GMD3 Revised Management Program

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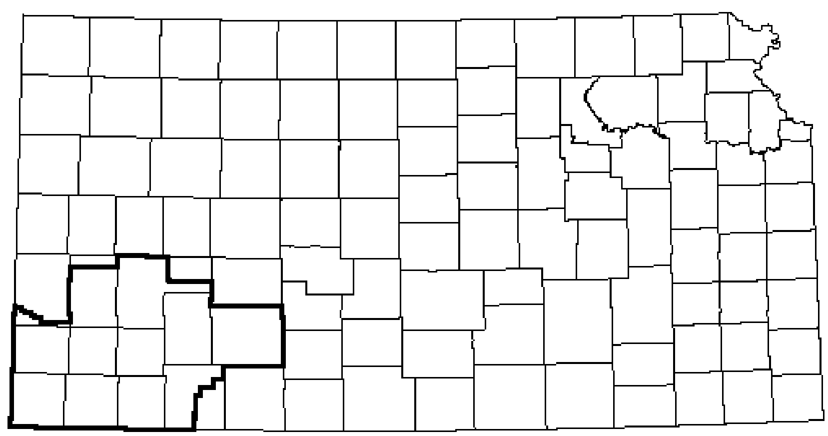

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Groundwater Management District
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Southwest Kansas Groundwater Management District No. 3

Revised Management Program

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MISSION

In 1972 the Kansas Legislature ratified the Groundwater Management District Act. The first law contained in the act challenged each District with a mission founded in the following declaration:

K.S.A. 82a-1020. Legislative Declaration. It is hereby recognized that a need exists for the creation of special districts for the proper management of the groundwater resources of the state; for the conservation of groundwater resources; for the prevention of economic deterioration; for associated endeavors within the state of Kansas through the stabilization of agriculture; and to secure for Kansas the benefit of its fertile soils and favorable location with respect to national and world markets. It is the policy of this act to preserve basic water use doctrine and to establish the right of local water users to determine their destiny with respect to the use of the groundwater insofar as it does not conflict with the basic laws and policies of the state of Kansas. It is, therefore, declared that in the public interest it is necessary and advisable to permit the establishment of groundwater management districts.

ORGANIZATION OF THE DISTRICT

A series of informational meetings were sponsored by the Southwest Kansas Irrigation Association in the fall of 1973 to determine the will of the people relative to the formation of a local groundwater management district, also commonly referred to as a GMD. As a result of these meetings a steering committee was formed to carry out the organization of the District according to procedures provided in the GMD Act. On December 4, 1974, the steering committee filed a declaration of intent, along with a map of the proposed District, with the Chief Engineer of the Division of Water Resources (DWR), Kansas State Board of Agriculture. The Chief Engineer consulted with the steering committee, conducted appropriate geological studies and reviewed input from people in the fringe areas of the District. On August 25, 1975, the Chief Engineer certified the description of the lands proposed to be included in this new taxing subdivision of the State.

Next, the steering committee circulated a petition throughout the proposed area. After receiving the proper number of signatures it was submitted to the Secretary of State for approval. The petition was approved on October 13, 1975 and was followed by an election that was held on February 24, 1976. The election resulted in 1,155 voters in favor and 230 opposed. The Secretary of State was compelled by the election results to issue a Certificate of Incorporation on March 23, 1976. The Certificate of Incorporation has been filed at each county's Register of Deeds Office that is located within the District. An organizational meeting to elect the initial Board of Directors was held in Garden City, Kansas on April 6, 1976. The second Annual Meeting was held March 23, 1977 and since then the Annual Meetings have been held on the fourth Wednesday of February.

The District is governed by a 15-member Board of Director's that is elected by a general constituency of the qualified voters. Each county is represented by at least one director who resides in that county. Any type of "water user", as defined in K.S.A. 82a-1021(k), may be elected to serve as one of the 12 county positions. In addition to the 12 individual county positions, there are also 3 "at-large" board positions that are designated to represent only a single type of water usage. One such position represents all municipal water usage. Surface Water users and Industrial water users also receive additional representation through an "at-large" representative. The District is financed by an annual property tax assessment that is levied against local landowners and water users. This is accomplished through an annual budgeting process that includes a public hearing of the proposed tax assessments as well as the District's financial status for the ensuing year.

The District's headquarters are located in Garden City, Kansas. The District conducts its regular monthly business meetings on the second Wednesday of each month and provides an Annual Meeting for the election of

Board members on the fourth Wednesday during the month of February. Public hearings are regularly provided to allow public input on the budget, management programs, and other pertinent activities. A detailed set of bylaws has been adopted by the board and are regularly reviewed and updated. Each year members of the Board are appointed to serve on at least one sub-committee. Each committee addresses issues on an as-needed or ad hoc basis as directed by the Board. The committees are as follows: Executive, Policy, Finance, Research & Development, and the Annual Meeting Committee.

CHARACTERISTICS OF THE DISTRICT

General Characteristics of the District

The District includes approximately 5,392,229 acres, or approximately 8,425 square miles of land. This includes all of Morton, Stevens, Seward, Stanton, Grant, Haskell, Gray, and Ford Counties as well as parts of Meade, Finney, Kearny, and Hamilton Counties. Land surface elevations range from approximately 3500 feet above sea level (ASL) in the west to less than 2300 feet ASL in the east. The land surface slopes in an east-southeast direction at a gradient ranging from 5 to 20 feet per mile.

There are approximately 12,405 established water rights that comprise approximately 30 percent of all Kansas water rights. They authorize approximately 10,500 non-domestic water wells (Figure 1 – Water Rights Map). The most common source of water for these wells is the High Plains Aquifer, which includes the Ogallala Formation, and is an unconsolidated, unconfined aquifer that receives very little recharge. In comparison, approximately only 75 wells are authorized to tap into the Confined Dakota Aquifer System, which is commonly referred to as the "Dakota Aquifer". (See also K.A.R. 5-1-1. Definitions.) The characteristics of these aquifers can vary dramatically throughout the District. The quality of the ground water in the High Plains and Dakota Aquifers is generally fresh although in some locations the salinity exceeds recommended limits for drinking water. The saturated thickness of the High Plains Aquifer ranges from 20 feet to 600 feet within the District. Well capacities range from 20 gallons per minute (gpm) to 3,000 gpm. Historic depletion also varies spatially across the District as documented in the Kansas Geological Survey (KGS) Open File reports 2001-45 and 2002-26 (Woods and Sophocleous 2001, 2002). Overall, the water level decline rate in the Ogallala/High Plains Aquifer in Kansas has decreased from 1.4 feet per year from 1969 to 1979, to just over 0.5 feet per year from 1989 to 1999 [2004 Kansas Water Plan].

There are two river systems that interact with their respective alluvial aquifers, the Arkansas River and the Cimarron River. Most of the Arkansas River and much of the Cimarron River are losing streams within the District, meaning that when the rivers are flowing some of the flow recharges the underlying aquifer. There are 6 irrigation systems that divert water from the Arkansas River between the Colorado-Kansas state line and Garden City. Separate ditch irrigation companies owned by farmer-shareholders control approximately 140,000 acre-feet of surface water rights from the Arkansas River according to David Brenn, Arkansas River Compact Commissioner. Portions of the headwaters of tributaries of the Pawnee River are located in eastern Finney, northeastern Gray, and northern Ford counties in the District.

The alluvial aquifers of these headwaters are too small to be a significant water source within the District.

Corn is the most popular irrigated crop according to annual water use reports collected by the DWR. The Net Irrigation Requirement (NIR) for corn ranges from 13.7" in Ford County to 15.4" in Morton County; this is in addition to the average precipitation of only 19 inches (K.A.R. 5-5-12, Net irrigation requirements at 50% chance of rainfall; K.A.R. 5-6-12, Average annual precipitation). Each year approximately 2.1 million acres of cultivated farmland are irrigated within GMD3 (annual water use reports averaged for 1992 through 1996).

Approximately 134,000 persons reside in the District. In contrast to the sparse human population, this District could have the highest concentration of feeder cattle in the nation. The current property value is approximately $8 billion dollars, of which almost $2.3 billion is residential property (Docking Institute of Public Affairs, March 2001).

High Plains Aquifer Characteristics

The High Plains Aquifer consists mainly of a heterogeneous assortment of sand, gravel, silt and clay of Tertiary and Quaternary age that was deposited by streams that flowed eastward from the Rocky Mountains. The aquifer sediments overlie an eroded bedrock surface of Permian and Cretaceous age. The Tertiary Ogallala Formation makes up the main part of the aquifer in western Kansas. Because of the similarity in composition, the Tertiary sediments are difficult to distinguish from the younger Quaternary sediments. The aquifer varies widely in type of material, thickness, and layer continuity. Individual beds generally are not continuous and within short distances may grade laterally or vertically into material of different composition. Hydraulic conductivity and specific yield depend on sediment types, and vary widely both vertically and laterally. Some layers are cemented and are referred to as mortar beds and caliche. Although the aquifer is generally unconfined, confined and semi-confined conditions may occur locally. Thick clays are present in the deeper portion of the aquifer in Seward and Meade counties.

The thickness of the unconsolidated sediments varies greatly due mostly to the uneven bedrock surface. Saturated thickness ranges up to more than 500 feet as illustrated on the attached Figure 2 (Woods and Sophocleous 2002, Current Saturated Thickness Map). The areas of greatest thickness are found between the Bear Creek and Crooked Creek-Fowler Faults, which are shown on the Woods and Sophocleous maps. Thickness may change by as much as 250 feet across the fault zones, which are a result of subsidence associated with the dissolution of Permian evaporites. The greatest saturated thickness typically occurs where the unconsolidated sediments overlie the deepest channels in the bedrock.

Regional ground-water flow is from west to east at an average rate of about 1-foot per day or less. Buddemeier et al. (2003; Figure 1.1) includes a recent water table elevation map; ground-water flow is perpendicular to the contours. Depth to water is variable and exceeds 300 feet in a large portion of Haskell County and in portions of Grant and Stanton counties (Woods and Sophocleous 2001).

In some areas, such as the Arkansas and Cimarron River corridors, the High Plains Aquifer is hydraulically connected to overlying alluvium. In the case of the Arkansas River corridor, the alluvium is differentiated from the High Plains Aquifer on the basis of the greater permeability of the alluvium and an underlying lower permeability zone, which results in differences in water levels between the aquifers. The High Plains Aquifer is also connected to the underlying Lower Cretaceous Dakota Aquifer in some locations (see following section).

References and additional information (see full listing below): Buddemeier et al. 2003; Cederstrand 1998a, 1998b; Gutentag et al. 1981; Gutentag et al. 1984; Sophocleous et al. 2001; Sophocleous 2003; Stullken et al. 1985; Woods and Sophocleous 2001, 2002; Young et al. 2000.

Bedrock Aquifer Characteristics

Sandstones within the Dakota Bedrock Aquifer yield water to wells within GMD3. The yield of wells screened in Dakota sandstones is typically smaller than the yield of wells in the High Plains Aquifer. The Dakota Aquifer underlies and is in hydraulic connection with the High Plains Aquifer in the southern part of GMD3 (see map in High Plains Atlas, http://www.kgs.ukans.edu/HighPlains/atlas/aqrelmap.gif). In the northern part of the District, low permeability shale and chalk overlie and hydraulically isolate the Dakota Aquifer from the overlying High Plains Aquifer. The management program recognizes the change from good hydraulic connection to isolation for water rights appropriations. Further information on the Dakota Aquifer is available online at http://www.kgs.ku.edu/Dakota/vol1/index.html. Permian bedrock underlies the High Plains Aquifer in the southernmost part of the District. The Permian bedrock is not used for irrigation in the District except in locations where the High Plains Aquifer is thinly saturated, such as in a small part of Morton County.

Precipitation and Recharge

The climate of Southwestern Kansas is semiarid, characterized by moderate precipitation, low humidity and high evaporation. Annual precipitation increases to the east and typically ranges from 16 to 24 inches. Most of the precipitation falls during the growing season, April through September.

Potential sources of recharge to the aquifer include precipitation, surface water (including the Arkansas and Cimarron Rivers and irrigation ditches), return flow from irrigation, lateral ground-water flow, and flow from adjacent aquifers. Recharge generally increases with increased precipitation, but is affected by soil properties, land cover and land use. Regional areal recharge estimates are low, typically less than about one inch annually. Recharge may be higher locally, such as beneath river and ditch corridors, irrigated land, and sand dunes.

References and additional information (see full listing below): Gutentag et al. 1981; Hansen 1991; Hecox et al. 2002; Luckey et al. 1986; Luckey and Becker 1999; Sophocleous 1998; Sophocleous 2003; Sophocleous et al. 2001; Sophocleous and Pradhananga 2003; Stullken et al. 1985; Whittemore 2002; Young and Buddemeier 2002.

Water Use and Water-Level/Saturated Thickness Declines

In the 1940s, referred to as predevelopment conditions, there were only several hundred irrigation wells in Southwestern Kansas. The number of large-capacity wells has increased dramatically since 1950. Today there are more than 10,000 non-domestic water wells (Figure 1). Figure 3 illustrates relative density of water use. Heavy ground-water development, where discharge has been much greater than recharge, has resulted in ground-water level declines of over 200 feet and of over 70 percent in some areas (Woods and Sophocleous 2002, Change in Saturated Thickness map). See illustration in attached Figure 4.

Under predevelopment conditions, ground water discharged naturally to surface waters, including the Arkansas and Cimarron rivers. Ground-water declines have resulted in streamflow declines as the ground-water levels dropped below stream levels. Historically, the Arkansas River was a gaining stream, meaning it received baseflow or groundwater discharge along nearly all of its length in Southwest Kansas. Today's flow in the Arkansas River and in irrigation ditches infiltrate and recharge the alluvial and High Plains Aquifers. Water-level declines have also reduced the discharge of ground water to the Cimarron River.

In 1981, Gutentag et al. (1981, p. 62) noted that a comparison of well locations and water-level declines suggests a cause and effect relationship between well density and water level changes. The areas of greatest well density generally correspond to the areas of greatest withdrawals and water-level declines. Irrigation development resulted in depletion of ground water in storage (ground-water mining). These authors also noted those areas with declines of 40 percent or more had already experienced a large reduction in well yields and a large increase in the cost of pumping. A comparison of current maps (Water Rights Fig. 1, Water Use Density Fig. 3, and Change in

Saturated Thickness Fig. 4) illustrates that the relationship between well density, water use density, and water-level declines continues today. Areas of greatest water-level declines are centered in Grant and Haskell counties, and include eastern Stanton, northern Stevens, and parts of southern Finney and southeast Kearny counties.

References and Additional Information (see full listing below):

Gutentag et al. 1981; Upper Arkansas River Corridor Study - Ground-Water Levels: http://www.kgs.ukans.edu/Hydro/UARC/water-levels.html; Woods and Sophocleous 2002.

Water Quality

Ground water in the High Plains Aquifer is generally fresh. Salinity is an issue 1) where Arkansas River water, which is high in sulfate concentration, recharges the alluvial and High Plains Aquifers (Upper Arkansas River Corridor Study: http://www.kgs.ukans.edu/Hydro/UARC/) and 2) where Permian bedrock discharges high-chloride concentration water into the base of the aquifer, particularly in parts of Meade and Seward counties. The High Plains Atlas contains a regional ground-water quality map showing areas affected by high chloride and/or sulfate contents: http://www.kgs.ukans.edu/HighPlains/atlas/wqpmap.gif. Agricultural chemicals particularly nitrate and pesticides have resulted in local ground-water contamination (see the USGS High Plains NAWQA website: http://webserver.cr.usgs.gov/nawqa/hpgw/HPGW_home.html).

WATER SUPPLY PROBLEMS & SOLUTIONS

Depletion of the Unconfined High Plains Aquifer

Over-estimating the recharge, competition for new wells and the over-appropriation of water rights contributed to the depletion or mining of the aquifer. The major water supply problem is the inherent lack of surface water supplies, and that the rate of groundwater renewal, or recharge, doesn't keep-up with the rate of withdrawal, or demand on the aquifer.

Soon after being incorporated, the District adopted the following three restrictions that significantly reduced development, but failed to prevent depletion. First of all, minimum distances between water wells were required (K.A.R. 5-23-3). Along with that, allowable aquifer depletion criteria were adopted to restrict the amount of water that could be allotted to each well according to the natural limits of the aquifer (K.A.R. 5-23-4). Additionally, the amount of water that could be requested for each acre of land to be irrigated was limited (K.A.R. 5-23-5). Over-appropriation of non-domestic uses of water continued in spite of these seemingly severe measures.

In response to over-appropriation and with the help of the Chief Engineer the District has closed 230 of its 250 townships to further appropriation and has adopted safe yield criteria in the remaining 20 townships that are open to further appropriation (K.A.R. 5-23-4a and K.A.R. 5-23-4b). This culminated from four separate administrative actions instigated by the District in the years 1991, 1996, 2000, and 2002. The District also increased restrictions in well spacing regulations again in 2000 and 2003 (K.A.R. 5-23-3).

Improved and Focussed Strategic Planning

A series of studies ranging from enhancing recharge to the economic impact of irrigation in the District helped confirm the need for long-term strategic planning to address the rate of decline of the aquifer. One such study reacted to the District's region of most significant historic depletion that is located along the Bear Creek Fault in the central-west portion of District. The geologic characteristics near the fault area inspired the Board of Directors to hire an expert to perform a spot-evaluation of the related groundwater interactions. Dr. Greg Pouch of Illinois Wesleyan University completed the Bear Creek Fault Recharge Study in 2001. He found at least six areas along the fault zone where groundwater discharges to the atmosphere, indicating that the fault acts as a barrier to groundwater flow and that recharge to the aquifer uphill from the fault would not provide water to the area downhill of the fault. He also noted that holding water from unusual and intermittent high flows in the Arkansas River in surface impoundments does not appear to be an efficient means of water supply due to the high evaporative losses from such ponds, but that infiltrating such water into the aquifer might be useful.

A second study of similar intent was concluded about 1 year following the Bear Creek Fault Study that made similar conclusions. This second study considered building a reservoir near Kendall for the purpose of regulating the flow of water in the Arkansas River and was conducted by Spronk Water Engineers of Denver, Colorado. The premise for the study was to evaluate whether stored river water intended for use in Kansas irrigation ditches could be controlled in a more beneficial and efficient manner than was being done with the John Martin Reservoir located a considerable distance upstream in Eastern Colorado. The study implied that the potential benefits of installing a new reservoir were outweighed by the anticipated water lost due to evaporation of surface water in storage. Besides water lost to the atmosphere from evaporation, retaining water in a reservoir can create negative impacts on water users located downstream of the dam by inhibiting the natural recharge of their source of supply that would occur if the flow of surface water hadn't been retained by the reservoir.

The District also sponsored a comprehensive economic study during the same time the Kendall Dam Study was being conducted. The economic study was intended to help understand why irrigators face economic difficulties while their irrigated crop production drives the second strongest economy of the state. The Docking Institute located at the Fort Hays State University finished the study in March of 2001. The study provided comprehensive insight of the economic dynamics associated with irrigation crop production in Southwest Kansas. These studies and numerous others either sponsored by the District, or others interested in the future of Southwest Kansas, led the District to recognize the ongoing need for comprehensive strategic planning. On October 10, 2001 the board adopted an Aquifer Management Protocol to be used to research, discover, and evaluate aquifer characteristics that could enhance future water management decisions. The protocol has been developed in conjunction with the DWR, KGS, the Kansas Water Office and the Kansas Water Authority.

Throughout the strategic planning process a continued sense of urgency exists for real-time accurate aquifer characteristics. Accordingly, the District sponsored the 4/10/02 update of KGS High Plains Aquifer Saturated Thickness Study (Refer to KGS Open File Report 2001-45). Following the continuance of that long-term initiative, it also became apparent that essential aquifer bedrock information had not been updated for 30 years. Accordingly, the District initiated and sponsored a comprehensive update of the bedrock elevation information and map. The District entered into a contract with the KGS to complete this study tentatively by mid-2004. In addition to obtaining better information about the aquifer, the demand is also growing for qualified expertise needed to evaluate and substantiate District operations and future decisions. Sensing this growing need, the Board of Directors passed a resolution on July 9, 2003 to engage experts on an as-needed and ad hoc basis to provide scientific input for board and staff decisions. This bold resolution also provides the foundation for unbiased and credible peer review of District operations and future plans.

Improve On-site Management

On-site water management begins with preventing the waste of water. Soon after becoming incorporated the District has been the primary agency responsible for curtailing waste of water violations. A corrective course of action is normally and consistently established on the same day a waste of water complaint is received. Aside from establishing a quick-response attitude towards curtailing waste of water and other water right violations, the District has assisted implementing state mandated water conservation plans. The District provided compliance monitoring and public assistance in cooperation with the DWR and under contract with the KS Water Office to insure compliance with water conservation plans from 1990 to 1995. GMD3 also became the first groundwater management entity located in Kansas to mandate the installation of permanent flow meters on non-domestic wells. The program began in 1991 and became effective in 1993. The program became fully implemented with meter installation reports confirmed by 1996. Sensing a need for increased enforcement of the flow meter requirement the Board of Directors increased flow meter inspections by over 200 percent during 2002 without increasing taxes. The new and innovative program proved to be fiscally viable by contracting with seasonal field inspectors, rather than hiring full or part-time employees. Beginning in 2002 the total annual inspections were increased from 800 to nearly 2,500 inspections. In addition to that, meter violations have decreased dramatically. Besides the obvious economic advantages of contract labor, this method also helps catch violations that are committed on weekends and evenings on the pretense that regular employees are off-duty.

Curtail the Unlawful Use of Water

The District recognized the need to curtail the unlawful use of water and took decisive action resulting in positive outcome. A new management initiative adopted in 2000 focused on self-governance through regulatory compliance. The District also became less dependent upon the State to provide enforcement. Following this newly adopted philosophy, the District decided to begin by identifying and eliminating land being irrigated without lawful authority. During February of 2002 the District utilized satellite imagery to review over 30,000 parcels of land, or nearly 5.4 million acres. Reflecting the due diligence of area landowners, unlawful irrigation was identified on only 81 parcels, which was a very positive discovery. In spite of the optimistic findings of the satellite reconnaissance, legal notices were served to the alleged violators on 3/8/2002 and by mid-2003 nearly all of these cases were resolved with only one case requiring a court-ordered injunction to curtail the unlawful use of water. Following that successful enforcement action, the District launched another new initiative later to address allegations of another type of the unlawful use of water commonly referred to as "overpumping". The Board of Directors adopted a resolution on November 13, 2002 to curtail overpumping using current rules. District staff initiated the program early in 2003 that resulted in confirmation of approximately 31 cases of unauthorized water use during the 2003 irrigation season. The District issued written directives during 2003 ordering the unlawful use of water to stop immediately and will be monitoring over 50 wells during 2004 as a continuance of this program.

Water Quality Protection

Backflow prevention is an essential first step in the prevention of manmade contamination. The District acted early to assure water quality protection from manmade constituents. The District required Backflow preventers or check-valves as early as 1978. This was part of the first set of rules promulgated by the District. Later this regulation was rescinded and replaced by a statewide regulation developed by the DWR. Inadequate well construction standards can be another leading cause of manmade groundwater contamination. In conjunction with the KS Department of Health & Environment under new rules ratified during 2002 by the Kansas Legislature, the District plans to develop well construction standards that prevent the migration of water between different sources. During the late 1970's and early 1980's it became apparent that wells being constructed in alluvial river valleys needed to be built with permanent barriers preventing river water from reaching the aquifer. Improperly constructed wells can create a conduit allowing the river water that is of uncertain quality to migrate along the outer wall of the well casing that eventually might contaminate the aquifer. Similar criteria are required to prevent contact between confined and unconfined aquifers. In addition to those conditions the Permian Beds Geologic Formation found in parts of Meade and Seward counties can contain high concentrations of naturally occurring chlorides, sulfates, or other undesirable water constituents. Soon after discovering this potential contamination problem in the mid-1980's the District adopted similar well construction restrictions that targeted specific locations in both Meade and Seward counties.

Besides well construction, monitoring water quality is another essential component to protecting the aquifer. The District has established a monitoring network consisting of 250 well sites that have been sampled and analyzed since 1988. In 2001 the District changed from gathering samples utilizing seasonal student labor, to contracting the work with the nationally respected and state-certified Servi-Tec Laboratories of Dodge City. Servi-Tec Lab personnel perform the field sampling and laboratory analysis. They also locate and identify the sampling sites using Global Positioning System (GPS) technology. The sampling site locations are illustrated in Figure 1.

In the late 1980's the state mandated "local environmental planning" and in response the District provided staff, financial support, and administrative oversight for the Southwest Kansas Local Environmental Planning Group (LEPG) from 1990 to 2002. This group established and enforced sanitary ordinances in at least 12 counties in Southwest Kansas. In 2002 the District relinquished management of the LEPG to the existing LEPG Board of Directors and their staff. The LEPG no longer receives funding from the District.

PROGRAMS & GOALS TO BE UNDERTAKEN

Ogallala-High Plains Aquifer Management Protocol

The 2005 State Water Plan asserts that GMD3 is responsible for determining hydrologic subunits in areas inside the GMD3 boundaries. This is in response to declines in water levels and the economic future of the water resource. The tasks described are intended to meet planning and management goals, and focus attention on refining hydrologic subunit boundaries in those areas. The subunits will be based on hydrogeologic parameters and assigned a priority (high, medium, and low) to assist future work efforts and focus on more detailed water management strategies in higher priority areas while deferring work on the lower priority areas until a later time. A fundamental premise of this protocol is that it shall remain open to change or modification as better information is available or as changes occur in the hydrological, economical, and legal or policy making process. The completion of these protocol tasks is dependent upon current and anticipated budgetary constraints determined by the GMD3 Board of Directors.

Objectives as Outlined by Ogallala Aquifer Management Advisory Committee

- Identify preliminary hydrologic subunits
    - Identify key parameters for water resource management
    - Identify hydrologic subunits

Classify hydrologic subunits as high, medium, or low priority
    - Rate of decline
    - Time to reach selected threshold value
    - Water Right criteria
    - Socio-Economic Impact of declines
- Establish preliminary water management goals for high priority subunits
    - Water Management Plans based on priority
    - Analysis of data needed for plans
    - Identify and develop management plan options
- Define criteria for determining success
- Define level of progress in water reduction
- Course of action if goals are not achieved
- Assistance programs for farmers to transition to dry land farming

Goals to Identify, Classify and Manage Hydrologic Subunits

The planning goals are to identify hydrologic subunits for water management based on areas with relatively short time remaining to reach selected threshold water levels under present rates of withdrawal. Threshold water levels are defined as those levels where large-scale withdrawals for irrigation would not be any lower than what is practical for that area (could vary between subunits). After identification, hydrologic subunits will be classified as high, medium, or low priority areas. The medium and low priority areas will be addressed in alternative ways or later.

After classification, management goals will be applied to high priority areas where the withdrawal rate has exceeded the aquifer's ability to sustain long-term irrigation. The District will define new management strategies to help decrease water consumption in these high priority subunits as deemed necessary by the District to decrease the rate of aquifer decline. The threshold level will be intended to define the minimum saturated thickness required to sustain a flow rate normally used for irrigation in an area.

Identification of Hydrologic Subunits

Hydrologic subunits should identify areas in the Ogallala-High Plains Aquifer with similar hydrogeologic parameters and groundwater dynamics.

Hydrogeologic parameters are numerical and describe the hydrogeologic characteristics of an aquifer, which deal with groundwater and related geologic aspects of surface waters. Groundwater dynamics address the changes in these parameters (i.e. change in saturated thickness, change in water levels, etc.). Hydrogeologic parameters are included in the following list:

1. Water Level Variations
2. Land Surface and Bedrock elevation
3. Aquifer storage coefficient
4. Precipitation
5. Soil type
6. Saturated Thickness
7. Withdrawal rate (projection of historic water use)
8. Aquifer discharge estimates (historic values)
9. Hydraulic Conductivity
10. Location (latitude and longitude)

Analytical techniques will be applied to those parameters for which adequate data is available and used to: 1) identify areas with similar parameters: and 2) adequately define planning priorities. Parameters selected for the analysis must establish a sound scientific basis for approach. Cluster analysis is one analytical technique that can be used to identify and classify areas with similar hydrogeologic parameters. The data are clustered into manageable subunits based on the ten variables with the results represented in map form. Cluster overlaps may occur between the fringe areas and the GMD3 boundaries.

After cluster analysis, or some other computational method, has defined the subunits, a water budget computation can be applied based on spatial distribution of similar attributes. A water budget is a technique used to describe the relative abundance of water supply in each subunit and compare the wet and dry years.

The planning criterion for identifying hydrologic subunits is to have a single value for each section (1 sq. mi.) for nine of the listed variables. This requires determining a single value from many data points for some sections. In areas where data does not exist for every section, it requires interpolation or extrapolation from adjacent areas. The legal township boundaries will not be necessarily used to define hydrologic subunits although the size (approximately 36 square miles) is expected to be the minimum size used for a subunit. To achieve the planning goal to identify hydrologic subunits it is expected that current available data will be sufficient.

Classification of Hydrologic Subunits

The District will classify subunits by estimating the amount of time it takes to reach a pre-determined threshold. Classification of high priority areas should include analysis of water right criteria, groundwater levels, water use, aquifer characteristics, well yield, aquifer discharge, and withdrawal rates. Analysis could include, for example, quantifying selected parameters in a water budget. In addition, cluster analysis could be used to further refine classification of priority areas. Definition and justification of socio-economic criteria could also be included as a secondary approach to classifying subunits. If these criteria are used then socio-economic thresholds should also be defined. For example, pumping water levels affect costs and pumping rates, which will limit the number of acres irrigated and/or crop produced.

When classifying hydrologic subunits, water rights within an area and adjacent areas should be evaluated to compare existing water rights to water supply. Then a determination can be made on the relative time remaining to reach threshold water levels. Regarding large-scale withdrawals for irrigation, threshold water levels would not be set lower than what is practical for that area. In contrast, there may be areas presently at a threshold water level where few if any water rights have a significant impact on the water supply. Such areas should not be classified as high priority.

Density of water use and pumping rates tend to be higher within the GMD3 boundaries than in the fringe areas, due to the larger volume pumped and the greater saturated thickness. Wells inside the GMD3 boundaries may intercept groundwater flow to areas outside the GMD3 boundaries, or be dependent on groundwater flow from within the GMD3 boundaries. Determining where these interfaces occur is essential in classifying priority areas, as well as identifying management strategies that need to be coordinated between the GMD3 boundaries and the fringe area. Since the fringe areas are managed under the jurisdiction of the DWR, then GMD3 will coordinate with the DWR in developing compatible criteria for areas adjacent to the fringe areas.

Analysis of water levels can be approached from two perspectives in classifying threshold water levels, historic water level declines or historic water use rates. The historic water level declines can be projected at a continuous rate until they reach a given threshold water level. Another approach is to project historic water use rates until the volume in storage reaches a level corresponding to a given threshold water level. In both approaches the spatial variability of the aquifer characteristics (for example, storage coefficient, hydraulic conductivity, etc) are required. A determination of the aquifer's ability to sustain a flow rate normally used for irrigation in that given area will be used to establish the threshold for high priority subunits.

Aquifer discharge is another component that can be used in classifying hydrologic subunits in the Ogallala-High Plains Aquifer region. Discharges to streams or wetlands are limited by arid climatic conditions coupled with declining water tables from aquifer withdrawal. Therefore, aquifer discharge will not occur in all areas. This component of the groundwater budget typically occurs at alluvial interfaces near the fringes of the Ogallala-High Plains Aquifer formation. (Note: Inclusion of the surface elevation will address ET loss from shallow water tables). By identifying the areas where aquifer discharge occurs, an estimated base flow measurement can be taken throughout the year. Another method of estimating aquifer discharge is the application of Darcy's law. Darcy's Law requires hydraulic gradient, hydraulic conductivity, and saturated thickness for the application.

Aquifer recharge rates are variable across the Ogallala-High Plains Aquifer region and include the measure of vertical and lateral movement of surface or groundwater to the aquifer system. Hydrogeologic parameters used in determining vertical movement of ground or surface water recharge rates are precipitation, soil type, and depth to water. Groundwater elevation gradients, hydraulic conductivity, and saturated thickness control lateral recharge rates. Recharge rates and withdrawal rates are often compared to determine the level of withdrawal to the amount being replenished. Areas where withdrawal rates exceed recharge will be identified and classified.

Field verification during the planning process may be required to further refine hydrologic subunits. In priority areas a more extensive data verification or, in a few instances, a targeted data collection may be necessary. However, in the water management analysis the scale of analysis would remain at 1 square mile. Current rules for determining water availability are based on safe yield or other criteria that severely limit the opportunity to qualify for a new appropriation.

Note: Coordination through with the Division of Water Resources will be necessary to ensure consistent subunit classification results throughout the Ogallala-High Plains Aquifer.

Preliminary Delineation of Aquifer Subunits in GMD3

Until better information is available the areas depicted in the map of the High Plains Aquifer as delineated in Figure 5 will be used to classify priority ground water decline areas. This map has been adopted in the Water Conservation section of the 2005 Kansas State Water Plan (SWP). As stated in the 2005 SWP: "Figure 5 indicates the relative need for management and conservation through a priority ranking of 1-4, with 1 being the areas with a shorter estimated usable lifetime for the aquifer to support 400 gpm well yields, and having a history of higher ground water usage. Overlaying the estimated usable life of the High Plains Aquifer with the average annual reported ground water use generated the map. The estimated usable lifetime of the High Plains Aquifer is based on ground water decline trends from 1991 – 2001 and the estimated minimum saturated thickness necessary to support 400 gallons per minute pumping for 90 days (see Figure 13 in KGS Open-File Report 2002-25D). The second database is the density of annual reported ground water use, average over the years 1990 – 2000, within a 5-mile radius area (see Figure 15b in Open-File Report 2002-25D). The priority zones are defined using a combination of the estimated usable lifetime and the density of reported annual ground water usage. Areas with insufficient data and water levels for 2001 greater or equal to those in 1991 are also indicated in Figure 5." Refinements to the parameters for this analysis would be made to define subunit boundaries.

Establishing Water Management Goals for High Priority Areas

In comparing water management strategies within hydrologic subunits, the threshold water level and the withdrawal rate are the variables that can be defined or controlled by water use management. A threshold water level will indicate when the annual demand on subunit water supply will change significantly, because the saturated thickness will no longer provide adequate pumping rates. Water table elevation, bedrock elevation, and hydraulic conductivity are aquifer characteristics needed to establish this threshold water level.

Withdrawal rates are a measure of the extent of development in the area and computed from water use report data available from the Kansas Department of Agriculture - Division of Water Resources (KDA - DWR) water rights information system (WRIS). By statute, water use data is collected from every authorized point of diversion that has a permit to appropriate water. The water use data can be used to identify management strategies in high priority areas, along with other data determined by GMD3 to be viable.

A list of various water use goals will be generated to establish management strategies in each high priority area. These management strategies shall include definition of the level of progress in water use reduction, criteria for success, a course of action if goals are not achieved, and identify programs for farmers to transition to dryland.

Public meetings will be held to review the management strategies with water users in priority areas. The meetings will: 1) review analysis conducted by GMD3 and DWR; 2) receive input from the attendees on preferred strategies; and 3) determine what additional management strategies should be considered by GMD3 and DWR to achieve management goals. In addition, GMD3 will work with the Division of Water Resources (DWR), Kansas Water Office (KWO), Kansas Geological Survey (KGS), Kansas State University (KSU), other Groundwater Management Districts (GMD), and others to develop economically acceptable transition plans.

Timeline for Identifying, Classifying, and Managing Hydrologic Subunits for Areas Inside the GMD3 Boundaries

The identification of hydrologic subunits was completed as prescribed by the Chief Engineer on November 14, 2003. This involved planning and coordination of tasks with key personnel of the DWR, the KWO, and the KGS. The tasks will interface with the state water plan and DWR objectives. Data sets compiled for this effort will be combined with KGS data sets as part of the database for the Ogallala-High Plains Aquifer Management Plan. Efforts on classifying hydrologic subunits will follow identification tasks (tentatively November 2004). Subsequent years will focus on establishing management strategies for implementation in high priority areas.

The following tasks are anticipated for the planning process and identification of hydrologic subunits:

- Identify and quantify key parameters for hydrologic subunits
  - Minimum flow rate required to support irrigation
  - Trend data
  - Thresholds for sustainable management
- Review research conducted on Ogallala-High Plains Aquifer (review bibliography contents)
- Define subunits at the interfaces with DWR near the GMD3 boundaries.
- Identify areas where Ogallala-High Plains is estimated to be confined/unconfined
- Address overlap between areas inside/outside GMD3 boundaries
- Define geographic reference of management areas

Follow-Up Tasks for Classification of Hydrologic Subunits

Classification and Management Strategy Tasks

- Obtain accurate point of diversion information
  - Saturated Thickness
  - Well depth
  - Depth to bedrock
  - Ogallala-High Plains wells hydraulically connected to alluvium
  - Identify areas of recharge to Ogallala-High Plains
- Quantify water use by aquifer source, depth to water, type (irr, mun and vested, appropriated).
- Water Quality
- Field Verification: design and implementation of appropriate monitoring and measurement strategies.
- Water Budget
  - Establish dates to base budget
  - Identify parameters that are in agreement by all parties
- Create master database to track data compilation and analysis
  - Assist with identifying priority areas
  - Track rate of decline
  - Make information available to all parties and the general public (online)
- Establish guidelines for meetings between key personnel in DWR, KWO, KGS, KSU, GMD3, and other entities.
  - Who presents?
  - Frequency of meetings?

CONCLUSION

All District policies and procedures are intended to work in harmony with rules and regulations adopted by the Chief Engineer, Division of Water Resources, according to the authority vested in the Chief Engineer by the Kansas Legislature through the Water Appropriation Act. The Board of Directors regularly evaluates the District's mission, policies and goals in order to assure the proper management of the local water resources.

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GLOSSARY

Alluvial: soil or earth material which has been deposited by running water as in a riverbed, flood plain, or delta. [1]

Alluvium: the gravel, sand, silt, and clay and similar unconsolidated material deposited in comparatively recent geologic time by a stream or other body of running water as sorted or semi sorted sediment in the bed of the stream or on its floodplain or delta. [2] A general term for deposits of clay, silt, sand, gravel or other particulate material that has been deposited by a stream or other body of running water in a streambed, on a flood plain, on a delta, or at the base of a mountain. [1]

Appropriation right: is a right, acquired under the provisions of article 7 of chapter 82a of the Kansas Statutes Annotated and acts amendatory thereof and supplemental thereto, to divert from a definite water supply a specific quantity of water at a specific rate of diversion, provided such water is available in excess of the requirements of all vested rights that relate to such supply and all appropriation rights of earlier date that relate to such supply, and to apply such water to a specific beneficial use or uses in preference to all appropriations right of later date. K.S.A. 82a-701 (f).

Appropriated water: a quantity of water from a well, stream, river, reservoir, or other source reserved for a specific use and place of use under state water right laws, statutes, or regulations.

Aquifer: any geological formation capable of yielding water in sufficient quantities that it can be extracted for beneficial purposes. K.S.A. 82a-1021. A geologic formation, a group of formations, or a part of a formation that is water bearing. [1]

Aquifer, Alluvial: an aquifer comprised of unconsolidated materials, usually gravel, sand, silt, and clay that have been deposited by running water in comparatively recent geologic time. [2]

Aquifer, Bedrock: Dakota aquifer system shall include the Dakota formation, the Kiowa formation, the Cheyenne sandstone and where hydraulically connected the Morrison formation. K.A.R. 5-1-1 (t).

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[1] Water Words Dictionary. Nevada Division of Water Resources. Department of Conservation and Natural Resources, A Compilation of Technical Water, Water Quality, Environmental, and Water-Related Terms.

[2] From GMD3 regulations adopted in 2000.

Aquifer, Confined: an aquifer which is bounded above and below by formations of impermeable or relatively impermeable material. [1]

Aquifer, Unconfined: an aquifer made up of loose material, such as sand or gravel that has not undergone lithification (settling). [1] Unconfined Dakota aquifer system means that portion of the Dakota aquifer system not overlain by Graneros shale. K.A.R. 5-1-1 (aaaa).

Bedrock: a general term for solid rock that lies beneath soil, loose sediments, or other unconsolidated material. [1]

Chief Engineer: the Chief Engineer of the Division of Water Resources of the Kansas Department of Agriculture. K.S.A. 82a-701 (b).

District: the Southwest Kansas Groundwater Management District No. 3, Garden City, Kansas.

Domestic use: the use of water by any person or by a family unit or household for household purposes, or for the watering of livestock, poultry, farm and domestic animals used in operating a farm, and for the irrigation of lands not exceeding a total of two (2) acres in area for the growing of gardens, orchards and lawns. K.S.A. 82a-701(c).

DWR: the Division of Water Resources, Kansas Department of Agriculture, Topeka, Kansas.

GMD3: Southwest Kansas Groundwater Management District No. 3, Garden City, Kansas.

Groundwater: water below the surface of the earth. K.A.R. 5-1-1 (gg).

Groundwater Management District Act: K.S.A. 82a-1021 *et seq.*, and amendments thereto.

Hydrogeologic: those factors that deal with subsurface waters and related geologic aspects of surface waters. [1]

Hydrogeologic parameters: numerical parameters that describe the hydrogeologic characteristics of an aquifer such as porosity, permeability and transmissivity. [1]

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[1] Water Words Dictionary. Nevada Division of Water Resources. Department of Conservation and Natural Resources, A Compilation of Technical Water, Water Quality, Environmental, and Water-Related Terms.

Hydrogeology: the part of geology concerned wit the functions of water in modifying the earth, especially by erosion and deposition, geology of groundwater with particular emphasis on the chemistry and movement of water. [1]

Hydrologic: of or pertaining to hydrology, that is the science dealing with water, its properties, phenomena, and distribution over the earth's surface. [1]

K.A.R.: Kansas Administrative Regulations. Standards, statements of policy or general orders, including amendments or revocations thereof, of general application and having the effect of law, issued or adopted by a state agency to implement or interpret legislation enforced or administered by such state agency or to govern the organization or procedure of such state agency. K.S.A. 77-415 (4).

KCC: Kansas Corporation Commission, Topeka, Kansas.

KGS: Kansas Geological Survey, Lawrence, Kansas.

K.S.A.: Kansas Statutes Annotated—the laws passed by the Kansas Legislature and signed by Governor.

KSU: Kansas State University, Manhattan, Kansas.

KU: Kansas University, Lawrence, Kansas.

KWO: Kansas Water Office, Topeka, Kansas.

Non-domestic: all other beneficial uses of water including stock watering, municipal, irrigation, industrial, recreation, waterpower, artificial recharge, hydraulic dredging, contamination remediation, dewatering, fire protection, thermal exchange, and sediment control in a reservoir. K.A.R. 5-1-1(o).

Over-appropriation: water use that exceeds the long-term sustainable yield of the water supply, including hydraulically connected surface and ground water.

Overpumping: common or slang expression referring to the unlawful diversion or pumping of water in excess of the authorized annual quantity of water.

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[1] Water Words Dictionary. Nevada Division of Water Resources. Department of Conservation and Natural Resources, A Compilation of Technical Water, Water Quality, Environmental, and Water-Related Terms.

Recharge: the natural infiltration of surface water or rainfall into an aquifer from its catchments area. K.A.R. 5-1-1 (fff).

Revised Management Program: each Groundwater Management District is required under the provisions of the Kansas Groundwater Management District Act, K.S.A. 82a-1029, to have a Management Program. The Board is required to review it at least annually. The management plan and any revisions must be reviewed by the Chief Engineer to ensure that it is compatible with the Kansas Water Appropriation Act and any other state laws and policies. The GMD Act, K.S.A. 82a-1021, defines it as a written report describing the characteristics of the district and the nature and methods of dealing with groundwater supply problems within the district. It shall include information as to the groundwater management program to be undertaken by the district and such maps, geological information, and other data as may be necessary for the formulation of such a program.

Saturated Thickness: the thickness of the portion of the aquifer in which all pores, or voids, are filled with water. In a *confined aquifer* this is generally the aquifer thickness. In an *unconfined aquifer* this is the distance between the water level and the base of the aquifer. [1]

Static Water Level: the depth below land surface at which the top of the groundwater is found when not affected by recent pumping. K.A.R. 5-1-1 (rrr).

Surface Water: water in creeks, rivers, or other watercourses, and in reservoirs, lakes and ponds. K.A.R. 5-1-1(zzz).

Threshold: the minimum saturated thickness to maintain a rate normally used for irrigation in an area.

Unconsolidated regional aquifer system: a body of mostly unconsolidated and heterogeneous water bearing deposits that are hydraulically and geologically contiguous, and are capable of yielding water in sufficient quantities for beneficial use. K.A.R. 5-1-1 (bbbb).

Waste of water: any act or omission that causes the application of water to an authorized beneficial use in excess of the needs for this use in connection with the place of use authorized by a vested right, an appropriation right, or an approval of application for a permit to appropriate water for beneficial use. Parts of K.A.R. 5-1-1 (cccc).

[1] Water Words Dictionary. Nevada Division of Water Resources. Department of Conservation and Natural Resources, A Compilation of Technical Water, Water Quality, Environmental, and Water-Related Terms.

Water Appropriation Act: the Kansas Water Appropriation Act, K.S.A. 82a-701 *et seq.,* and amendments thereto.

Water Balance: the method of determining the amount of water in storage in a basin storage area by accounting for inflow to, outflow from, and changes in storage in that basin storage area.