submit it to the Texas Water Development Board for review and approval.

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Sue Young

Sue Young
General Manager

enclosures

P O BOX 1001 131 WEST 5TH STREET COLORADO CITY, TX 79512
(325) 728-2027 FAX (325) 728-3046

LONE WOLF GROUNDWATER CONSERVATION DISTRICT

August 12, 2014

West Brook ISD
102 East Bertner
Westbrook, Texas 79565

Re: Lone Wolf Groundwater Conservation District Management Plan

The Lone Wolf Groundwater Conservation District has updated the District Management Plan for 2008 to 2013. The new Management Plan, dated 2014 to 2019, will replace the old Management Plan and brings the District up-to-date with current state laws. Under §36.1072, Texas Water Code, as amended, the District must review and revise its management plan every five years and submit it to the Texas Water Development Board for review and approval.

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Sincerely,

Sue Young

Sue Young
General Manager

enclosures

P O BOX 1001 131 WEST 5TH STREET COLORADO CITY, TX 79512
(325) 728-2027 FAX (325) 728-3046

LONE WOLF GROUNDWATER CONSERVATION DISTRICT

August 12, 2014

Water and Waste Water Engineer
Texas Department of Transportation
125 East 11th Street
MNT Division
Austin, Texas 78701-2409

Re: Lone Wolf Groundwater Conservation District Management Plan

The Lone Wolf Groundwater Conservation District has updated the District Management Plan for 2008 to 2013. The new Management Plan, dated 2014 to 2019, will replace the old Management Plan and brings the District up-to-date with current state laws. Under §36.1072, Texas Water Code, as amended, the District must review and revise its management plan every five years and submit it to the Texas Water Development Board for review and approval.

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Sincerely,

Sue Young

Sue Young
General Manager

enclosures

P O BOX 1001 131 WEST 5TH STREET COLORADO CITY, TX 79512
(325) 728-2027 FAX (325) 728-3046

Lone Wolf Groundwater Conservation District

August 13, 2014

Kevin Patteson
Executive Director
Texas Water Development Board
P O Box 13231
Austin, Texas 78711-3231

Dear Mr. Patteson:

The Lone Wolf Groundwater Conservation District Board of Directors approved the Management Plan for Years 2014-2019 on August 12, 2014. At this time, the Board officially submits its plan to the Texas Water Development Board.

Should you have questions regarding the plan, please contact us at 325.728.2027.

Sincerely,

Sue Young

Sue Young
General Manager

P O BOX 1001 131 WEST 5TH STREET COLORADO CITY, TX 79512
(325) 728-2027 FAX (325) 728-3046