LONE WOLF GROUNDWATER CONSERVATION DISTRICT
PO BOX 1001
COLORADO CITY, TEXAS 79512

MANAGEMENT PLAN
2003-2013

HISTORY OF THE DISTRICT

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 and authorized a tax rate not to exceed 03 cents per $100 valuation on February 2, 2002. A five-member elected board of directors governs the 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 certification by the Texas Water Development Board. The plan remains in effect for ten years after the date of certification by the Texas Water Development Board, or until a revised or amended plan is approved and certified.

REGIONAL COOPERATION AND COORDINATION

The District is a member of the West Texas Regional Groundwater Alliance. The Alliance consists of 12 locally created and locally funded districts that encompass almost 8.75 million acres or 13,000 square miles of West Texas. The Alliance was originally formed in 1988 with four groundwater districts. The current member districts are:

Coke County UWCD	Emerald UWCD	Glasscock County UWCD
Hickory UWCD	Irion County UWCD	Lipan-Kickapoo WCD
Plateau UWC&SD	Santa Rita UWCD	Sterling County UWCD
Sutton County UWCD	Menard County UWD	Lone Wolf GCD

This Alliance was created because the local districts have a common objective to facilitate the conservation, preservation, and beneficial use of water and related sources.

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 guidepost for determining the direction or priority for all District activities. All operations of the District, all agreements entered into by the District and any additional planning efforts in which the District may participate will be consistent with the provisions of this plan.

The District will adopt rules relating to the permitting of wells and the production of groundwater. The rules adopted by the District shall be pursuant to TWC 36 and the provisions of this plan. All rules will be adhered to and enforced. The promulgation and enforcement of the rules will be based on the best technical evidence available.

The District shall treat all citizens with equality. Citizens may apply to the District for discretion in enforcement of the rules on grounds of adverse economic effect or unique local conditions. In granting of discretion to any rule, the Board shall consider the potential for adverse effect on adjacent landowners. 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 or local water management entity.

MANAGEMENT OF GROUNDWATER SUPPLIES

The District will manage the supply of groundwater within its boundaries in order to conserve the resource while seeking to maintain the economic viability of all resource user groups, public and private. In consideration of the economic and cultural activities occurring within the District, the District will identify and engage in such activities and practices, that if implemented would result in a reduction of groundwater use. An observation network shall be established and maintained in order to monitor changing storage conditions of groundwater supplies within the District. The District will make a regular assessment of water supply and groundwater storage conditions and will report those conditions to the Board and to the public. The District will undertake, as necessary and cooperate with investigations of the groundwater resources within the District and will make the results of investigations available to the public upon adoption by the Board.

The District will adopt rules to regulate groundwater withdrawals by means of spacing and production limits. The District may deny a well construction permit or limit groundwater withdrawals in accordance with the guidelines stated in the rules of the District. In making a determination to deny a permit or limit groundwater withdrawals, the District will consider the public benefit against individual hardship after considering all appropriate testimony.

The relevant factors to be considered in making a determination to deny a permit or limit groundwater withdrawals will include:

1) The purpose of the rules of the District
2) The equitable distribution of the resource

3) The economic hardship resulting from grant or denial of a permit or the terms prescribed by the permit

In pursuit of the Districts mission of protecting the resource, the District may require reduction of groundwater withdrawals to amounts, which will not cause harm to the aquifer. To achieve this purpose, the District may, at the Boards discretion amend or revoke any permits after notice and hearing. The determination to seek the amendment or revocation of a permit by the District will be based on aquifer conditions observed by the District. The District will enforce the terms and conditions of permits and the rules of the District by enjoining the permit holder in a court of competent jurisdiction as provided for in TWC '36.102.

A contingency plan to cope with the effects of water supply deficits due to climatic or other conditions will be developed by the District and will be adopted by the Board after notice and hearing. In developing the contingency plan, the District will consider the economic effect of conservation measures upon all water resource user groups, the local implications of the degree and effect of changes in water storage conditions, the unique hydrogeologic conditions of the aquifers within the District and the appropriate conditions under which to implement the contingency plan.

The District will employ all technical resources at its disposal to evaluate the water resources available within the District and to determine the effectiveness of regulatory or conservation measures. A public or private user may appeal to the Board for discretion in enforcement of the provisions of the water supply deficit contingency plan on grounds of adverse economic hardship or unique local conditions. The exercise of said discretion by the Board, shall not be construed as limiting the power of the Board.

ESTIMATE OF EXISTING TOTAL USEABLE AMOUNT OF GROUNDWATER IN THE DISTRICT

The available supply from the aquifer is defined by Region F as an annual effective recharge plus a portion of the water taken from storage. According to the Region F Plan the Dockum aquifer located within the District has an annual recharge of 8,744 acre-feet per year. It is estimated that 5,274 acre-feet of water is used from storage each year. Therefore, the total available groundwater resource is 14,018 acre-feet per year.[1] The demands used in this analysis are drought year demands. From this analysis it is projected that 75% of the recoverable storage in the District will be consumed within 50 years. In most years the demands may be less then predicted, thereby reducing the amount of mining of the aquifer. However, if the aquifer is too heavily mined there may be less water available for future use. Again, these numbers are drought demand years and therefore do not imply that the supplies will necessarily be depleted in 50 years. [2]

Additionally, it is estimated that 1,172,000 acre-feet of groundwater is contained in storage within the District of which 351,600 acre-feet is retrievable.[3]

[1] Region F Water Plan (2001) Table 3-1
[2] Region F Water Plan (2001) Chapter 3-2
[3] Region F Water Plan (2001) Table 3-6

HISTORICAL USE, PROJECTED DEMAND AND SUPPLY OF WATER

The following is an estimate of Groundwater Pumpage for Mitchell County, Texas (in acre-feet/year).[4]

Aquifer	Year	Municipal	Mfg	Power	Mining	Irrigation	Livestock	Total
Other	1980	2	0	0	0	0	2	4
Dockum	1980	223	0	0	116	3,218	50	3,607
Other	1984	2	0	0	0	0	2	4
Dockum	1984	152	19	0	620	2,739	42	3,572
Other	1985	1	0	0	0	0	2	3
Dockum	1985	174	19	0	621	4,414	32	5,260
Other	1986	1	0	0	0	0	2	3
Dockum	1986	182	19	0	586	2,765	38	3,590
Other	1987	1	0	0	0	0	2	3
Dockum	1987	117	0	0	551	2,262	36	2,966
Other	1988	1	0	0	0	0	2	3
Dockum	1988	139	0	0	518	2,129	39	2,825
Other	1989	2	0	0	0	0	2	4
Dockum	1989	136	0	0	483	1,477	38	2,134
Other	1990	2	0	0	0	0	2	4
Dockum	1990	131	0	0	483	1,593	38	2,245
Other	1991	2	0	0	0	0	2	4
Dockum	1991	122	0	0	252	2,241	39	2,654
Other	1992	0	0	0	0	0	2	2
Dockum	1992	177	0	0	252	953	42	1,424
Other	1993	0	0	0	0	0	2	2
Dockum	1993	193	0	0	244	1,313	49	1,799
Other	1994	0	0	0	0	0	2	2
Dockum	1994	199	0	0	244	1,240	44	1,727
Other	1995	0	0	0	0	0	2	2
Dockum	1995	198	0	0	141	410	42	791
Other	1996	0	0	0	0	0	2	2
Dockum	1996	336	0	0	141	1,044	37	1,558
Other	1997	0	0	0	0	0	2	2
Dockum	1997	171	0	0	141	985	39	1,336
Other	1998	0	0	0	0	0	2	2
Dockum	1998	353	0	0	141	809	43	1,346
Other	1999	0	0	0	0	0	2	2
Dockum	1999	418	0	0	141	2,776	43	3,378
Other	2000	0	0	0	0	0	2	2
Dockum	2000	1,369	0	0	141	5,549	42	7,101

[4] Texas Water Development Board, Use Survey

50-Year Water Demand Projections Mitchell County[5]
(Values are in Acre-Feet per Year)

	Historical	Projected					
User Group	**1996 Water Use**	**2000 Water Demand**	**2010 Water Demand**	**2020 Water Demand**	**2030 Water Demand**	**2040 Water Demand**	**2050 Water Demand**
Total Municipal	1,709	2,298	2,223	2,135	2,041	1,954	1,896
Total Manufacturing	0	0	0	0	0	0	0
Total Steam Electric	4,071	4,000	4,400	5,280	6,336	7,603	9,124
Total Mining	141	223	106	53	26	9	0
Total Irrigation	1,076	2,238	2,226	2,215	2,204	2,193	2,182
Total Livestock	389	530	530	530	530	530	530
Overall Total	**7,386**	**9,289**	**9,485**	**10,213**	**11,137**	**12,289**	**13,732**

50-Year Comparison of Currently Available Supply to Projected Demands by Category[6]
(Values in Acre-Feet per Year)

	2000 Water Demand			2010 Water Demand			2020 Water Demand		
User Group	**Supply**	**Demand**	**Diff.**	**Supply**	**Demand**	**Diff.**	**Supply**	**Demand**	**Diff.**
Total Municipal	3,439	2,298	1,141	3,423	2,223	1,200	3,407	2,135	1,272
Total Manufacturing	0	0	0	0	0	0	0	0	0
Total Steam Electric	3,970	4,000	-30	3,943	4,400	-457	3,916	5,280	-1,364
Total Mining	1,000	223	777	1,000	106	894	1,000	53	947
Total Irrigation	2,435	2,238	197	2,435	2,226	209	2,435	2,215	220
Total Livestock	530	530	0	530	530	0	530	530	0
Overall Total	**11,374**	**9,289**	**2,085**	**11,331**	**9,485**	**1,846**	**11,288**	**10,213**	**1,075**

	2030 Water Demand			2040 Water Demand			2050 Water Demand		
User Group	**Supply**	**Demand**	**Diff.**	**Supply**	**Demand**	**Diff.**	**Supply**	**Demand**	**Diff.**
Total Municipal	3,386	2,041	1,345	3,362	1,954	1,408	3,343	1,896	1,447
Total Manufacturing	0	0	0	0	0	0	0	0	0
Total Steam Electric	3,897	6,336	-2,439	3,882	7,603	-3,721	3,861	9,124	-5,263
Total Mining	1,000	26	974	1,000	9	991	1,000	0	1,000
Total Irrigation	2,435	2,204	231	2,435	2,193	242	2,435	2,182	253
Total Livestock	530	530	0	530	530	0	530	530	0
Overall Total	**11,248**	**11,137**	**111**	**11,209**	**12,289**	**-1,080**	**11,169**	**13,732**	**-2,563**

The current water supply in the District consists of groundwater, surface water and reuse.

[5] Region F Water Plan (2001) Table 2-3
[6] Region F Water Plan (2001) Appendix B, Table 5

ESTIMATE OF ANNUAL RECHARGE TO THE DOCKUM

Recharge occurs rapidly where the Dockum outcrops or is near the surface in Scurry, Mitchell, Sterling and Coke counties. Elsewhere, the Dockum is buried at depths that generally eliminate recharge. The TWDB estimates that 19,880 acre-feet of annual effective recharge occur in these four counties.[7] The annual effective recharge in the District is estimated to be 8,744 acre-feet.

Developed areas of the Santa Rosa Formation of the Dockum aquifer derive recharge both locally from the land surface and from undeveloped areas, including the Cretaceous sediments in Nolan County which contribute water to the areas of development. The amount of recharge any particular area might receive depends on a number of factors such as soil and rock type, topography, extent of cultivation and intensity and distribution of rainfall. [8]

The best indicator of the adequacy of recharge is the performance of water levels in wells. Water levels, together with the amount of water pumped, can be used to estimate the amount of water available on a continuing basis. To provide a historical reference of water levels the Lone Wolf GCD began an ongoing quarterly water level monitoring program in the Spring of 2002.

METHODS TO INCREASE NATURAL OR ARTIFICAL RECHARGE

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 and to date remains an ongoing program. 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. Estimates of the amount of water used by different species of plants in Region F are summarized below.[9]

[7] Region F Water Plan (2001) Chapter 3-24
[8] Victor M. Shamburger, Jr., Report 50: Groundwater Resources of Mitchell and Nolan Counties, Texas, (Texas Water Development Board, June 1967) Page 67
[9] Region F Water Plan (2001) Chapter 5-90

Plant	Water Loss (in/yr)	Water Loss ac-ft/ac/yr
Juniper	23.3-25.00	1.94-2.08
Mesquite	19.2-26.3	1.60-2.19
Salt Cedar	27.3-234	2.28-19.52

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 recently 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. [10]

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

[10] Region F Water Plan (2001) Chapter 5-95

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.[11]

HYDROLOGICAL RESOURCES AVAILABLE WITHIN THE LONE WOLF GROUNDWATER CONSERVATION DISTRICT.

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 within 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 is 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.[12]

[11] Region F Water Plan (2001) Chapter 5-89

[12] Victor M. Shamburger, Jr., Report 50: Groundwater Resources of Mitchell and Nolan Counties, Texas, (Texas Water Development Board, June 1967) Page 12

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 Formation 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 a 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 silty shales 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, lenticular, 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 is 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.[13]

[13] Victor M. Shamburger, Jr., Report 50: Groundwater Resources of Mitchell and Nolan Counties, Texas, (Texas Water Development Board, June 1967) Page 23

Cretaceous Rocks (Trinity and Fredricksburg Groups)
The Cretaceous rocks which occur in the area are of Lower Cretaceous age and belong to the Trinity and Fredricksburg 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 Fredricksburg 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.[14]

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.[15]

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 Truijillo 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

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[14] Victor M. Shamburger, Jr., Report 50: Groundwater Resources of Mitchell and Nolan Counties, Texas, (Texas Water Development Board, June 1967) Page 24
[15] Victor M. Shamburger, Jr., Report 50: Groundwater Resources of Mitchell and Nolan Counties, Texas, (Texas Water Development Board, June 1967) Page 30

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 north-east 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 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 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 Aquifer Water Table

Groundwater in the Santa Rosa 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 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 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 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 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 1990's 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 area 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 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 area 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 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 miligrams 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 75 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 for gravels (the Santa Rosa Aquifer) contains 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 as 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 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 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 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.

METHODOLOGY FOR TRACKING DISTRICT PROGRESS IN ACHIEVING MANAGEMENT GOALS AND OBJECTIVES

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. The presentation of the report will occur during the last monthly Board meeting of each fiscal year, beginning 2004. The report will include the number of instances in which each of the activities specified in the Districts management objectives was engaged in during the fiscal year. Each activity will be referenced to the estimated expenditure of staff time and budget in accomplishment of the activity. The notations of activity frequency, staff time and budget will be referenced to the appropriate performance standard for each management objective describing the activity, so that the effectiveness and efficiency of the Districts operations may be evaluated. The Board will maintain the report on file, for public inspection at the Districts offices. This methodology will apply to all management goals contained within this plan.

GOALS, OBJECTIVES AND 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.*

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 Water Information Management Systems (WIMS) database. Annual reports detailing the number of wells drilled, production data and intended use of the wells will be maintained at the District office.

Standard

1.1.1 Data gathered and reports generated detailing the number and type of wells drilled.

Objective

1.2 The Lone Wolf Groundwater Conservation District will develop and enforce 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.

Standard

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

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.

Standard

1.3.1 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*

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.

Standard

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

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.

Standard

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

Goal

3.0 *Controlling and Preventing subsidence*

Objective

3.1 The geologic framework of the District precludes significant subsidence from occurring. This management goal is not applicable to the operations of the District.

Standard

3.1.1 None.

Goal

4.0 *Addressing Conjunctive Surface Water Management Issues*

Objective

4.1 There are no surface water management entities within the District. Although the CRMWD and UCRA operate around and sometimes in Mitchell County, each has indicated this item does not apply to them. Therefore, this management goal is not applicable to the operations of the District.

Standard

4.1.1 None.

Goal

5.0 *Addressing Natural Resource Issues that Impact the Use and Availability of Groundwater and are Impacted by the Use of Groundwater*

Objective

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.

Standard

5.1.1 Annually publicize the importance of plugging or capping wells.

Goal

6.0 *Addressing Drought Conditions*

Objective

6.1 The District will develop and maintain a drought contingency plan to include recommended rationing and conservation techniques.

Standard

6.1.1 Development of a Drought Contingency Plan.

Objective

6.2 Quarterly, review 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.

Standard

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

Objective

6.3 Quarterly 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.

Standard

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

Goal

7.0 *Addressing Conservation*

Objective

7.1 The District will develop and implement a water level monitoring program to include at least 30 water wells throughout the District. The District will gather water levels at least twice per year on each of the 30 water wells to determine the effects of pumping and weather conditions on the aquifer. Data files will be built and maintained at the District office. Annual reports will be presented to the board on the status of the water level monitoring program.

Standard

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

Objective

7.2 District staff will write or sponsor at least four media releases per year on various issues relating to conservation. These articles will be sent to local media outlets for publication. The District will maintain a file detailing all newspaper articles and radio and television coverage on conservation issues.

Standard

7.2.1 The number of media releases sent to local media outlets.

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