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# Kansas Geological Survey

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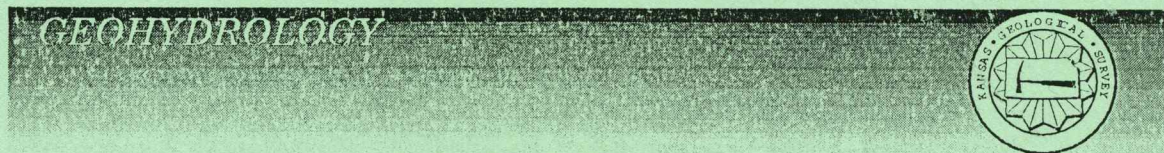
*Final draft submitted for contract compliance and funding agency review*

## HIGH PLAINS AQUIFER EVALUATION: Report of Progress and Products, FY 1999

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## Executive Summary

The High Plains Aquifer Evaluation (HPAE) Project has as its primary objective the establishment of baselines for, and rates of change of, water quantity and water quality parameters in the High Plains Aquifer. In order to assess the effectiveness of programs designed to manage resources, the baseline and rate determinations must be not only quantitative, but also interpreted in the context of their inherent uncertainties. FY1999 has been a start-up year, with the full project envisioned as requiring up to six additional years.

The project focuses on issues relevant to the Kansas Water Plan Objectives, and will also provide significant input to the Kansas Water Authority response to House substitute for Senate Bill 287. To ensure that the results are useful to the State's water management, regulatory, and coordinating agencies, the Kansas Geological Survey is working in close partnership with the Kansas Water Office, and has developed a Coordinating Council structure to facilitate active participation by other state and local water agencies. Electronic media (Internet, World Wide Web) are used to develop innovative approaches to communication, information exchange, and review of plans and progress.

In addition to organizational and communication developments, technical progress has been made in three significant areas in FY1999:

*Definition of terms and concepts:* Quantitative measurement and calculation is not possible in the absence of a generally-accepted, rigorous definition of both objectives and the terms and methods used to describe and implement them. Sections B and C of report OFR 99-21A present and explain systematic approaches to definitions that are both relevant to the objectives, and feasible to implement within the legal, management, and scientific context. Both water quantity (with a primary initial focus on groundwater level) and water quality issues are addressed. These definitions have progressed through draft stages which have been posted on project WWW pages for agency review and comment.

*Database design and data acquisition:* In spite of the existence of relatively extensive centralized databases maintained by KGS, the US Geological Survey, The Division of Water Resources, and the US Environmental Protection Agency, there has never been any consolidated database which contains all or nearly all of the available information on High Plains Aquifer water content, water quality, hydrogeologic characteristics, or relevant program and agency activities. Such databases are a prerequisite for project success; they have been designed, and implementation is in progress (see section D, OFR 99-21A). The water quantity (level) database is nearing completion, a water quality database is in the final design stages, a database of agencies and individual contacts has been assembled (Appendix C), and a database of relevant programs has been initiated (exemplified and described in Appendix D). A library of statewide and High Plains ArcView coverages is being assembled in the KGS Oracle database using the Spatial Database Engine (SDE); this will facilitate both spatial analysis and interpretation of the data and presentation of results.

*Uncertainty assessments:* Knowledge of uncertainties in individual measurements and in their generalization over space and time is essential to understanding the rates and causes of change in

the groundwater resource. Open-File Report 99-21B presents three exploratory studies of factors affecting uncertainties in water quantity determinations.

The first set of studies (Buddemeier, Escobar, and Mosteller) uses water level data available in the KGS WIZARD database to determine the degree to which the annual (winter) water level measurements represent an equilibrated water table, and how important is residual disequilibrium from water extraction. The limited suite of wells that have long-term subannual records suggest that water level trends in similar wells located a few miles apart record essentially identical trends over time scale of several years. However, both within-year seasonal records and comparison of seasonal behaviors between years in the same well reveal a high degree of variation, limiting the potential for useful interpretation of records at a local scale over time periods of a few years. Repeat measurements show that a significant minority of wells are still in a phase of rapid water level change at the January measurement time; these extensive departures from an equilibrium water table do not appear to be simply predictable, and are not consistent in time or space. Analysis of conservative pumping and recovery scenarios with the SUPRPUMP well drawdown program confirms that significant winter season changes can be expected in proximity to irrigation wells.

The second study (McElwee and Bohling) is a model-based investigation of the sensitivity of recharge or flux estimates to uncertainties in aquifer parameters. The results indicate that tolerable levels of noise reduction require averaging over several model nodes; if node spacing is roughly equivalent to the spatial density of measurement points, these computational findings reinforce and amplify the empirical conclusions that data uncertainty makes short-range, short-term interpretations inadvisable.

The third investigation (Zheng) reports on an innovative approach to analyzing trends in regional water table elevations and individual well deviations from those trends. Using Wizard data for the GMD1 area, this study provides striking reinforcement of the observations in the initial reconnaissance study. Large scale water level trends are clearly discernible, but individual wells are highly variable in terms of the qualitative and quantitative fidelity with which they represent those trends, leaving a high level of uncertainty in any individual uncertainty or sub-decadal change.

Development of a workplan for FY2000 (section E, OFR 99-21A) is one of the major FY1999 products. KGS has worked closely with KWO and other agencies to develop, plans, supporting data, and work agreements. FY2000 work will continue, and in most cases complete, the development of comprehensive High Plains databases. A systematic estimation of decadal-scale changes in water levels and their uncertainties will be made at the scales of the whole aquifer, GMDs and river basins, and in smaller administrative or geohydrologic units to the extent feasible. An overview assessment of High Plains water quality will be made, with further evaluation of the extent to which decadal-scale changes can be assessed and smaller areas independently evaluated. For both water quantity and quality, development and evaluation of appropriate statistical and data analysis techniques will continue, as will evaluation of needs and potential for future improvements in the database available for resource assessment and program evaluation.

**High Plains Aquifer Evaluation Issues and Progress: An Overview**  
KGS OFR 99-21A

Compilers: R. W. Buddemeier, D. O. Whittemore

Contributors: G. C. Bohling, R. W. Buddemeier, C. A. Escobar, J. M. Guinotte, P. A. Macfarlane, C. D. McElwee, J. D. Mosteller, J. A. Schloss, M. A. Sophocleous, M. A. Townsend, S. S. Vaughn, D. O. Whittemore, D. P. Young, Li Zheng

***A. Project History, Evolution, and Approach***

**1. Initial Development**

The High Plains Aquifer Evaluation project has developed new approaches in a number of areas of water resource information, research, and management support. The project was developed out of discussions between Kansas Water Office (KWO) staff and staff of the Geohydrology Section of the Kansas Geological Survey (KGS) during Spring and Summer, 1998. At that time it was clear that an improved basis for quantitative assessment of the effectiveness of Water Plan programs and projects was needed, and the formulation of Water Plan Objectives was in progress.

It was recognized that it would be a massive and unprecedented undertaking to establish baselines for water quality and water quantity in the High Plains Aquifer (Figure 1) against which past and future changes could be measured and the effects of programs assessed. Among the required -- and largely novel -- characteristics of the project were:

- An active partnership between KWO and KGS in the ongoing, evolutionary design of the data collection and research program;
- A high level of involvement and cooperation with other state water agencies and with the groundwater management districts -- not only for technical review and advice, but for active assistance in assembling the necessary information and data;
- An explicit emphasis on the need for quantitative assessment of uncertainties in the baselines, and on their implications for measurement of changes and assessment of programs;
- Expanded reliance on electronic (e.g., World-Wide Web) communication and information distribution; and
- A multi-year program that would progressively emphasize and review different sections of the aquifer (roughly coincident with the groundwater management districts) while constructing comprehensive databases and overall assessments at the whole-aquifer level.

In addition to these jointly determined characteristics, the KGS team adopted some internally innovative approaches in terms of organization (designation of the HPAE project as a section-level effort) and management (use of a manager-coordinator-task leader structure rather than the traditional 'principal investigator' approach). The long-term joint plan developed was for seven years of effort, beginning with reduced funding (\$25,000) in the start-up year (FY1999) and then increasing to \$150,000/year in the following 6 years. The first-year contract is contained in Appendix A of this report.

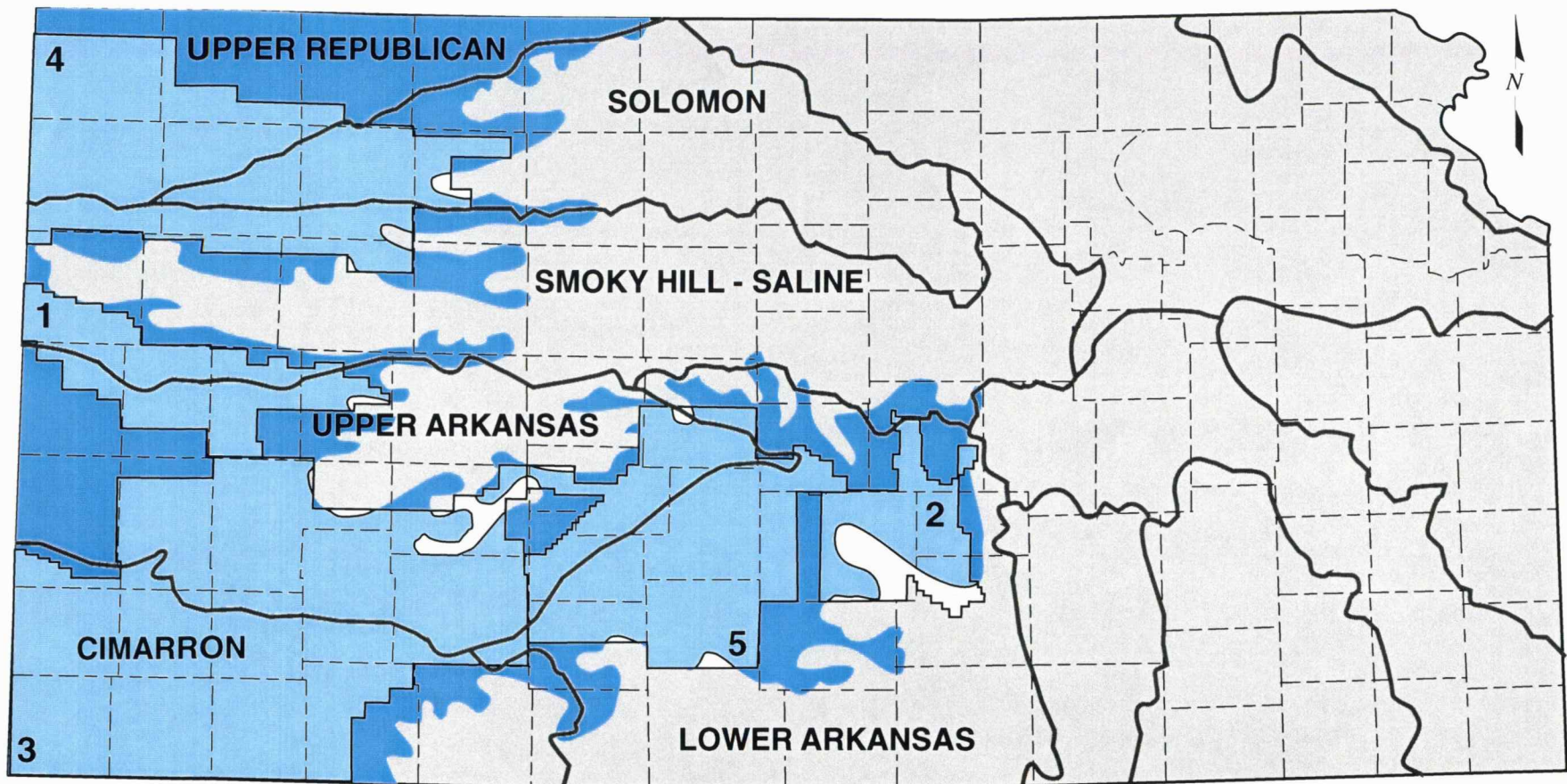


Figure 1.

### High Plains Aquifer Extent, Groundwater Management Districts and Basin Boundaries

- county boundary
- GMD boundary
- basin boundary

Within GMD

- High Plains Aquifer
- Non-High Plains Aquifer

Outside GMD

- High Plains Aquifer
- Non-High Plains Aquifer

## 2. Planned Accomplishments

During FY1999, the HPAE project has met all of the contract requirements for deliverables (Appendix A). At least as important to long-term success has been the concurrent development of workplans, and the scientific and institutional infrastructure.

*Organizational relationships:* A Coordinating Council (CC) has been formed, staffed by representatives of the key state and local water agencies. Membership is listed in Part 2 of Appendix B. The group met twice during FY1999 to advise on approaches and review plans and progress, and will meet again in the first quarter of FY2000. In addition to functioning as an advisory group, individual members have been key contacts in coordinating the data collection efforts.

Because of its geographically inclusive nature (see Figure 1), the HPAE project has potential synergies with other research projects and water-related activities. In the interests of efficiency in resource use and optimization of products, activities within KGS are being coordinated with Upper Arkansas River Corridor and Equus beds Mineral Intrusion projects (KWO) and the TMDL Assessment project (KDHE). Externally, we have established liaisons and/or cooperative arrangements with the US Geological Survey (both local district and the High-Plains NAWQA program), with KWRI (W. Hargrove, KSU), with R. Sleezer (ESU), who is carrying out intensive groundwater-related studies in the Equus beds area, and with the DWR project to develop time-to-depletion estimates for the Ogallala aquifer (T. Huntzinger).

Liaison with the groundwater management districts (GMDs) has been established to determine the sequence of regional studies within the aquifer system (but see items IA3 below), and to identify and assemble relevant data held at the local agency level.

*Communication:* The basic structure of a three-tiered approach to electronic communication has been developed. KGS has an internal website for convenient internal storage and review of project information, and a prototype public set of pages on the High Plains Aquifer and the project outcomes is in development and review. However, the major development has been the combination of a website and e-mail as a means of communication between project personnel and non-KGS participants and advisors. The prototype set of pages () is 'unlisted' to provide some degree of privacy for the intended users, but is not access-controlled. A new, password-controlled page () has been established and tested, and will be implemented as the primary electronic link early in FY2000. Appendix B contains a copy of a recent version of the index page for this site, plus the list of Coordinating Council and project members that is one of the documents linked to the index page.

*Information and data management:* Central goals of the project are assembling a comprehensive water quantity and water quality database, interpreting its contents in the context of water resource management needs and activities, and active cooperation with agencies that have a variety of needs, interests and levels of technical development (e.g., data records ranging from paper forms in conventional files through a variety of spreadsheets and computer text reports to relatively sophisticated relational databases). This has required not only data assembly, formatting, and entry, but a substantial amount of development in the area of database design and linkage. The results have been major progress toward a both a comprehensive database and information management structures that will make the data, and supporting data and information

such as GIS coverages, accessible not only to researchers but to the participating agencies as well. Details of these activities are presented in sections IA4, ID, and IE1 (below) of this report.

### 3. Project evolution and modifications

It was anticipated from the outset that the HPAE project would evolve as the KWO strategies for defining and meeting Water Plan Objectives developed, and as project-based experience accumulated. This has happened; in addition, external developments and legislative actions in the 1999 Session have further modified the context and directions of the project.

A major early transition occurred when it was recognized that the project objectives could not be defined in terms of the effects of only Water Plan projects, but had to operate in the context of all programs that potentially affect High Plains water quality or quantity. This dramatically expanded the potential scope of the program identification effort (Appendix D), as did the discovery of just how many programs meet the criteria. One of the results of recognizing this higher level of complexity was a decision, taken jointly with KWO and reviewed by the CC, to prioritize program information assembly to (a) Water Plan programs, (b) other major or potentially high-impact programs with quantifiable objectives or effects, and (c) all others, and to consider this a supporting activity rather than a primary objective. See also comments in the introduction to Appendix A.

An operational change was imposed when the Governor's Budget Office cut the funds allocated to the project for FY2000 from \$150,000 to \$75,000. Although KWO was subsequently able to identify \$15,000 to supplement the reduced budget, the reduction of resources in the critical first 'full' year of the project has necessitated postponement or reduction of a number of originally planned activities.

An additional major strategic change was dictated by legislative passage of House substitute for Senate Bill 287, which stated in part: *"The Kansas Water Authority shall study and develop recommendations related to aquifer resources, recharge rates, availability of surface water resources and the long-term prospects related to any necessary transition to dryland farming in areas of the state to maintain sustainable yield and minimum streamflow levels. Report to the Legislature due on or before January 8, 2001."* Because of its strong overlap with the objectives and activities of the HPAE project, this mandate has had the effect of revising the initial strategy of working through the aquifer on a GMD-by-GMD basis (see Appendix A and the material posted at the URLs identified in Appendix B), and has dictated development of initial overview assessments followed by more detailed regional and topical follow-up studies. These changes are reflected in section E of this report (below).

### 4. Technical Progress

*Definition of terms and concepts:* Terms such as "depletion, contamination, degradation, water level, water quality, water quantity," etc., are widely used and are implicitly quantitative. However, in the absence of an explicit definition it is not possible to quantify these terms in ways that will be understandable and acceptable to all participants, much less derive measures of

change and uncertainty. Definition and explanation of the concepts of water quantity and water quality baselines for the High Plains Aquifer have been a major focus; the working definitions are presented in sections IB and IC of this report (below).

*Data acquisition and assembly:* Since the data management effort is a major part of the project, separate sections are devoted to descriptions of the basic approach (section ID, this report) and planned future activities (IE, this report). Accomplishments for FY 1999 include: (a) design and linkage of operational working databases (see section ID); (b) acquisition and/or consolidation of all water level data from the KGS, DWR, and USGS databases; (c) acquisition of locally held water level data for the GMD2 area; (d) assembly of relevant water quality data (inorganic constituents, some VOC data) from KGS, USGS, and EPA-Storet databases (note: the last item includes all or most of the data produced under the KDHE programs for monitoring surface water quality (stream and lake stations) and groundwater quality (state-wide well network)); (e) acquisition of GMD2 water quality data; (f) acquisition and incorporation of water quality data for municipal water supplies the state from KDHE; and (g) development of ArcView coverages (see sections ID and IE1 below) to facilitate data visualization, interpretation, and development of map products.

*Uncertainty assessments:* There have been no rigorous prior assessments of compound uncertainties in water level or water quality determinations, and there are no standard methods that can be routinely applied to a resources and data as heterogeneous as those associated with the High Plains Aquifer. Several pilot investigations have been undertaken to develop a preliminary assessment of water level uncertainties, their origins, and their implications for both the analysis of existing data and the improvement of future data collection and analysis. These are reported in OFR99-21B, the second portion of this composite report.

#### ***B. Water level/quantity baseline definition***

*The following material was posted April 4, 1999 on the HPAE website for CC review and discussion, and was modified and re-posted April 26. See the website for comments received and posted.*

The following definitions are applicable at the whole-aquifer or large regional (e.g., GMD or basin) scale. Their possible extension or modification to apply to more local areas, down to the level of townships, will be addressed as part of the FY2000 project work plan

Three levels of definition are used:

- 1. The annual water table elevation of an unconfined aquifer is derived from the measured or inferred water table based on point measurements during a specific period in time. It approximates as closely as possible the configuration the water table would have after equilibration of all distortions due to pumping or other artificial stresses.**
- 2. The water table elevation baseline of an unconfined aquifer will be derived from interpolation of multiple annual water table elevations. The time intervals used will be determined: 1) based on objective and systematic methodologies for applying baseline data**

to specific uses, and 2) by the objective of representing as accurately as feasible the configuration the water table would have in the absence of distortions due to pumping or other artificial stresses.

**3. The baseline storage of an unconfined aquifer will be calculated using: a) the water table elevation baseline of the aquifer, b) best available bedrock surface elevation data, and c) three-dimensional data on distribution of specific yield within the saturated volume of the aquifer.**

Note a: Areas of perched, confined, or semi-confined aquifer conditions will need to be identified and addressed with different baseline definitions for specific applications or different scales of consideration. Although the areas of concern can be identified generically, individual treatments must be developed on a case-by-case basis.

Note b: KGS will provide the scientific components of the baseline definitions and the means of combining them, but will produce a formal determination based on specific years only on the basis of consensus among the participating agencies.

Note c: Quantitative identification of uncertainties in baselines and component variables will be conducted; methods and definitions will be discussed in a subsequent section.

*Rationale and discussion:*

BASELINE 1. A line serving as a basis; esp: one of known measure or position used (as in surveying or navigation) to calculate or locate something. 2. The area within which a baseball player must keep when running between bases. 3. The back line at each end of a court in various games (as tennis). 4. A set of critical observations or data used for comparison or a control. (Webster's Ninth New Collegiate Dictionary)

"Baseline" in the sense used within the High Plains Aquifer Evaluation Project is clearly most closely allied to definition 4, but with an obvious relationship to definition 1. Because the Kansas Water Plan Objectives set forth certain goals to be achieved by 2010, the water quality and quantity baselines are operationally defined as a basis for comparison and control (in this discussion "control" is used in its scientific, experimental-design sense, although legislative and management bodies could chose to exercise control in the more common sense of the word).

The Objectives specify or imply that the comparison must be quantitative, so the definition of 'baseline' is necessarily quantitative. Uncertainty is an issue because definition 4 in this case cannot be transformed into definition 1 — a precisely or absolutely known baseline is not realistically achievable. Therefore the significance and utility of any comparison will depend on the precision and accuracy with which the baseline state and the compared condition are known.

The time scale of both definition and data collection are significant because the Objectives address the issues of change over time (i.e., trends or shifts in 'baseline'), and the data exhibit temporal variability in addition to any systematic trends that may occur.

The following is an initial attempt (for review and discussion) to arrive at a useful definition of a water quantity baseline, and to explore how it might be practically identified and applied.

1. The quantity of water considered is the quantity of water that is extractable with present technology and is contained within the aquifer at the reference time (to be discussed later). If we could write equations describing the distribution of water throughout the aquifer, the quantity would be the double integral over saturated thickness and specific yield (or effective porosity). Although this is conceptually straightforward, its measurement or calculation is not, and we rely on spatially and temporally distributed measurements to estimate the integrated characteristics.
2. Because the issue of concern is the change in water inventory, and the specific yield of a given volume of the aquifer can be considered time-invariant, the primary issue is the change in saturated thickness with time. Since the bedrock elevation is also time-invariant, this means that water table elevation (assuming an unconfined aquifer—see below) can be treated as proportional to the volume of water contained in the underlying aquifer as long as the changes in saturated thickness do not result in a significant change in the average specific yield of the saturated volume of the aquifer. At time scales of years to a few decades, this condition is reasonably well met — most of the High Plains Aquifer has saturated thicknesses on the order of a hundred feet and recent annual decline rates of a foot or less, so the expected changes (on the order of percents) in saturated thicknesses are unlikely to cause large changes in the relationship between saturated thickness and total water volume.
3. We therefore come to the conclusion that measurement of change in water table elevation is the critical element in determining the rate of change in water inventory. Understanding the detailed relationship between the water table elevation, saturated thickness, and water inventory will be important in allocating water rights, in developing management models, and in interpreting changes in specific locales, but the primary need for quantifying the depletion rate is an accurate picture of the time course of water table elevation changes.
4. On an annual basis, we idealize the representative water table elevation as the configuration it would have if it had fully recovered from pumping stresses. This idealized condition never occurs, but it is far easier to approximate this relatively smooth surface than to measure with accuracy the highly variable water table topography of a stressed aquifer. It is the quality — accuracy and consistency — of the estimate that determines the uncertainty of a baseline derived from measured water table elevations.
5. Measurements in a single year are not generally considered optimal for estimating a short-term water table baseline. The term ‘baseline’ carries with it an implication of normality and standardization, and any given year may be atypical in terms of the effects of economic or climatic variations that affect water recharge and withdrawal. This is one reason that water levels are commonly averaged over several years; another is a ‘time for space’ tradeoff in acquiring a larger number of measured values, and therefore reducing the effects of measurement errors or outliers on the overall pattern. The selection of the number of years to be averaged is a practical issue, and is determined by the needs of programs and managers. Intervals long enough to average out climatic variability are far too long to detect trends on management time scales; in

the present case the requirement of having rate determinations (that is, differences in water table elevations) that can be compared on a time scale of 10-15 years means that a 3-5 year averaging period is about as long as can practically be used.

### *C. Water-quality baseline definition*

Evaluation of whether the 2010 objective of water quality remediation in the Kansas Water Plan is being met, and development of recommendations (per Senate Bill 287) on the chemical quality of water resources require a determination of the spatial and temporal characteristics of water quality in the High Plains aquifer. Determination of a water-quality baseline comprises a fundamental part of such information. The baseline provides a critical data set and interpretation of conditions for a particular period that can be used for future comparison for evaluating the impact of remediation and protection actions, as well as changes in environmental and management actions that can impact water quality.

There are three main considerations for developing a water-quality baseline:

- 1) The particular chemical parameters for representation of water quality,
- 2) The time or period that the baseline data represent,
- 3) The spatial coverage of the baseline, i.e., both areal and depth divisions for the aquifer.

*1. Chemical parameters:* The Water Plan objective on water quality remediation states: by 2010, significantly reduce the percentage of monitoring well network wells (all networks) contaminated by nitrate, chloride, sulfate or volatile organic chemicals caused by human activity. These chemical constituents are the focus for water-quality baseline development in the HPAE project.

*2. Time considerations:* Two different levels of temporal baseline definition are proposed for each of the water-quality parameters:

- a) Time-independent water quality data, and
- b) Data grouped according to time intervals appropriate to the data distribution or evaluation needs.

The first approach includes all data for a particular chemical parameter for the entire area of interest. The value of this method is that it gives an overview of the entire data coverage. If there are multiple samples at a particular sampling point, the value selected from the group could be from the beginning, middle, or end of the sampling period depending on the type of data overview desired. The second approach allows determination of a more time-specific baseline, especially where examination of the data according to temporal grouping reveals significant changes with time. The selection of a particular period appropriate for the baseline to be used for future water-quality evaluation should be better than using data from the entire period of record if sufficient data exist for the subset.

3. *Spatial considerations*: Two different spatial considerations for baseline definition are proposed for the water-quality parameters:

- a) Stratification by depth in the aquifer, and
- b) Spatial division into hydrological, chemical, or management regions.

Depth stratification generally involves dividing the aquifer into data coverages for the shallow, main production zone, and near-bedrock layers of the aquifer. In specific study areas, lithology and stratigraphy determine the selection of these or other depth intervals, but as a starting point, standard depth ranges relative to the water table are appropriate.

Spatial definitions of a water-quality baseline can be based on environmental or management considerations, or both. KWO has specified interest in reviewing aquifer resources based on whole aquifer, GMD, river basin, hydrogeologic subunits, and if possible, townships – subdivisions which encompass both environmental and legal/management considerations at a variety of spatial scales.

Chemical divisions can be used to generate water-quality provinces in the aquifer that are dependent on the concentration distribution and source characteristics of individual constituents.

The final baselines chosen will consider the most appropriate combinations of the above spatial and temporal factors for the selected water-quality parameters and the questions under consideration. The combined approaches can be summarized as four categories of baseline types for each chemical parameter:

- 1) **Spatial and time-independent water-quality knowledge,**
- 2) **Spatial-independent, time-dependent water-quality coverage,**
- 3) **Depth-stratified and/or areal-designated, time-independent water-quality coverage, and**
- 4) **Depth-stratified and/or areal-designated, time-dependent water-quality coverage.**

Water-Quality Baseline Definition Discussion:

*Water-quality parameters*

A water-quality baseline does not consist of a single, simple data set because there are hundreds of different chemical parameters that could be potentially used for baseline determination. For a practical approach, a subset of the chemical parameters must be selected that most efficiently represents the water-quality conditions for the primary uses of the water. Primary uses of water in Kansas include drinking, agricultural uses such as livestock and irrigation, and industrial. Selection of key chemical constituents should consider whether they could indicate significant contamination of waters for all these uses.

Nitrate, chloride, and sulfate are all inorganic constituents that occur in elevated concentrations in High Plains aquifer waters. Each is of fundamental interest for drinking-water use. There is a primary standard or maximum contaminant level (MCL) of Kansas for nitrate

above which waters cannot be used for supplies for public use. The major sources causing concentrations of nitrate exceeding this standard in Kansas are associated with human activities. High nitrate contents can also be an indicator of the possibility that certain other water-quality parameters might be of concern, for example, bacteria in waters from poorly constructed wells. Varying background levels of nitrate exist in all Kansas waters from natural sources. The main sources causing increases substantially above the background are related to both agriculture and human and animal wastes. Environmental factors such as drought or wet periods can operate in conjunction with human activities to vary the nitrate amount leached from soils that reaches ground water.

Secondary or recommended standards exist for both chloride and sulfate for drinking water. In addition, high concentrations are not desirable for stock and irrigation water use and for certain industrial uses that require low salinity. Both chloride and sulfate have different natural and human sources in Kansas and are constituents that are among the more frequent water-quality problems observed in the state. These constituents are general indicators of the salinity and, thus, the concentrations of other major inorganic constituents in water, as well as the potential for higher levels of minor and trace substances depending on the sources.

Volatile organic chemicals (also known as VOC's) are a group of organic compounds that can vaporize relatively easily. They range widely in solubility in water but are of concern to health at relatively low concentrations in water. Drinking-water MCL's of Kansas exist for a variety of different VOC's. Other than petroleum products, VOC's are among the most frequently observed organics contaminating the High Plains aquifer. The sources of elevated VOC concentrations are clearly contamination from human use or chemical processes related to human activities. Although some VOC's are used as agricultural pesticides, the main water-quality problems of VOC's in Kansas derive from commercial and industrial use. Thus, VOC's represent contamination from types of sources that are different from inorganic constituent sources and are clear indicators of human contamination.

#### *Spatial considerations*

The shallow layer represents the near water-table conditions that are the first to be affected by areal infiltration of recharge and contamination from the surface. Water supplies derived from the shallow portion of an aquifer tend to be from small wells such as those used for domestic and limited stock supplies. The main production zone of an aquifer is usually the mid-to deep portion of the saturated thickness. Supplies pumped from this zone include large capacity irrigation, municipal, and industrial wells and also many domestic and larger stock wells. Deep wells screened only near the underlying bedrock surface are typically observation wells that monitor the distribution of particular contaminants, such as salt-intrusion from bedrock into the aquifer base or contaminants dense enough to reach the bottom of an aquifer and flow along the often less permeable bedrock surface.

Hydrologic divisions could be derived from differing hydrogeologic characteristics of areas of the High Plains aquifer, such as the western, largely Ogallala portion versus the mainly Quaternary sediments of south-central Kansas. Other hydrogeologic divisions could include logical separations where the aquifer is not present or is thinly saturated, for example, between

northwest and west-central Kansas where most of the aquifer sediments were removed by erosion. These separations generally coincide with management areas of the groundwater management districts. At smaller scales, variations in lithology, land and water use, and hydrologic parameters such as permeability and porosity may provide a logical basis for defining subunits of the aquifer.

As an example of a water-quality province, subdivisions for chloride could include areas of low chloride concentration distinguished from other areas and depths of elevated chloride derived from natural saltwater sources and anthropogenic pollution such as oil field brine and salt-mine/processing wastes. For nitrate the provinces could comprise different areas and depths of low nitrate and high nitrate concentrations, and could include consideration of hydrogeochemical characteristics of the aquifer that control concentrations. This approach could point to the development of a baseline that would guide the use of different monitoring approaches (in distribution and sample frequency) as needed in different provinces, including along transition zones and in areas identified as particularly sensitive to changes.

#### Overview and summary:

Ideally, the baseline definition with some spatial stratification and designation for a particular period will be the most definitive for evaluation of future water-quality information. However, limitations in the spatial and temporal distribution of the data for particular chemical constituents mean that longer time intervals and little or no depth stratification may be necessary for particular baselines.

The particular baselines to be selected will depend on an examination of all the temporal and spatial data available for a particular chemical parameter and of acceptable quality (within error limits). In addition, the objectives of monitoring after baseline establishment should be considered. These include determination of locations of new, human-related pollution as well as concentration changes in and movement of existing human-related and natural contamination. The final baseline development will involve consensus definition of the spatial, temporal, and uncertainty characteristics that meet the programmatic needs of the participating agencies, and determination that the baselines can be used by all participants and are feasible to implement and apply to aquifer evaluation with the resources available to the project.

#### ***D. Data management and visualization***

Microsoft Access software was chosen for the working database. Access is a relational database and is widely used and readily available (part of the Microsoft Office package). Access is compatible with Oracle (the KGS and DWR central database software). This means that when databases are deemed complete and ready for public access, they can be transferred into the KGS data system that is already linked to the WWW. Access tables can be transformed readily from or to spreadsheet or word processing formats, making it appropriate for data exchange with organizations that may not be using relational databases.

Information has been entered into four Microsoft Access databases: contacts, programs, water quantity metadata, and metadata on water quality data and data sources. The fields in each table are shown in Figure 2. The contacts and programs databases will be linked into a relational database structure (see Fig. 2); this will permit, for example, associating data or contacts with specific programs. The metadata and data tables can be linked via contact, agency or program. As data are assembled, they are being added into or linked to the present metadata tables.

The data being assembled represent observations widely separated in both space and time, and are potentially related to a variety of other factors-- geology, soils, land use, climate, etc. In order to meet the challenges of visualizing and interpreting the data, and of presenting them to other project participants in an understandable and relevant fashion, KGS is developing a system to support visualization, selection, and mapping of HPAE data. This approach utilizes ArcView software, which can combine geospatial data layers in a map format with a system of "queries" for selecting and examining data sets in a variety of modes. An additional software package called Spatial Database Engine (SDE) is being used to store the spatial components of GIS data directly in Oracle. This facilitates central storage, retrieval, and updating of spatial data. DASC is also moving to distribute many of its coverages through this medium. In support of HPAE and related projects, the GH section at KGS has developed a growing SDE library that complements the DASC holdings and that will facilitate interpretation, review and illustration of the water quantity and quality data. Table 1 presents a list of coverages already loaded into SDE or planned for inclusion by both DASC and the Geohydrology Section of KGS.

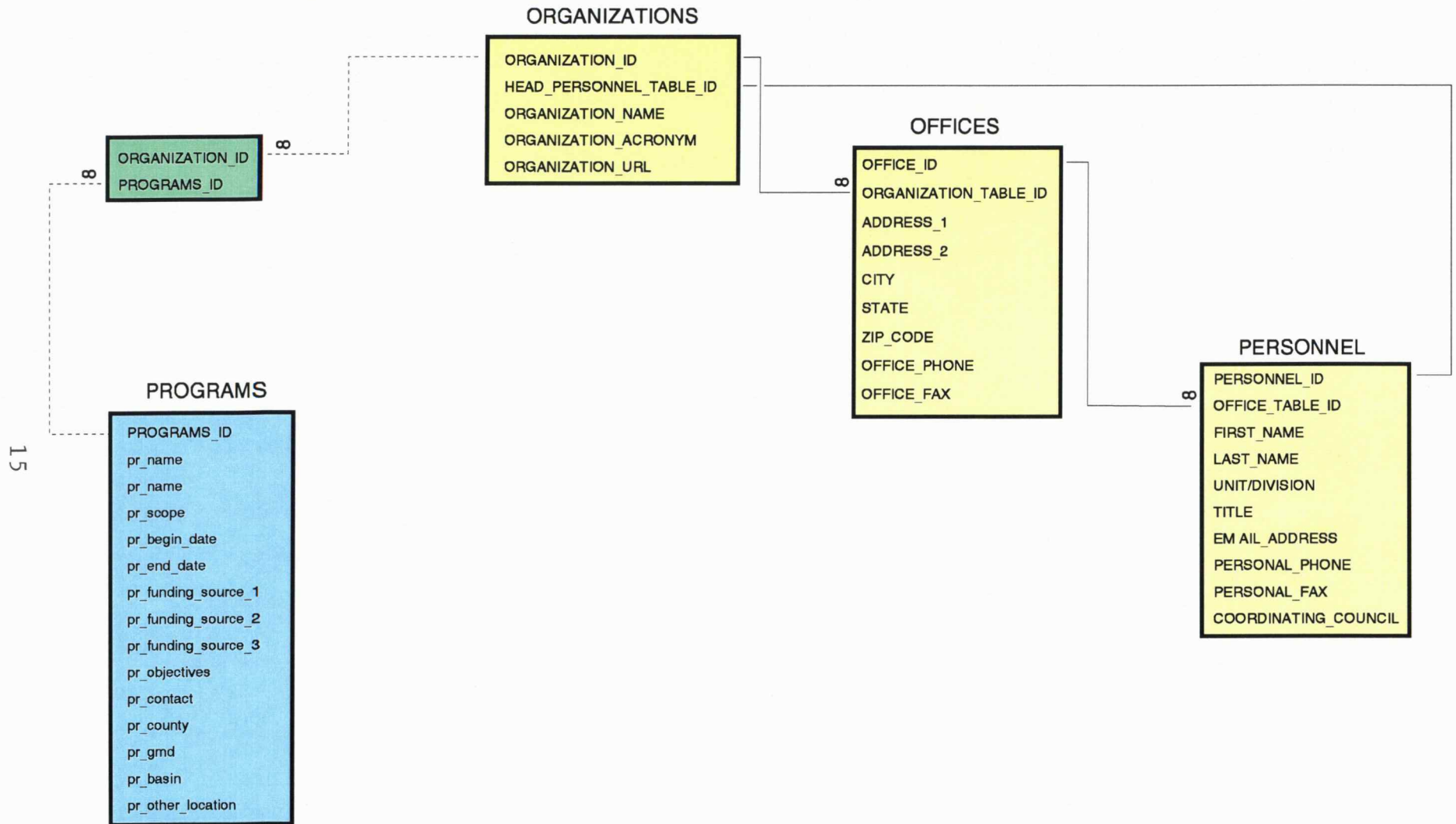


Figure 2 Database design for Programs and Contacts databases

**Table 1: Arc-Info coverage availability from the Oracle Spatial Data Engine (SDE)**

**Coverages Loaded into SDE as of 6/17/99**

USER	COVERAGE	SCALE	SOURCE/DESCRIPTION
GEOHYDRO	annual_precip	1:78740	OreStU/ann avg polys fr PRISM grids
GEOHYDRO	basins	500K?	KWO/12 major basin boundaries in KS
GEOHYDRO	cities	24-100K	USCB/city polys w/extra attribs
GEOHYDRO	cnty_seats	24-100K	USCB/county seat polys w/extra atts
GEOHYDRO	counties	24K	KCD/extra attributes from GEOHYDRO
GEOHYDRO	faults	n/a	GEOHYDRO/major fault lines
GEOHYDRO	geology	500K	KGS/surface geology polys
GEOHYDRO	gmds	?	?(is source KDA's DWR?)
GEOHYDRO	highways	24K	KCD/state and fed only, extra attribs
GEOHYDRO	hp_base	500K	USGS/High Plains base contours
GEOHYDRO	hp_extent	500K	USGS/High Plains extent
GEOHYDRO	hp_hydr_cond	1M	USGS/hydraulic conductivity
GEOHYDRO	hp_spec_yld	1M	USGS/specific yield
GEOHYDRO	hypso	2M	USGS/land surface contours
GEOHYDRO	igucas	?	wimas cdrom
GEOHYDRO	kdhe_gw_sites	24K	KDHE/groundwater monitoring sites
GEOHYDRO	kdhe_lk_sites	24K	KDHE/lake monitoring sites
GEOHYDRO	kdhe_sw_sites	24K	KDHE/surface water monitoring sites
GEOHYDRO	ulc	100K	ERRORS...
GEOHYDRO	lss_sections	24K	USGS-KCD/section polys
GEOHYDRO	lss_tr	24K	USGS-KCD/township polys
GEOHYDRO	quadrangles	24K	KGS/USGS 7.5' topo quad boundaries
GEOHYDRO	ailroads	24K	KCD/major railroads
GEOHYDRO	fl_lakes	500K	EPA/water bodies
GEOHYDRO	fl_streams	500K	EPA/streams w/names fr GEOHYDRO
GEOHYDRO	sec_corners	24K	KCD/section corners
GEOHYDRO	tate	24K	KCD/state outline derived from counties
GEOHYDRO	statsgo	500K	NRCS/soil polys; attribs fr GEOHYDRO
GEOHYDRO	temperature	1:78740	OreStU/ann avg polys fr PRISM grids
GEOHYDRO	wimas	100K	KDA/points of diversion
DASC	ks_admin_bnds	24K	KGS/Admin boundaries, more to come
DASC	alluvial_aquifers	500K	KGS/alluvial aq extent
DASC	dakota_aq_base	1M	KGS/Dakota aq base contours
DASC	dakota_aq_extent	M	KGS/Dakota aq extent
DASC	dakota_aq_potent	1M	KGS/Dakota aq potentiom contours
DASC	dakota_aq_tds	1M	KGS/Dakota aq total diss solids contours
DASC	dakota_aq_top	1M	KGS/Dakota aq top contours
DASC	glacialdrift_aq_ext	500K	USGS/Glacial drift aq extent
DASC	glacialdrift_aq_base	500K	USGS/Glcl drift aq base contours
DASC	glacialdrift_aq_pot	500K	USGS/Glcl drift aq potentiometric contrs
DASC	env_risk_identsites	100K	KDHE/identified sites 1995
DASC	tsds	100K	KDHE/treatment storage disposal sites
DASC	hp_base	500K	USGS/High Plains base contours
DASC	hp_extent	500K	USGS/High Plains extent
DASC	kcd_counties	24K	KGS/county boundaries
DASC	kcd_highways	24K	KGS/major roads
DASC	kcd_hy	24K	KGS/hypsography contours
DASC	kcd_railroads	DASC 24K	KGS/major railroads
DASC	ks_soils	500K	NRCS/STATSGO map units
DASC	swims_wp	?	?/SWIMS water points
DASC	tiger_counties	100K	DASC/based on US Bur of Census 1992
DASC	tiger_school_dist	100K	DASC/based on US Bur of Census 1992
DASC	tigai	100K	DASC/Native American Reserv bounds

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**DASC data holdings not yet in SDE:**

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NAME	TILING	DASC input to SDE?
Admin-bound:	state	partial
DEM-24K	24K quad	yes
DEM-100K	100K quad	yes
DEM-250K	250K quad	yes
DLG-24K	24K quad	yes
DLG-100K	100K quad	yes
DLG-2M	state	soon
DRG	24K	yes
DRG	100K	yes
DRG	250K	yes
Endan Sp Habit.	county	later (uses Arc Regions, complic.)
Stream eval	huc8 basin	yes
Endan Sp Occur	state	soon
Envir data src	state	soon
Envir Monit.	state	soon (6 layers)
Envir Regul	state	soon (5 layers)
Envir Risk	state	soon (1 of 2 layers)
FEMA	state	soon
GNIS	N/A	no (view software is proprietary)
GPS-base	N/A	no
HUC-8	state	soon
HUC-11	state	soon
HUC-14	state	later (no metadata in place yet)
Hydro-24K	24K quad	yes
Hypso-100K	100K quad	yes
KATS	huc 11	yes
KCD	townships	yes
KCD	hydrology	yes
land cover	county	yes (KARS updates: summer 1999?)
landsat TM	scene	no (distrib to state agencies ONLY)
LEGS-Dist	state	yes
LULC-250K	quad	?
NHI	state	soon
NWI	24K	yes
Orthophotos	qtr_quads	no
PLSS Counties	county	yes
RWD Bound	state	soon
RWD Distr	state	soon
Soils (24K)	county	doubt (very much work)
SSURGO	county	incomp. (certified version of above)
SWIMS	huc8	yes (water bodies, networks later)
TIGER	county	yes
Watersheds	state	soon
WIMAS	state	no

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**GEOHYDRO data holdings not yet in SDE:**

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psss_counties	24K
psss_qsec_pts	24K
psss_sec_pts	24K
storet	n/a
climate	? (EarthInfo NCDC stations)
huc8	24K
huc11	24K
huc14	24K
stream gauges	? (from USGS, not yet retrieved; in progress)

**Oracle tables that need to be "enabled":**

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wimas (needs to be loaded into Oracle, SDE coverage version dropped)  
wizard  
wwc5

## *E. FY2000 work plans*

### 1. Data acquisition, management and visualization

Assemble into common, accessible databases available water-level data and readily available water quality (nitrate, chloride, sulfate, and volatile organic chemicals) data for the period of record for the High Plains Aquifer.

- Basic database design is complete (see preceding sections), but still modifiable.
- Complete assembly of the aquifer-wide water level database is anticipated by 31 Dec 99; an essentially complete compilation of long-term records will be complete by 20 Aug 99.
- Complete design for water quality database before the end of FY2000.
- Assembly of relevant water quality data is targeted for completion in FY2000; however, because these data are widely distributed among various agencies their assembly is not completely under the control of KGS. Analyses (see section IE3 below) will proceed on the basis of the data available.

Complete (with ongoing updates and appropriate additions) the SDE database of coverages described in section ID above, establish guidelines and procedures for data visualization and selection, and prepare appropriate maps and figures to support KWO and other agencies.

Produce as appropriate, and/or advise the KWO on actual or potential products that can contribute to other KWO Objectives, in particular:

- Wetland and riparian management, where priority wetlands depend upon ground-water discharge for their maintenance;
- Data and Research, with particular emphasis on the assembly of integrated, accessible databases and the identification of significant research needs, and;
- Public Information and Education, especially in terms of developing project-relevant information materials and cooperating in their dissemination.

### 2. Water level/ Water quantity analysis

- Estimate probable uncertainty in data points or well records, and means of reducing that uncertainty for (i) existing data, and (ii) new data.
- Use analysis and comparison of case study locales with high densities of data to evaluate the feasibility of and requirements for assessment of water-quantity changes at the levels of the spatial units listed below.
- Obtain the best available estimate of the water-level surface elevations over time for aquifer, regional, and local scales, and determine uncertainties in these trends and the key factors affecting the uncertainties.
- Estimate the area-weighted average annual decline rate in water levels over time for (i) the High Plains and Ogallala Aquifers, (ii) each Groundwater Management District (GMD), (iii) those portions of each Water Plan river basin overlying the High Plains Aquifer, and (iv) High Plains Aquifer subunits defined on the basis of similarity and homogeneity of hydrogeologic properties (analogs of ground-water basins).

- Compare the results obtained with the analyses performed under contract 99-132 (High Plains Aquifer Evaluation – Ogallala Decline Study) for the periods 1969-1979, 1979-1989, and 1989-1999.
- Assess, select, and initiate trials of statistical or model techniques that can optimize precision and/or accuracy of interpretation of available water quantity data, and can assess the relationship between water level and actual groundwater quantity changes.

### 3. Water quality analysis

- Develop an initial overview assessment of the state of knowledge about water quality in the aquifer and its trends over time, including description and definition of monitoring well networks and contamination, and estimated uncertainties and limitations.
- Based on the readily accessible data, determine the number and percentage of monitoring network wells contaminated with nitrate, chloride, sulfate, and volatile organic chemicals (VOC) for the periods 1969-1979, 1979-1989, and 1989-1999 for (i) the High Plains and Ogallala Aquifers, (ii) each Groundwater Management District (GMD), (iii) those portions of each Water Plan river basin overlying the High Plains Aquifer, and (iv) High Plains Aquifer subunits defined on the basis of similarity and homogeneity of hydrogeologic properties (analogs of ground-water basins), and for (v) ground-water quality provinces (see discussion under item C above).
- Identify other data that can be acquired to improve water-quality evaluation, and initiate programs of acquisition, assembly and processing.
- Initiate analysis and comparison of case study locales with high densities of data to evaluate the feasibility of and requirements for assessment of water-quality changes at the levels of the spatial units listed above.
- Assess, select, and initiate trials of statistical or model techniques that can optimize precision and/or accuracy of interpretation of available water quality data.

**High Plains Aquifer Evaluation Water Quantity Uncertainties: initial assessments**  
KGS OFR 99-21B

***A. Spatial and temporal variability, observed and modeled***

R. W. Buddemeier, J. D. Mosteller, C. A. Escobar

1. Introduction

The HPAE project is specifically tasked with addressing the issue of uncertainties in baselines of groundwater quantity and quality in the High Plains Aquifer; in addition, DWR has expressed interest in developing 'time-to-depletion' maps, which will depend heavily on the accuracy and precision of the databases used for calculation.

One of the systematic uncertainties in using measured water levels to calculate change in inventory is the degree of recovery of the water table from pumping stresses. The annual measurement program typically measures wells in January; in most irrigated areas, this is commonly 4-5 months after the end of major pumping and a similar time interval before the beginning of the next season's pumping. However, water level recovery to a near-equilibrium elevation also has a time constant of months, and is a function of the amount and areal extent of drawdown, the time since cessation of pumping, and the aquifer characteristics (see companion report). In addition to regional recovery effects, measurements can be affected by relatively small local effects (e.g., wintertime well pumping for equipment test purposes) if they occur close to the point and time of measurement.

The assumption of the previous paragraph is based on irrigation practices for crops such as corn, sorghum, beans, etc. However, winter wheat is a major Kansas crop, and a significant fraction of that percentage is irrigated -- with a very different schedule from that of the summer crops (Danny Rogers, pers. commun.). Wheat is typically irrigated in the fall, well into October and sometimes even November. This places the end of irrigation only 2-3 months prior to the measurement time. When winters and springs are dry, irrigation may also occur in the early spring; this, and in some areas the practice of "pre(-planting)-irrigation" means that some limited pumping can occur as early as March or April, which narrows the 'window of opportunity' for measurements in the absence of irrigation pumping.

In general, failure to achieve full water table equilibration will result in a measured value of elevation lower (= greater depth to water) than the idealized 'true' value. The degree to which this is a problem for resource assessment depends on the amount of the deviation, and on its spatial and temporal consistency. A deviation which is small compared to the long-term trend in values, or to the magnitude of the signal being sought, will be of little concern. Larger deviations may not be a problem if they are consistent from year to year and place to place -- the differences in water level measurements may still yield a reasonably precise and accurate value if the biases are effectively removed in the process of calculating the difference.

2. Survey of spatial and temporal relationships in observed well responses

The goals of this aspect of the study are an initial evaluation of the uncertainty involved in representing the elevation of the water table with one measurement, in January, and to generate some initial comparisons with the elevation at final equilibrium. To evaluate this uncertainty, we look at two questions: (1) how do individual wells behave in different winters and (2) how closely do observed recoveries match to ideal recoveries (to determine when equilibrium is reached).

The wells studied were selected from the KGS database, and are observation wells from the western third of the state, where recharge is almost negligible. From a total of 130 observation wells that have data, only 11 met the criteria used in the final selection:

- At least 100 measurements in the whole, multi-year, period of record
- At least 2 measurements in each winter month
- Wells with aquifer codes QU (undifferentiated alluvium) and TO (Ogallala).

For each of these wells, a graph was plotted in Microsoft Excel to show the general trend of the aquifer over the whole period of record. Also, some winters were selected and plotted to show the recovery of each well, since it is very difficult to appreciate the recovery of three months on a scale of many years (see Figure 1). The examples in Figure 1 show that in most years, the water level was still rising at the end of the winter measurement period (Feb-Mar). In theory it should be relatively easy to determine when equilibrium the time and elevation of the equilibrium level, since the curve is a well-known logarithmic function. However, the water table response is a strong function of the local hydrogeologic properties of the aquifer (see section 4, below), the data for these wells are only from December to February, and examination of the plots makes it very clear that patterns of elevation change in many cases do not follow the theoretical form of the recovery curve.

Five winter periods are analyzed for each well. The arithmetic average and standard deviation of the absolute recovery (in feet) is calculated for each set of winters and shown in Table 1. Some of these wells show a relatively small standard deviation, which means that there exists some temporal consistency, that is, the wells behave relatively similarly from winter to winter. In other cases, however, there are both large absolute recovery values (several feet) and substantial year-to-year variation in the amount of wintertime change observed. In essentially all cases it seems likely that the water level observed in early January differs from an equilibrium value by at least several tenths of a foot, and this difference is not consistent from year to year and from well to well.

Chart4

08S 40W 12DBA +01

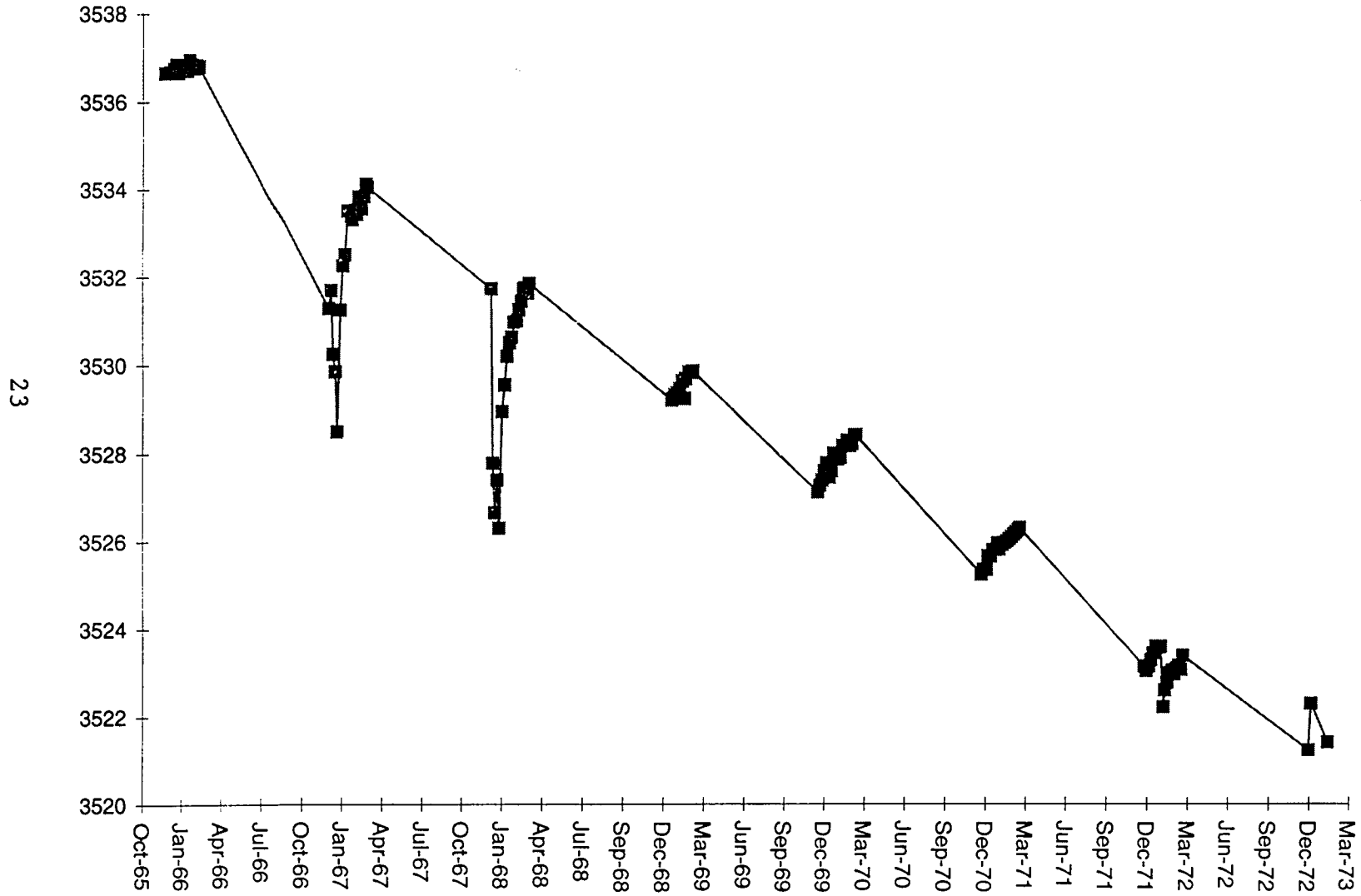


Figure 1.

Table 1: Water level recovery (feet of elevation), December-February, for selected winters

Well ID	Winter Recovery					Mean	Std. Dev.
06S 35W 26ACB	0.7	0.9	1.2	0.7	0.7	0.8	0.22
08S 34W 01BAC	1.0	1.0	0.7	0.6	0.7	0.8	0.19
08S 40W 12DBA	1.3	1.1	5.5	2.7	6.0	3.3	2.31
08S 40W 25AAC	0.8	0.4	2.0	0.5	0.9	0.9	0.64
17S 36W 33BCB	0.7	1.1	1.5	1.3	0.9	1.1	0.32
20S 33W 09BBB	0.2	0.4	-0.3	0.2	1.1	0.3	0.51
27S 38W 32BCC	4.0	3.2	2.5	2.0	2.4	2.8	0.79
30S 27W 23ABB	1.8	4.1	1.6	0.9	1.2	1.9	1.27

Since the average recovery for most of the wells represents a significant change, it is useful to look at the time patterns of change. To do so, the rate of change is calculated for the individual months of December, January, and February in those cases where sufficient data are available. A straight line is assumed for each of these months. This assumption is fairly close to the actual behavior for the months of January and February, when the curve is starting to flatten, but not for December. Table 2 (below) shows the rate of change for each month in two or three different years.

Table 2: Monthly elevation changes (feet) for selected winter periods

Well ID	December			January			February		
06S 35W 26ACB	0.3	0.5	0.1	0.2	0.2	0.3	0.2	0.3	0.7
08S 34W 01BAC	0.4	0.6		0.3	0.3		0.2	0.0	
08S 40W 25AAC	0.2	0.1	0.8	0.8	0.1	0.9	0.3	0.1	0.4
17S 36W 33BCB	0.4	0.3		0.4	0.2		0.3	0.2	
20S 33W 09BBB	0.0	0.2	-0.1	0.1	0.2	-0.1	0.1	0.0	-0.1

There is not much consistency among the recoveries of different years when looking at monthly rate of changes, but it can be seen that in some cases these wells are still relatively far from equilibrium at the end of the winter measurement period (Feb).

24S 33W

◆ 22 DCA ■ 28 DAA

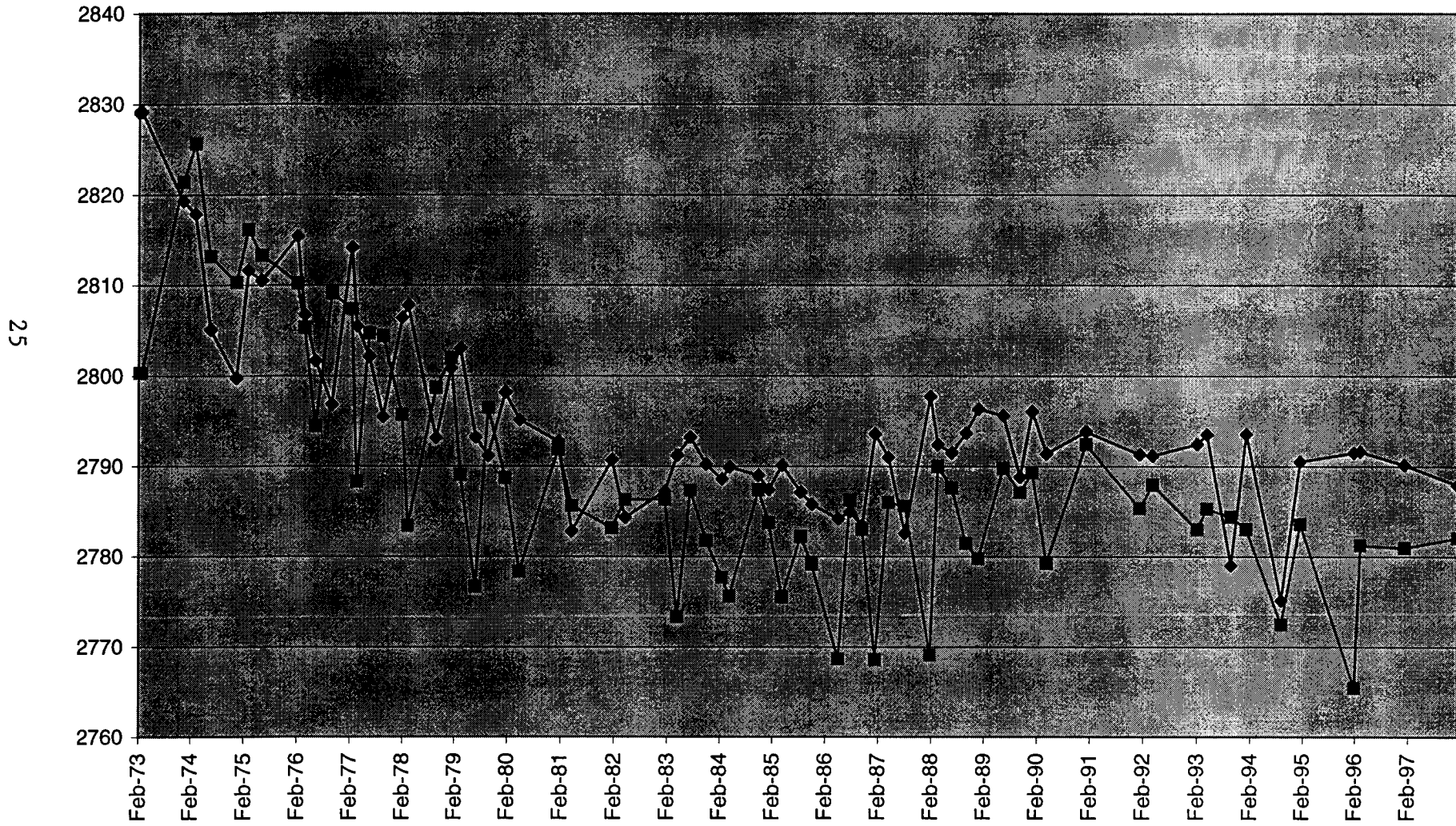


Figure 2.

To investigate the long-term consistency of behavior, data for several clusters of two or three wells from neighboring sections were plotted in the same graph for the entire period of record. Figure 2 provides one example of such a plot. In general, neighboring wells exhibit similar slopes when lines are fitted through the either all the points or the high points (presumably closest to recovery). Adjacent wells appear to reflect local trends in a comparable fashion over time scales of years, but as can be seen from Figure 2, measurements at the same time or over a period of a few years may give substantially different results.

### 3. Preliminary Investigation of High Plains Water Level Measurement Uncertainties

The program of annual water level measurements has recently introduced procedures for systematic resampling of wells as part of a quality control program. This affords the opportunity to test for state of recovery, based on the resampled data. As one of the steps in making a preliminary assessment of High Plains Aquifer measurements, the KGS Oracle database was queried, and a dataset was constructed for wells that met the following criteria:

1. Aquifer unit codes of TO and/or QU only;
2. Remeasured >2 days apart in 1997 or 1998
3. Depth to water >50' (to minimize effects other than pumping and recovery).

The requirement of 50' depth to water means that essentially all of the wells examined were in the Western High Plains (Ogallala) section of the aquifer. One well that showed a drop in water level >40' between measurements was excluded from the analysis; its inclusion would have made the results described below even more extreme.

Data were transferred from MS Access tables to an Excel spreadsheet, and differences in time (days) and depth (feet) were calculated. For ease in calculation, where multiple measurements were made on the same day, the differences were taken between the last measurement on the first day and the first measurement on the resample day. The original database contained times of measurement for some but not all of the records; these carried through into the spreadsheet, resulting in some differences in the handling of fractional days.

A total of 68 wells met the criteria specified; 53 of these showed positive or zero change in depth to water (water level rise), and 15 showed decreases. The results were normalized by calculating rates of change (ft/day) for all of the difference measurements. These results were analyzed in three ways, since the results may be relevant to different types of questions:

- The average and standard deviation of the rates ( $R_{all}$ ) were calculated for the values as obtained from all of the well data. It should be noted that the values are not normally distributed, so the standard deviation is only a qualitative indicator of distribution, used for the purposes of initial reconnaissance. This approach, considering both positive and negative changes, might be the sort of result applicable to estimating the precision/accuracy of water table estimates calculated over a large area based on annual measurements.

- The average and standard deviation ( $R_{abs}$ ) of the absolute values of the rates were calculated. This result would be of interest from the standpoint of knowing the overall stability of the water table elevation measured, independent of cause or direction of change.
- The average and standard deviation ( $R_{pos}$ ) of only the positive changes were calculated. This focuses on the sub-population of wells that are still in the recovery process or near equilibrium, but ignores a significant number of unexplained decreases in water table elevation.

The results are summarized in Table 3. In order to assess the significance of these observations, two threshold values were considered. First, the number of wells with rates of change  $> 0.05$  ft/day was determined (shown in the table as  $>0.04$ , since all values were rounded to 2 decimal places). This is a 'significant' change – a foot or more between measurements, which implies that the well is relatively far (several feet to tens of feet) from final equilibrium (see companion reports). Nearly a third of the measurements were in this category, as were the average rates for the absolute and positive changes.

The second threshold used was an approximate detection limit. Since it is evident from both the database and general experience that a depth to water measurement should be reproducible to within 0.1' in the absence of problems, the number of results with an average R value of  $>0.01$  (or an absolute difference of approx. 0.2' over the average measurement interval) was taken as an indicator of the fraction of wells with (conservatively) detectable change. 59% of the wells were in this category.

**Table 3: Summary of analysis for 1997-98 resampled High Plains wells with water depth**

	<u>&gt;50'</u>				
	dDays	dElev	Rall	Rabs	Rpos
	(days)	(feet)	(ft/d)	(ft/d)	(ft/d)
Mean	22.03	0.37	0.03	0.07	0.06
StDev	45.04	1.82	0.11	0.10	0.10
N			68	68	53
Threshold values					
% $>0.04$				31	30
% $>0.01$				59	59

The magnitudes of the uncertainties implied by this sampling are quite significant in the overall estimation of water level changes. Even in the most heavily and consistently depleted region of the state (Water Level Report Region I, corresponding approximately to GMD3 in SW Kansas), average annual declines over the region are typically only 1-2 feet; in other areas they are significantly smaller, with an average value approximating zero in the Eastern High Plains. Because of incomplete recovery, the average change of 0.37' over a roughly 3 week period

calculated from the resampled wells actually represents a substantially larger final discrepancy – uncertainty is at least as large as the average annual change in most regions.

The situation might be better if we could assume a constant bias in the measured wells. However, a total of 9 of the resampled wells were measured in both 1997 and 1998. The pairs of  $R_{all}$  values for these wells are: 0.04, 0.02; 0.00, 0.04; 0.01, 0.01; 0.29, 0.01; 0.32, 0.12; -0.05, 0.45; -0.18, 0.01; 0.00, 0.00; 0.09, 0.05. These results do not suggest spatial or temporal consistency of bias – individual wells may go from negative to positive deviations, or from large deviations to near equilibrium in successive years. Based on this very limited survey, it seems unlikely that uncertainties in differences will be any smaller than uncertainties in annual values.

It has long been recognized that the year-to-year or local values for changes are unreliable and that trends can only be assessed “based on a comparison of changes that occur over a period of several years or that emerge as a consistent pattern across a number of wells” (KGS Tech. Series 9, p. 3). This preliminary analysis suggests that this statement may be true for qualitative trends, but that effective quantification of trends using the present database and system of measurements may require a decadal time scale at the regional level. The problem is even more severe with respect to management or assessment at the sub-regional (e.g., township) level; here, the relatively low density of wells in the annual network means that substantial additional local measurements will be required to detect sub-decadal water table changes on the scale of feet over distances of miles.

Although this preliminary interpretation casts a rather pessimistic light on the prospects for precise resource or program evaluation, the situation is not necessarily irremediable. Even without increasing the number of wells currently in the annual network, it should be possible to redesign the network and sampling strategy to improve the representation of specific geohydrologic and water use areas, and to minimize the degree (and especially the variability) in sampling bias.

Retrospective and smaller-scale analyses can also be improved – both by adding data that exist outside of the annual monitoring program, and by reviewing past measurements in the context of local characteristics and water use patterns – even down to the level of individual wells. Although labor-intensive, this provides a way to develop better retrospective baselines for case studies or “type specimen” areas.

#### **4. Observation Well Drawdown Simulations Using Suprpump**

The groundwater flow modeling program Suprpump was utilized to simulate well responses under conditions commonly found in western Kansas in the High Plains aquifer. The objective was a theoretical test of the concept that a fixed measurement time may yield highly variable annual water levels due to factors such as volume of water pumped and date of last pumping in a given year. The function of the Suprpump simulations was to provide idealized recovery curves with which to compare the actual measurements, thus giving a relationship between the measured and equilibrium elevations.

The Suprpump modeling parameters used are as follows:

1. The Theis well function was used and the aquifer was assumed to be homogenous and isotropic. Boundary conditions utilized for the simulations consisted of impermeable boundaries on all sides enclosing an area of four square miles (two miles by two miles). Note that this is a conservative assumption from the standpoint of the calculations made – neglecting inflow or pumping effects from distances greater than approximately 2 miles from the observation point has the effect of artificially accelerating the apparent recovery.
2. The hydrologic characteristics of transmissivity and storage coefficient were based on estimates provided by P. A. MacFarlane (pers. commun.). These characteristic pairs of values were divided into three categories, high, medium and low, based on mean values found in the U. S. Geological Survey Water-Resources Investigations Report 85-4198, Geohydrology of the High Plains Aquifer, Western Kansas. The values used in the simulations are presented in Table 4.

Table 4. Hydrologic conditions utilized in Suprpump simulations.

	Transmissivity	Storage Coefficient
High Hydrologic Values	12000 ft <sup>2</sup> /day	0.25
Medium Hydrologic Values	8000 ft <sup>2</sup> /day	0.15
Low Hydrologic Values	4000 ft <sup>2</sup> /day	0.05

Each Suprpump simulation was run with four equally spaced pumping wells pumping at the same rates and intervals. The pumping wells in one Suprpump simulation were placed at 1000 ft from the observation well, in another at one-quarter mile (1320 ft.), and another at one-half mile (2640 ft.). The observation well was located in the center of the bounded area, at an equal distance from each of the four pumping wells. In one simulation the observation well was also a pumping well.

Three different pumping rates were used in the various Suprpump simulations. The rates utilized were 1000 gallons per minute, 1280 gallons per minute and 1600 gallons per minute. These pumping rates are typical of actual rates employed in irrigation wells in Western Kansas, although they are above the mean rates for this area. The pumping rates were derived from data reported in the publication, 1995 Kansas Irrigation Water Use (Kansas Water Office and the Division of Water Resources). The acre -eet per acre data, in addition to irrigation by township data, was used to calculate the total volume of water pumped from the four square mile simulation area during one irrigation season. A value of 1.23 acre feet per acre was calculated from available data as the average figure for the five ground water management districts. The total volume pumped from the four square mile area was also used to determine a total drop in head value. This value represents the new static water level reached after the end of the pumping season.

Suprpump limitations dictate 5 or fewer pumping wells per simulation. Since actual well densities may result in more than five wells within the four square miles simulated, the pumping rate for the simulated wells had to be adjusted to produce the same volume of water extracted by a greater number of actual wells.

The timing of a typical irrigation cycle for a well assumed to be pumping for approximately 80 hours (3.3 days) followed by no irrigation for the rest of a two week period (11.7 days) (P. A. Macfarlane, pers. commun.). Seven pumping cycles were used in the simulations for a total of approximately three months (87.3 days) irrigation. These parameters were used on the two initial simulations. Additional simulations with higher volumes of water pumped required that the timing data be adjusted to compensate for the 5 well limitation of the Suprpump program. One simulation was run using periods of 7 days pumping followed by 7 days of no pumping for six cycles with the seventh cycle consisting of 3.3 days pumping to generate the same total pumping period of 87.3 days.

The highest pumped volume was simulated by using 120 days of continuous pumping. This highest pumped volume was based on the volume extracted by a maximum well density of one well per quarter section, for a total of 16 wells for the four square mile area. The volume of water pumped in this case is comparable to that which would be pumped in the highest average pumping situations without representing an extreme outlier.

One simulation used five pumping wells, with the fifth pumping well also being the observation well in the center. The pump rate for each well was  $4/5$  the rate used in a previous simulation in order to generate the same total pumped volume of water for both simulations (1280 gpm vs. 1600 gpm). The drawdown curve for the observation well was of a greater magnitude, as would be expected, however, the tail of the curve, months after pumping, was similar to the four well simulation, since the total volume extracted was the same for both.

Figure 3 shows one set of representations from the large number of simulations generated. The major conclusion to be reached from the overall study, which is exemplified in the figure, is that even using conservative assumptions the simulated water level is significantly far from re-equilibration three to five months after the cessation of pumping. The simulated deviations have magnitudes comparable to those observed in the actual measured data.

## REALISTIC VS. AVERAGE SEASONAL DRAWDOWN (all obs wells), MEDIAN HYDROLOGIC VALUES

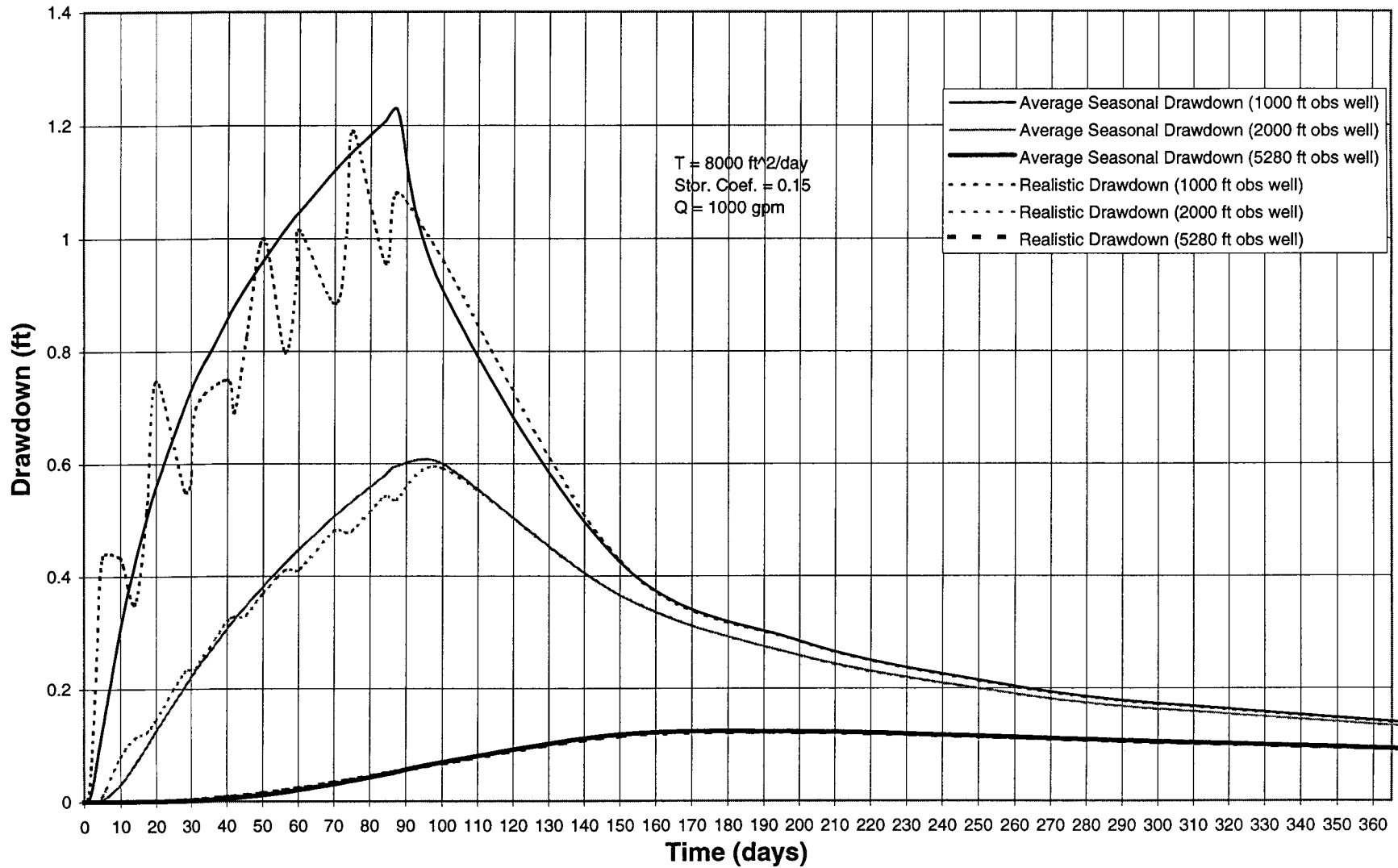


Figure 3.

Table 5. Pumping characteristics of the Suprpump simulations.

<i>F. Trial No.</i>	No. of wells	Boundaries	Flow rate gpm	AF/township	Cycle: on/off/total days
1	4	4 mi <sup>2</sup>	1000 gpm	3675.3	3.3 days/11.7 days/87.3 days
2	4	4 mi <sup>2</sup>	1600 gpm	5880.4	3.3 days/11.7 days/87.3 days
3	4	4 mi <sup>2</sup>	1600 gpm	30547.6	120 days/0 days/120 days
4	5	4 mi <sup>2</sup>	1280 gpm	30547.6	120 days/0 days/120 days
5	4	4 mi <sup>2</sup>	1600 gpm	11531.7	7 days/7 days/87.3 days

## ***B. Uncertainty Propagation in Ground Water Models***

C D McElwee and G C Bohling

In many parts of the US, ground-water levels are declining and state or local agencies are involved in managing the aquifer to achieve certain goals. These goals might involve stabilizing the water levels, planning the depletion period, or evaluating the effect of certain withdrawal activities. Ground-water models are often used to give guidance in managing an aquifer but invariably contain uncertainty in the input data. Typically, model input will include estimates or measurements of such things as hydraulic conductivity, storativity, bedrock elevation, recharge/discharge, and water levels. Water levels are often calculated as a function of the other input variables and may be used in an inverse scheme to refine the estimates of the input variables. However, it is possible to consider the heads as input and to calculate the recharge/discharge or net flux of water at any location as the output. In either case, the calculated output contains uncertainty which is propagated from the input variables. We examine that problem by two methods: Monte Carlo analysis and first order sensitivity analysis. Monte Carlo analysis constructs possible examples of output data (realizations) by randomly picking uncertain input variables from assumed reasonable distributions, to be used in the flow model. First order sensitivity analysis uses a truncated Taylor series to estimate sensitivity coefficients. Sensitivity coefficients are a measure of how much the model output changes when one input variable is changed by a certain amount. The Monte Carlo analysis has the advantage of giving the exact answer for the output uncertainty as the number of realizations used approaches a large number. However, it may be computationally intensive. First order sensitivity analysis is easier to do computationally but is only approximately correct. It predicts that the uncertainty distribution of the output variable is a sum of the uncertainty distributions of the input variables weighted by the sensitivity coefficients.

We have considered error propagation in steady-state ground water models by calculating the effect of normally distributed Gaussian errors (with a zero mean and specified standard deviation) in the head and hydraulic conductivity profiles on net model flux or recharge (R). The one standard deviation bounds calculated from the first order sensitivity analysis agree very well with the Monte Carlo results, but their center point is biased by the realization used for R. The results indicate that:

- First order sensitivity analysis is appropriate for calculating the uncertainty bounds for any magnitude of error that yields a meaningful estimate of R;
- Estimates of R are very sensitive to errors in head and hydraulic conductivity, and can only be made with confidence when the error is low; and
- Some averaging must be done even when noise levels are low.

We have found that an average window of 5-9 node points (specified of one half mile) is useful in suppressing noise, which means that it is unlikely that regional data on head and hydraulic conductivity can be used to infer the net aquifer flux or recharge on scales of less than several model node points.

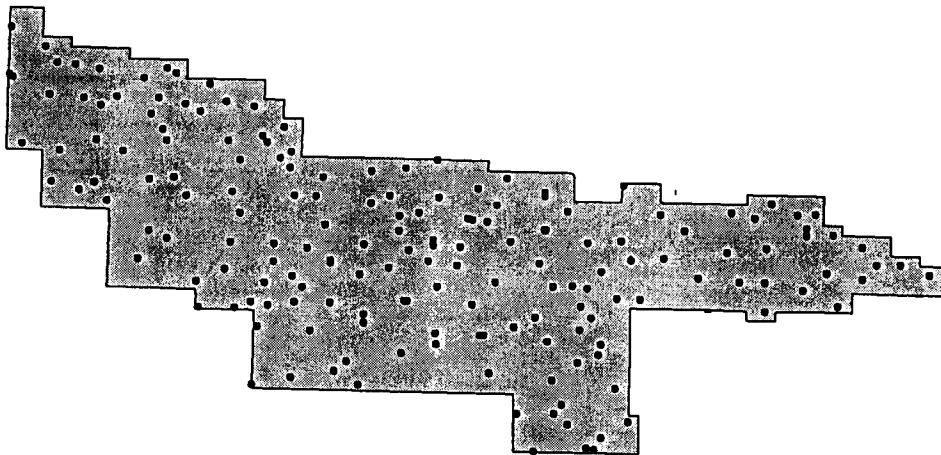
*C. Uncertainties and variabilities in assessing the aquifer depletion rate from water level measurements*

Li Zheng

In this section we describe our preliminary results on the uncertainties and spatial variabilities involved in the High Plain Aquifer (HPA) depletion rate assessment. We use the rate of decrease in water table elevation over the years to indicate the aquifer depletion rate. As an illustration, we choose the water level observations from GMD1 during the years 1988-1999 to assess the aquifer depletion rate. We show that the aquifer depletion rates calculated from the water level data from individual wells vary dramatically, from the highest value of 2.20 ft/year to the lowest value of -2.34 ft/year.

*Initial screening of water level data from GMD1*

The choice of this particular water level data set is based on two considerations. First, the year 1988-1999 is a period during which the water level data from all the available wells are relatively complete. The missing data are an insignificant part of the total entries. Second, the aquifer system at GMD1 has a relatively simple hydrological setting as compared to other GMDs in the HPA. Thus, the analysis has less chance of being complicated by other issues.



**Figure 1. Distribution of wells in GMD1**

In total, 186 wells are identified within GMD1, and their water level records from 1988-1999 are retrieved from HPA water level database. Figure 1 shows an outline map of the GMD1 with the well distribution indicated. Figure 2 and Figure 3 show the water table elevation from these 186 wells in 1993 and 1998 respectively, with z axis representing the elevation, and x axis (east-west) and y axis (north-south) representing the locations. Length units (meters) are the UTM coordinates. As shown, the water table demonstrates an obvious linear trend and, visually, the overall trend changes very little from year to year.

Further examination of the water level records at each well identifies three different patterns of water level change over time. Among many of the wells, a persistent decrease of the water level is observed. One example of these cases are shown in Figure 4, where the water table elevation at a single well is plotted against the years. Yet, there are some other wells where the water level data show the exact opposite pattern – a persistent increase of the water table elevation over the years. Figure 5 gives an example of such a case. There are also a significant number of wells where the water levels fluctuate over the years and show no persistent trend. Figure 6 and Figure 7 are two of such examples.

### *Assessing the aquifer depletion rate*

Without delving into too much of the complexity shown in Figures 5-7, and for the purpose of demonstrating the uncertainties and spatial variabilities of aquifer depletion rate, we took a rather simplistic approach in calculating the aquifer depletion rate. First, we further screened the well records for suspicious records (i.e., water level records that change over 10 ft from one year to the next), and also removed those records that have incomplete entries over the span of the 11 years. This left us a total 118 well records. The locations of these 118 wells are given in Figure 8 in the UTM coordinates. We then subtracted the water level in 1988 from the water level in 1999 and divided the difference by 11 years to obtain a depletion rate for each of the 118 wells. The values of these depletion rates are plotted in Figure 9, with  $z$  axis representing the depletion rate (ft/year), and  $x$  axis (east-west) and  $y$  axis (north-south) representing the locations.. Further we plot the histogram of 118 depletion rates in Figure 10. Both figures 9 and 10 show that the depletion rate varies dramatically over the space. The maximum depletion rate can be as high as 2.20 ft/year, and yet the highest negative depletion rate can also reach 2.34 ft/year. The mean depletion rate over the whole area is 0.35ft/year with a standard deviation of 0.68ft/year, while there is quite a significant number of wells having negative depletion rates as shown in Figure 10.

Further, we divided the area covered by the 118 wells into 9 blocks and 16 blocks of equal areas respectively, and calculated the mean depletion rate for each of the blocks. The results are shown in Figure 11 and Figure 12. From these plots, it is obvious that the north-west portion of the aquifer has the highest average depletion rate and the south-east is the area where water table changes very little or even increases over the years.

Figure 2: Water Table Elevation (ft) at 1993

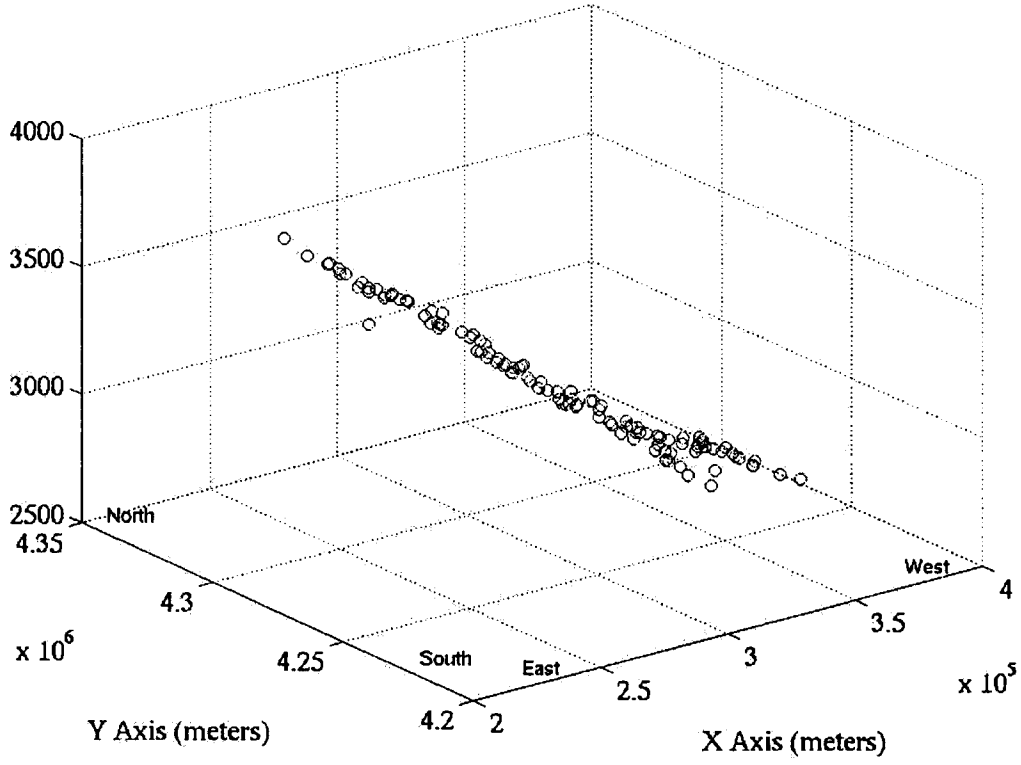


Figure 3: Water Table Elevation (ft) at 1998

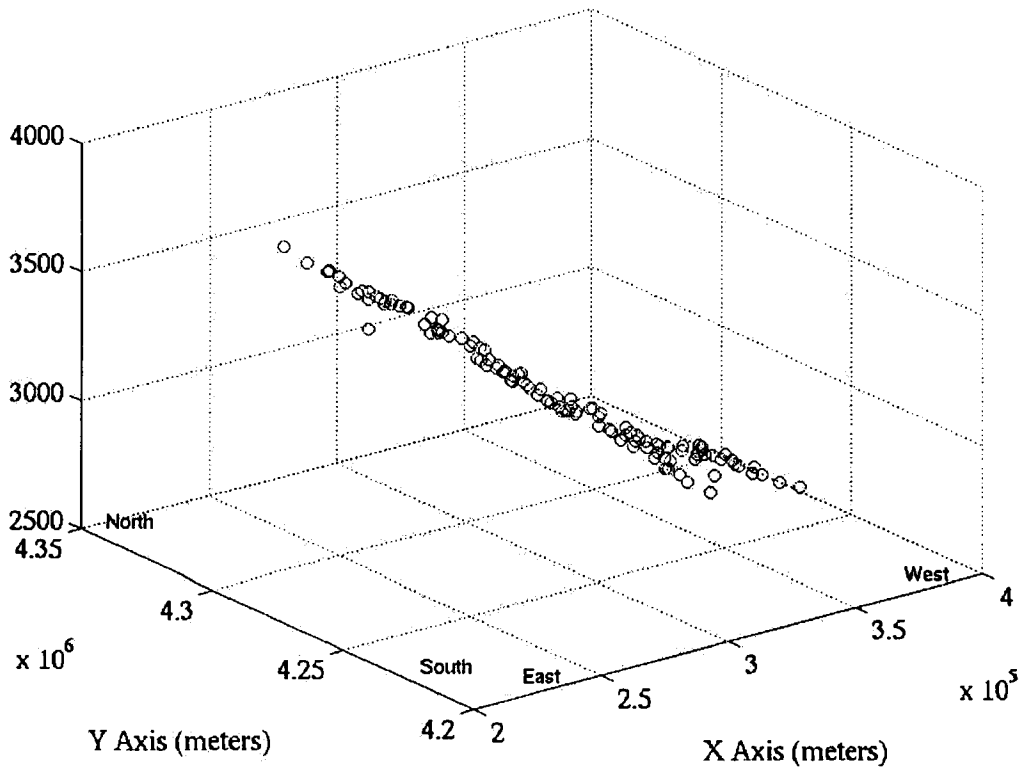


Figure 4: Water Table Elevations at x=250857 and y=4301174

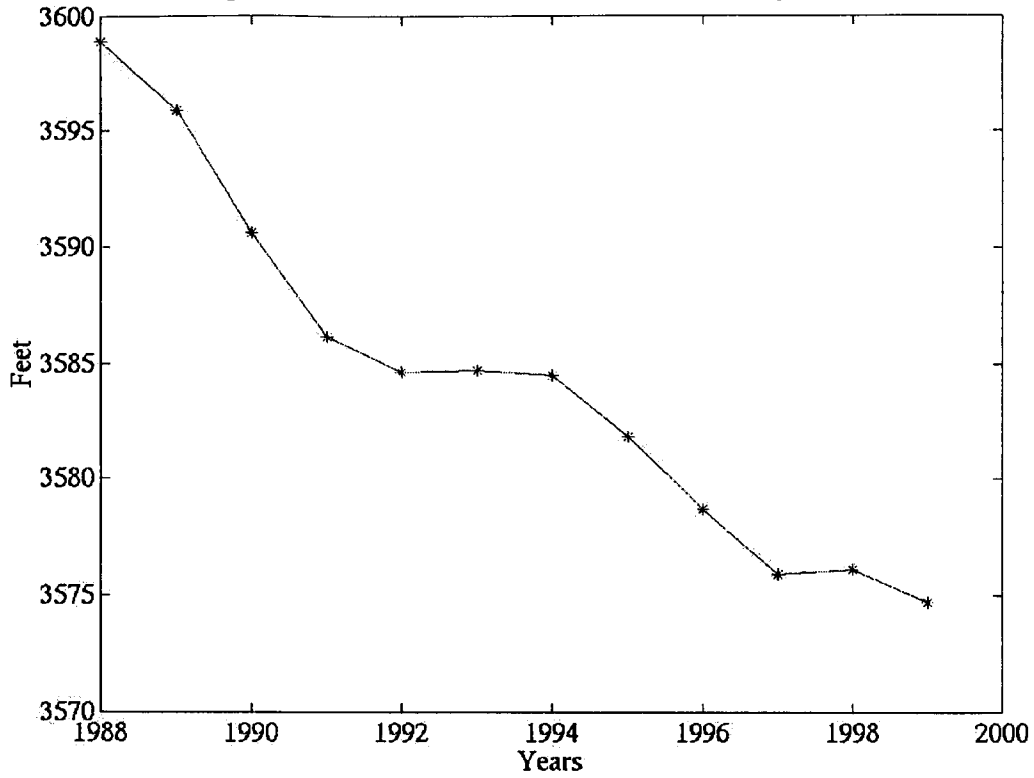


Figure 5: Water Table Elevation at x=322454 and y=4237039

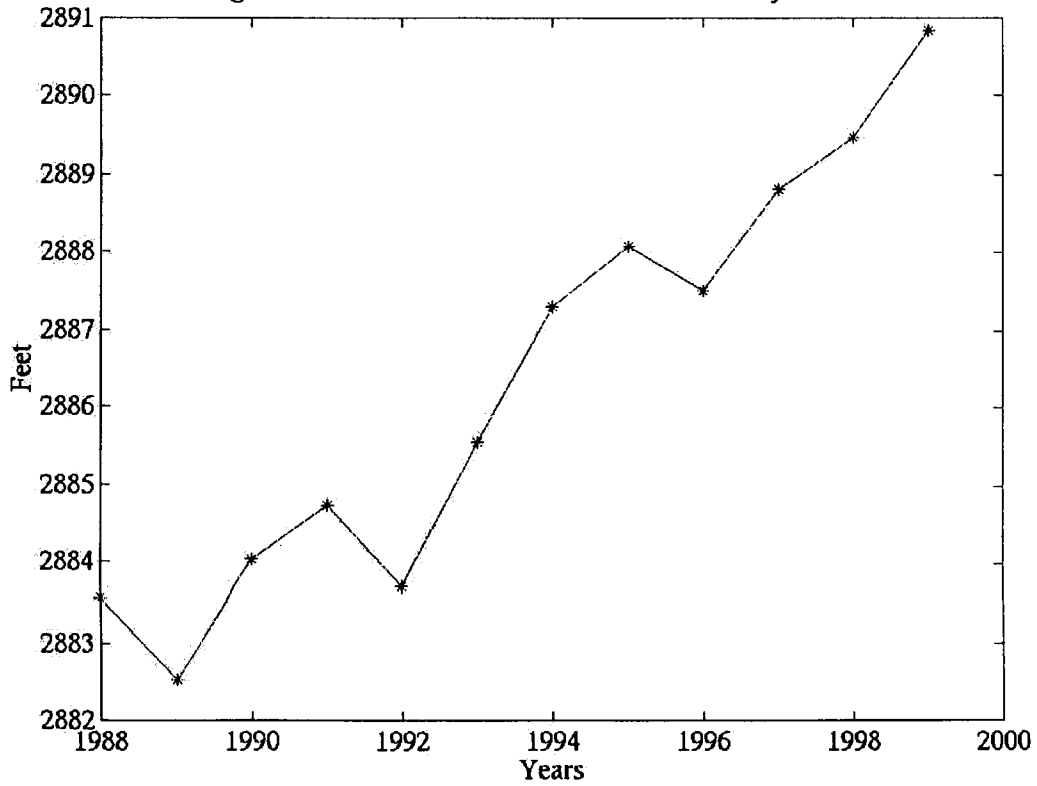


Figure 6: Water Table Elevations at x=369279 and y=4276378

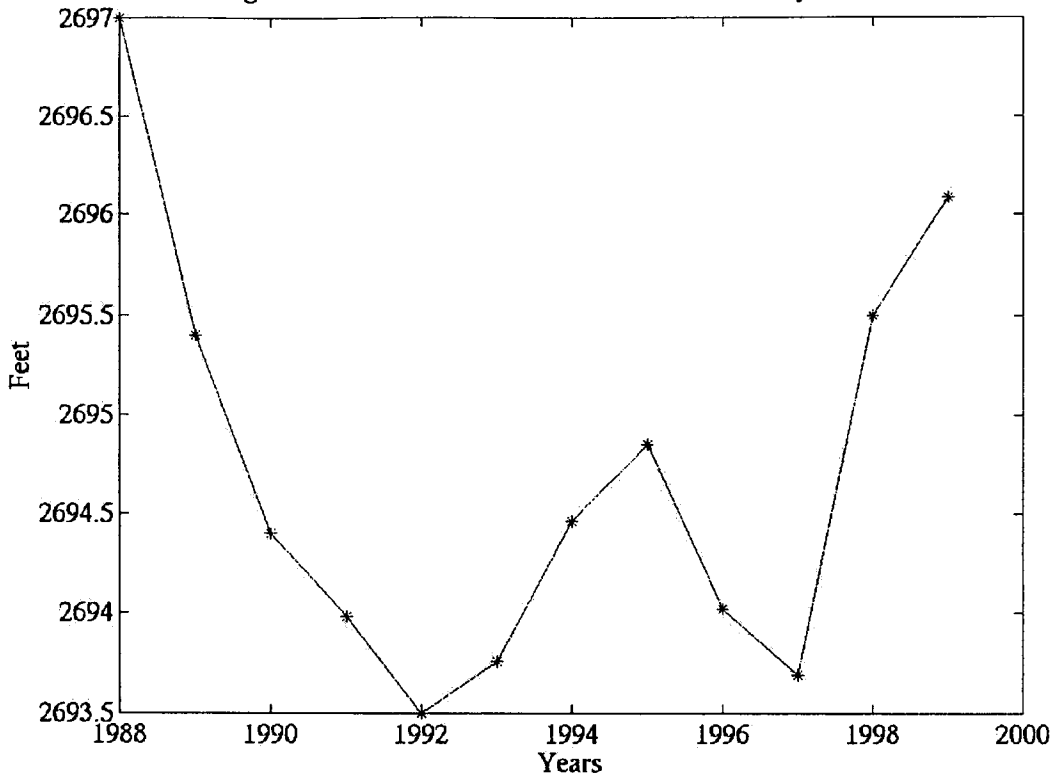
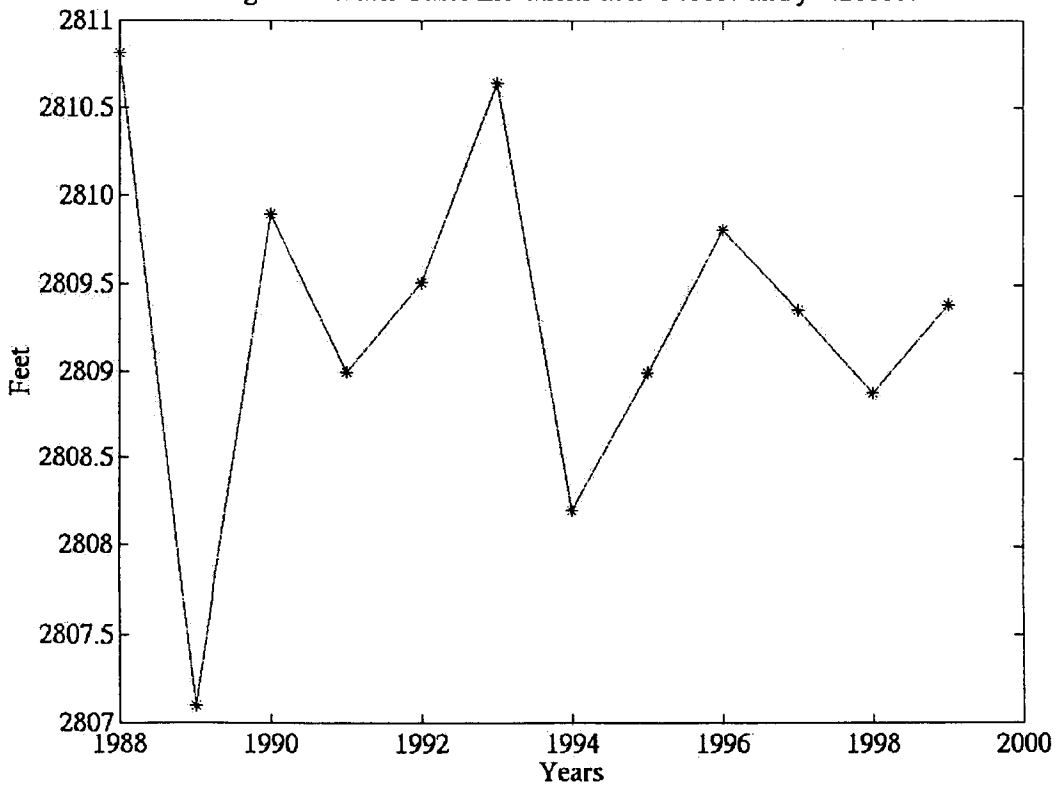


Figure 7: Water Table Elevations at x=346667 and y=4280087



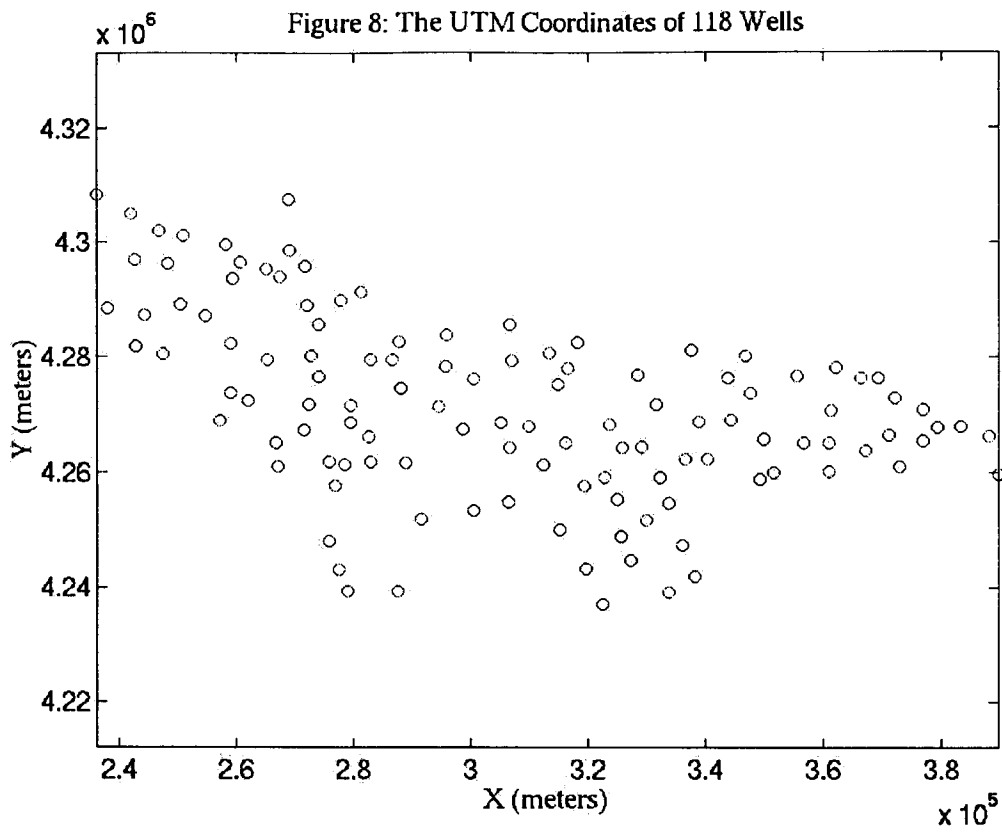


Figure 9: Depletion Rate at Each of the 118 Wells

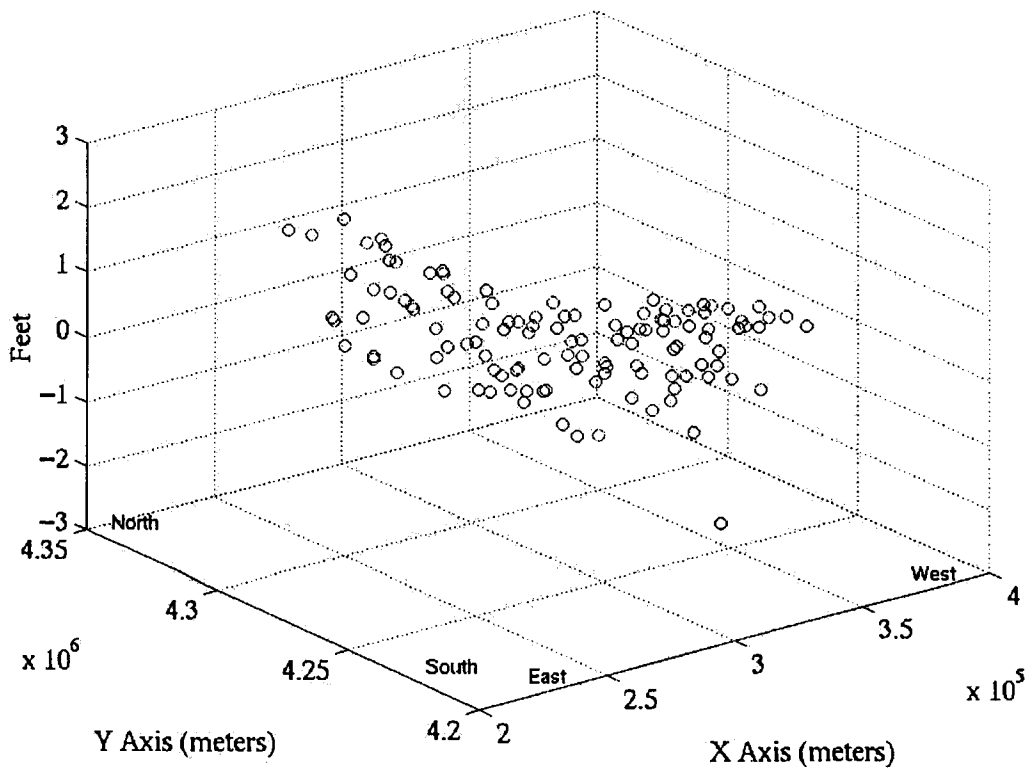


Figure 10: Histogram of Water Table Depletion Rate

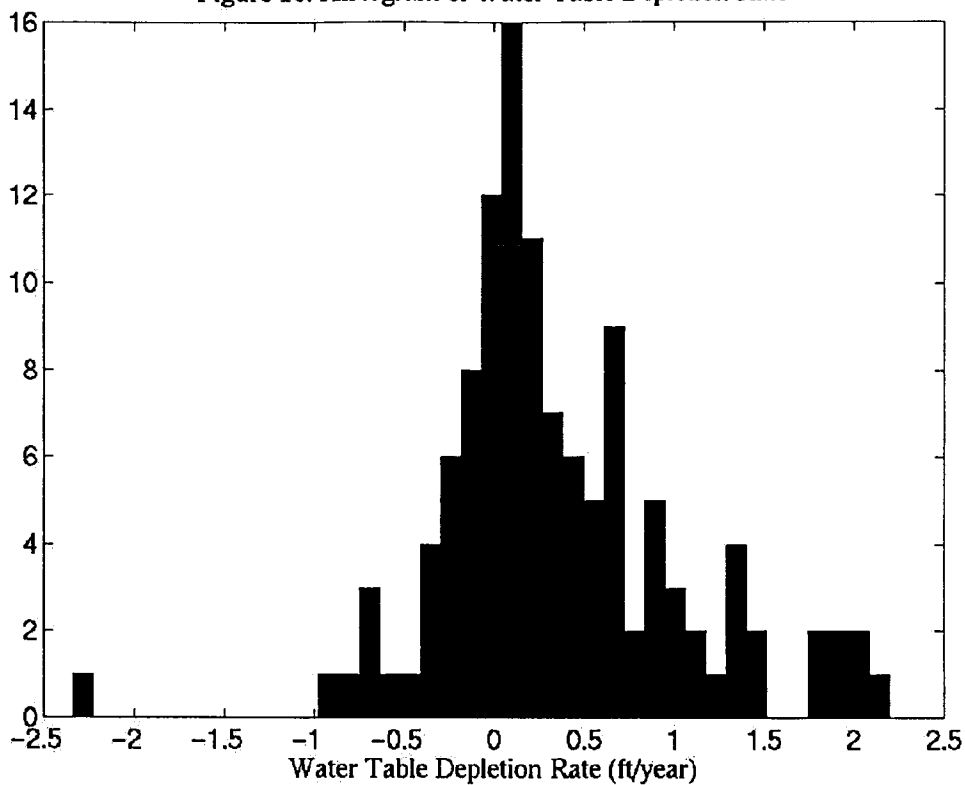


Figure 11: Average Depletion Rate at Each of the 9 Blocks

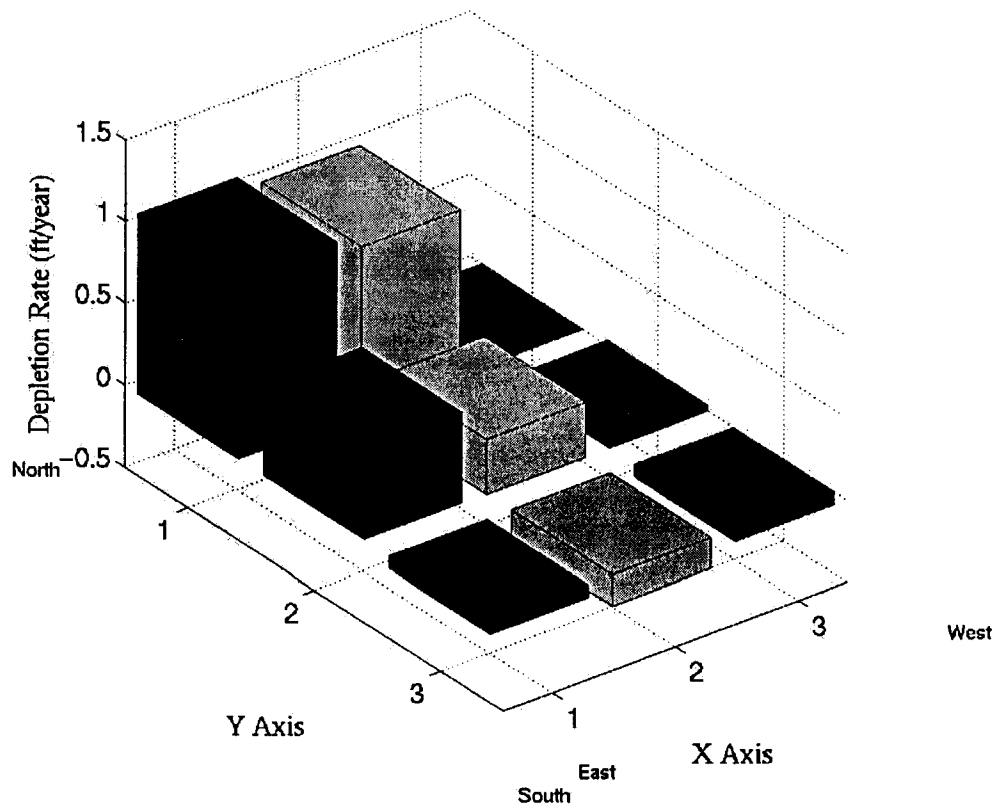
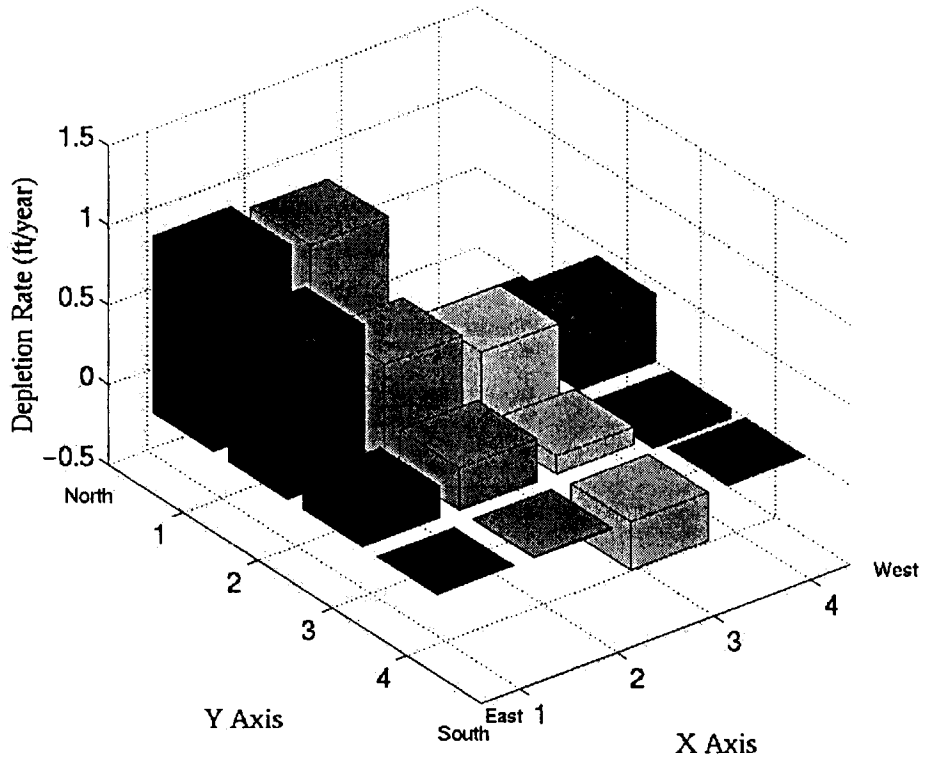


Figure 12: Average Depletion Rate at Each of the 16 Blocks



**Appendix A: FY 1999 contract**

The following pages contain a copy of the FY1999 contract between KWO and KGS for initiation of the HPAE project. The contract and attachment provide background information on the original concepts underlying the project and the definition of the first-year activities and products.

**University of Kansas Center for Research, Inc.**  
**Sponsored Project Budget Summary**

APPENDIX A

*Sharon W. Taylor*

3029

Acct Number:	15881	PI:	Whittemore, Donald O.
Agency:	Kansas Water Office	Co-PI(s):	McElwee, Carl D.
Award No:	Contract # 99-114		Townsend, Margaret
Budget Period:	07/01/98 - 06/30/99		
Project Type:	Research	Admin. Unit:	Kansas Geological Survey # 2950
	<input checked="" type="checkbox"/> Basic <input type="checkbox"/> Applied		
CFDA#	Compliances:		
	ACHE: <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Number: _____	Date: _____
	Animal Care: <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Number: _____	Date: _____
	Classified: <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	Period: _____	
Title: Evaluation of Ground-Water Quality Changes in the High Plains Aquifer			

		New Action:	Revised to Show* Notice of Award			
Category	Award					Category Code
Personnel						
Key Personnel						
Other	14,848					15881 -230
Classified						
Students						
Subtotal Salaries	\$ 14,848	\$ -	\$ -	\$ -		
Fringe Benefits	4,157					15881 -700
Tot. Salary/Fringe	\$ 19,005	\$ -	\$ -	\$ -		
Travel: Domestic	3,552					15881 -500
Foreign						
Supplies & Expenses	2,443					15881 -300
Other						
Subtotal Direct Costs Subject to IDC	\$ 25,000	\$ -	\$ -	\$ -		
Equipment						
Subtotal Costs Excluded From IDC Base	\$ -	\$ -	\$ -	\$ -		
Subtotal All Direct Costs	\$ 25,000	\$ -	\$ -	\$ -		
IDC Rate: 0%	-	-	-	-		
Project Total	\$ 25,000	\$ -	\$ -	\$ -		
Less Prior Year Balance						
Amount of This Award	\$ 25,000	\$ -	\$ -	\$ -		

Remarks:

\* Revised to show receipt of fully executed contract. This removes provisional status.

~ Key Personnel: Donald Whittemore (PI), Carl McElwee (CoPI), Margaret Townsend (CoPI)  
 ~ IDC Rate: NONE

Date: 7/23/98 By: ly

Approved: *Barbara A. ...*

xc: L.Taylor(8), CRINC, SPA, Auditors, File

OSP Project # 22517

## HIGH PLAINS GROUND WATER EVALUATION STUDY

Kansas Water Office

Contract No. 99-114

Page 1 of 3

### I. PROJECT TITLE

This contract, effective July 1, 1998, and entered into by the Kansas Water Office (KWO) and the University of Kansas Center for Research, Inc. (CRINC, FEIN#480680117, ~~2291~~ <sup>tdw 7/15, km/r 7/10/98</sup> 2385 Irving Hill Road, Lawrence, KS 66044) on behalf of the Kansas Geological Survey (KGS), shall be known as the "High Plains Ground Water Evaluation Study" All references to this contract shall include this title and the Kansas Water Office Contract Number 99-114.

### II. SCOPE OF WORK

Goal: Evaluate the impact of conservation and water-quality programs on ground water in the High Plains Aquifer at varying time and spatial scales.

- Objectives:
1. Establish the current baseline for ground water quality in the High Plains Aquifer for use in determining general trends and as a reference for future evaluation.
  2. Evaluate the rate of change in ground water levels over time related to the imposition of conservation practices.

Strategies: The activities accomplished during the effective period of this contract, in support of achieving the above objectives, include:

- a. Develop cooperative interactions with local, state and federal groups to determine the character, availability and utility of data.
- b. Collect existing information, data sets and coverages on water quality and water levels, bedrock surface, water use and consumption.
- c. Inventory the conservation and water quality management activities of local and state agencies in the High Plains Aquifer over 1990-1998.
- d. Define the procedures and analytical methods to appropriately evaluate conservation impacts on ground water levels.
- e. Define the time and spatial factors of a ground water quality database needed to establish a reference for past and future comparisons.
- f. Develop plans for acquiring data necessary for establishment of baselines and general trends in ground water quality and evaluation of changes in ground water storage.

Outcome: The ultimate outcome of the overall study at its conclusion will be current day reference data and its associated uncertainty on the High Plains Aquifer for evaluation of ground water levels and quality changes attributable to program activities through 2010.

### III. DELIVERABLES

The KGS shall deliver to the Kansas Water Office, 109 SW 9th St., Suite 300, Topeka, KS, 66612-1249, the following item, detailed in Attachment A and described herewith:

	ITEM	DELIVERY DATE
1.	A contract list of federal, state and local agencies, a summary of collaborative agreements and an inventory of their existing data.	December 31, 1998
2.	An inventory of geographically located management and protection activities from 1990-1998 by state and local entities.	December 31, 1998
3.	A work plan to evaluate conservation impacts on ground water supplies including existing data collection, additional measurements, sampling schemes, analysis and scheduling.	June 30, 1999
4.	A work plan to develop baselines for water quality at local and regional scales, including network coverages, sampling schemes and scheduling and parameter selection and analysis.	June 30, 1999

### IV. COMPENSATION

The KWO agrees to pay the CRINC \$25,000 for the required budget to provide the deliverable described in Section III and Attachment A. The detailed budget for this study is described in Attachment B. Payment shall be made upon a billing from the CRINC on June 30, 1999 and upon successful completion of this contract as described in Section V.

### V. COMPLETION OF THE CONTRACT

This contract shall be completed no later than June 30, 1999, unless otherwise modified in writing by mutual agreement of all parties. This contract shall be successfully completed upon review and acceptance by the KWO of the deliverables described in Section III. All items received by KWO may be used upon receipt.

**VI. MODIFICATION AND EXTENSION OF CONTRACT**

Contingent upon funding of this agreement, the parties may agree to modify or extend this contract through written approval of all parties. Any such agreement must be made no later than 60 days prior to the aforementioned completion date.

**VII. CONTACT PERSONS**

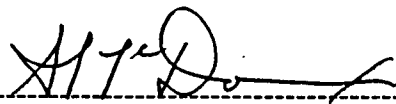
The KGS shall be represented by Don Whittemore (785-864-3965) and the Kansas Water Office shall be represented by Gerry Hargadine (785-296-3185).

**VIII. KANSAS CONTRACTUAL PROVISIONS ATTACHMENT**

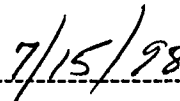
The provisions found in the Contractual Provisions Attachment (Form DA-146; Attachment C), which is attached hereto, are hereby incorporated in this contract and made a part thereof.

**IX. ACKNOWLEDGMENTS**

All products resulting from this contract shall acknowledge that this contract is funded by the State Water Plan Fund of the Kansas Water Office.

**X. SIGNATURES**

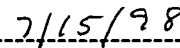
Al LeDoux, Director, Kansas Water Office



Date



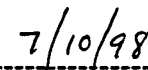
Terrie Wedel, Public Service Executive,  
Administrative Resources, KWO



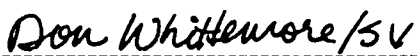
Date



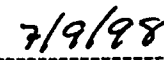
Lee C. Gerhard, Director, Kansas Geological Survey



Date



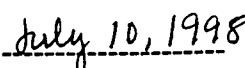
Don Whittemore, Principal Investigator, KGS



Date



Kim Moreland, Director, Contract Negotiations and Research  
Compliance, University of Kansas Center for Research, Inc.



Date

**Evaluation of Ground-Water Quantity and Quality Changes in the High Plains Aquifer:  
Focus on Impacts of Water Withdrawals and Agricultural and Industrial Sources**

*Data and Research Program of the Kansas Water Plan*  
Kansas Geological Survey – June 29, 1998

Water-Resource Issues:

Pumping withdrawals have caused long-term declines in the water levels of the High Plains aquifer in most of western Kansas (primarily the Ogallala aquifer), thereby decreasing the amount of water storage. Local areas of the High Plains aquifer in south-central Kansas have also experienced declines due to groundwater pumping, especially during dry periods. The water-level declines are inducing the movement of naturally poor quality and anthropogenically contaminated water into locations of good quality water. Contaminants from agricultural and industrial, point and non-point sources are also entering ground waters in the High Plains aquifer through direct infiltration or through stream-aquifer interactions. Consumption of water by evaporation and transpiration, mainly by irrigation, is increasing the salinity of recharge entering the aquifer.

State Directions and Goals

State directions and goals for water resources are being developed in the Kansas Water Plan. One of the major directions is to target data acquisition and analysis to provide information for management of water in storage. Goals for ground-water storage in Kansas provide targets for the year 2010 and address consumptive use and water levels in the High Plains aquifer and contamination by nitrate, salinity, and organic compounds. Comprehensive evaluation of the present water in storage and the long-term changes in water quantity and quality across the High Plains aquifer is necessary to meet these goals by providing data for the most efficient management and protection of the aquifer. The research will provide information for performance evaluation of other Water Plan projects, i.e., the determination of baseline conditions and trends against which the impact of other activities can be measured. A critical component of research design and interpretation will be the development of quantitative estimates of sensitivity and uncertainty in both input data and interpretation of results, which will need to inform both sampling and modeling designs. Consideration of temporal and spatial scales of forcing functions, and of the scales and representativeness of observed variations, will be vital because of the heterogeneity of the groundwater system and the potential mismatches between the scales of management programs (typically county size or greater, with time scales of years) and the intrinsic scales of groundwater processes (where spatial scales of sections correspond to time scales of decades). In year 1, KWO will coordinate the formation of an advisory Task Force of participating agencies to review and advise on project design and progress.

Study plan:

The study is proposed for a total of 7 years including the initial planning and development year. The first year will involve development of the study design to include consideration of how the results will be used in the performance evaluation of water management and protection projects of the Kansas Water Plan. Specific activities include coordination with local and state agencies, identification of existing water-quality and quantity information,

planning for integration of the information into a data base for use in the quality study and for construction of aquifer storage models, development of the appropriate data base structures, and preparation of a workplan and sampling strategy based on interagency regional priorities, and the requirements for program evaluations in the presence of uncertainties. The data bases and work plans will be further developed and refined during succeeding years.

In year two assembly of a ground-water storage model will begin in a selected priority region. As work concludes on one region, assembly of the ground-water storage model for the next will begin. As each model is finished, the results will be used to explore sensitivity to input data and assumptions, and to project groundwater storage (with an associated envelope of uncertainty) into the future for proposed management plans.

Investigation of the areal distribution of recharge in the High Plains will be tested and designed in year one and will begin in year two with a reconnaissance study of focused recharge sites (playa lakes, ponds, etc.) based on remote sensing techniques. Size, persistence, and association with known land uses, soil types, and climate variables will be used to develop a preliminary assessment of the distribution and potential importance of such sites, both for direct recharge and as a more general indicator of conditions relevant to areal recharge. Close coordination will be developed and maintained with the ongoing NRCS playa lakes water budget studies, as well as with the water storage model requirements and outputs. If there is potential to significantly improve recharge estimates by limited deployment of field studies, these will be designed in year 2 and initiated in year 3.

Water-quality investigations in the initial stages will involve: Developing sampling and analysis strategies based on the needs for quantitative, uncertainty-based evaluation of the programs of local and state agencies; contacting well owners for permission to sample; database design and initial compilation; and preparing equipment and determining procedures. Water sampling and analysis will be conducted during years 2-6 in the same order of aquifer subregions established as priorities for quantity assessment and program evaluation. Assessment of subregional quality changes and contaminant sources, updating of data bases, and production of GIS maps will follow each year of sampling. The final year of the study will comprise a comprehensive evaluation of water quality for the High Plains aquifer and production of maps and an overview report. The evaluation will include an assessment of the effects of storage changes on water quality and on its evaluation, and a plan for future monitoring for both quantity and quality evaluation to meet Kansas Water Plan goals. The results will provide the basis for performance evaluation of Water Plan and other management and protection activities.

#### Components of the proposed research:

The different data sets that exist in a variety of formats for parameters necessary for computing regional consumption (such as metered water use), for determining ground-water flow rates (hydraulic conductivity), and for computing the amounts of stored water (water-level data, bedrock configuration, recharge, and storage coefficient) will be assembled into a unified data base. These quantity-related parameters will be combined to formulate models which can be used to describe past aquifer storage and to predict future changes. The models will be used to estimate historic consumptive losses and future storage changes under different management plans and improvements in use efficiency. One parameter that is poorly understood is aquifer

recharge. Investigations will be included to estimate how this parameter may vary over the High Plains, especially in western Kansas where recharge is small.

Historic water-quality data will be compiled from a number of sources, including the KGS, KSU, KDA, KDHE, GMDs, USGS, EPA, LEPCs, and city/county health departments. This will be a cooperative effort with those agencies, including consultation throughout the project. Analyses of water samples from over 1200 irrigation wells collected by the KGS from 1975 to 1980 will be a major source of this data. The data will also be entered into the unified electronic data base for assessment of data distribution, preliminary evaluation of past and present water quality, and ongoing assessment of uncertainties and data needs. Where stream-aquifer interactions may have an important control on ground-water quality, a surface-water component will be included in the study. Information on surface-water quality and stream flows, primarily from the KDHE and USGS, will be compiled and evaluated for effect on ground-water quality changes.

A prioritized aquifer-wide sampling and analysis program will be designed based on initial analysis of scaling, uncertainties, and program requirements that will take advantage of: (1) as many of the irrigation wells sampled during 1975-1980 as can still be sampled, (2) additional irrigation or supply wells necessary to provide a comprehensive coverage of the High Plains aquifer in general, and specifically of the selected priority regions and programs, and (3) irrigation or supply wells in locations representative of potential major types of contamination sources. Analytical determinations will include major inorganic constituents (including nitrate and selected metals); selected organics (certain volatile chemicals and common pesticides and daughter products) and bacteria may be analyzed on a site- or program-specific basis based on efforts to develop this component of the study through collaborative interactions with other agencies. Selected well waters may also be analyzed for isotopes and/or other constituents to determine water source and estimate recharge and the effect of evapotranspiration on concentration of dissolved solids. Not all constituents will be determined for all samples; both the sampling design and the selection of analyses will be formulated to maximize information for funds available. The results will be used to evaluate local and regional changes in the aquifer, to establish a strategy for future monitoring by the state, and for development of recommended management actions for water-quality protection.

The sampling program design, models and interpretations, and recommendations for future evaluative activities will all require innovative approaches to overcome the recognized problems of scaling and uncertainty. A variety of multivariate, non-parametric, and regionalized analytical approaches will be required, dealing with spatial patterns, time series, and their interactions. Scenario approaches may be useful in dealing with indeterminate uncertainties (e.g., future climate and socioeconomic forcing of the groundwater system). In order to link the upscaling of point measurements and the downscaling of regional program (or natural forcing) effects, it may be appropriate to perform intensive studies of 'case study' sites determined to be representative of larger regional characteristics and/or responses. Methodological improvements, such as precise elevation determination of sampled wells and a greater reliance on dedicated monitoring installations, may well prove to be an essential part of long-range evaluation strategies. Such considerations will evolve throughout the course of the study, based on experience, continued analyses, and Task Force review and advice.

**Budget**

**Title: Evaluation of Ground-Water Quantity and Quality Changes in the High Plains Aquifer: Focus on Impacts of Water Withdrawals and Agricultural and Industrial Sources**

Principal Investigator: Donald O. Whittemore

Co-Investigators: Margaret A. Townsend, Carl D. McElwee

Dates: 070198 - 063099

Funding Agency: Kansas Water Office

Personnel [20]

Young, David (Environmental Engineer) (35625 annual gross @ 1.00 time x 6 biweekly)	8221.00
Vaughn, Sharon (Program Assistant) (28717 annual gross @ 1.00 time x 6 biweekly)	6627.00
Fringe benefits, staff @ .28	4157.00

**TOTAL PERSONNEL** 19005.00

Travel, in-state [41]

400 mi. RT @ .31/mi. x 6 trps.	744.00
Per diem: 78./day x 18 days x 2 persons	2808.00

**TOTAL TRAVEL** 3552.00

Supplies and Contractual Services [60]

Research and office supplies	1943.00
Computer software	500.00

**TOTAL SUPPLIES AND CONTRACTUAL SERVICES** 2443.00

Equipment [70] 0.00

**TOTAL EQUIPMENT** 0.00

**TOTAL DIRECT COSTS** 25000.00

Indirect Costs 0.00

**TOTAL COSTS** 25000.00

CONTRACTUAL PROVISIONS ATTACHMENT

ATTACHMENT C

**Important:** This form contains mandatory contract provisions and must be attached to or incorporated in all copies of any contractual agreement. If it is attached to the vendor/contractor's standard contract form, then that form must be altered to contain the following provision:

"The provisions found in Contractual Provisions Attachment (form DA-146a), which is attached hereto, are hereby incorporated in this contract and made a part hereof".

The parties agree that the following provisions are hereby incorporated into the contract to which it is attached and made a part thereof, said contract being the \_\_\_\_\_ day of \_\_\_\_\_, 1998.

3. TERMS HEREIN CONTROLLING PROVISIONS

It is expressly agreed that the terms of each and every provision in this attachment shall prevail and control over the terms of any other conflicting provision in any other document relating to and a part of the contract in which this attachment is incorporated.

4. AGREEMENT WITH KANSAS LAW

All contractual agreements shall be subject to, governed by, and construed according to the laws of the State of Kansas.

5. TERMINATION DUE TO LACK OF FUNDING APPROPRIATION

If, in the judgment of the Director of Accounts and Reports, Department of Administration, sufficient funds are not appropriated to continue the function performed in this agreement and for the payment of the charges hereunder, State may terminate this agreement at the end of its current fiscal year. State agrees to give written notice of termination to contractor at least 30 days prior to the end of its current fiscal year, and shall give such notice for a greater period prior to the end of such fiscal year as may be provided in this contract, except that such notice shall not be required prior to 90 days before the end of such fiscal year. Contractor shall have the right, at the end of such fiscal year, to take possession of any equipment provided State under the contract. State will pay to the contractor all regular contractual payments incurred through the end of such fiscal year, plus contractual charges incidental to the return of any such equipment. Upon termination of the agreement by State, title to any such equipment shall revert to contractor at the end of State's current fiscal year. The termination of the contract pursuant to this paragraph shall not cause any penalty to be charged to the agency or the contractor.

6. DISCLAIMER OF LIABILITY

Neither the State of Kansas nor any agency thereof shall hold harmless or indemnify any contractor beyond that liability incurred under the Kansas Tort Claims Act (K.S.A. 75-6101 et seq.).

7. ANTI-DISCRIMINATION CLAUSE

The contractor agrees: (a) to comply with the Kansas Act Against Discrimination (K.S.A. 44-1001 et seq.) And the Kansas Age Discrimination in Employment Act (K.S.A. 44-1111 et seq.) and the applicable provisions of the Americans With Disabilities Act (42 U.S.C. 12101 et seq.) (ADA) and to not discriminate against any person because of race, religion, color, sex, disability, national origin or ancestry, or age in the admission or access to, or treatment or employment in, its programs or activities; (b) to include in all solicitations or advertisements for employees, the phrase "equal opportunity employer"; (c) to comply with the reporting requirements set out at K.S.A. 44-1031 and K.S.A. 44-1116; (d) to include those provisions in every subcontract or purchase order so that they are binding upon such subcontractor or vendor; (e) that a failure to comply with the reporting requirements of (c) above or if the contractor is found guilty of any violation of such acts by the Kansas Human Rights Commission, such violation shall constitute a breach of contract and the contract may be canceled, terminated or suspended, in whole or in part, by the contracting state agency or the Kansas Department of Administration; (f) if it is determined that the contractor has violated applicable provisions of the ADA, such violation shall constitute a breach of contract and the contract may be canceled, terminated or suspended, in whole or in part, by the contracting state agency or the Kansas Department of Administration.

Parties to this contract understand that the provisions of this paragraph number 5 (with the exception of those provisions relating to the ADA) are not applicable to a contractor who employs fewer than four employees during the term of such contract or whose contracts with the contracting state agency cumulatively total \$5,000 or less during the fiscal year of such agency.

8. ACCEPTANCE OF CONTRACT

This contract shall not be considered accepted, approved or otherwise effective until the statutorily required approvals and certifications have been given.

9. ARBITRATION, DAMAGES, WARRANTIES

Notwithstanding any language to the contrary, no interpretation shall be allowed to find the State or any agency thereof has agreed to binding arbitration, or the payment of damages or penalties upon the occurrence of a contingency. Further, the State of Kansas shall not agree to pay attorney fees and late payment charges beyond those available under the Kansas Prompt Payment Act (K.S.A. 75-6403), and no provision will be given effect which attempts to exclude, modify, disclaim or otherwise attempt to limit implied warranties of merchantability and fitness for a particular purpose.

10. REPRESENTATIVE'S AUTHORITY TO CONTRACT

By signing this document, the representative of the contractor thereby represents that such person is duly authorized by the contractor to execute this document on behalf of the contractor and that the contractor agrees to be bound by the provisions thereof.

11. RESPONSIBILITY FOR TAXES

The State of Kansas shall not be responsible for, nor indemnify a contractor for, any federal, state or local taxes which may be imposed or levied upon the subject matter of this contract.

12. INSURANCE

The State of Kansas shall not be required to purchase any insurance against loss or damage to any personal property to which this contract relates, nor shall this contract require the State to establish a "self-insurance" fund to protect against any such loss or damage. Subject to the provisions of the Kansas Tort Claims Act (K.S.A. 75-6101 et seq.), the vendor or lessor shall bear the risk of any loss or damage to any personal property in which vendor or lessor holds title.

13. INFORMATION

No provisions of this contract shall be construed as limiting the Legislative Division of Post Audit from having access to information pursuant to K.S.A. 46-1101 et seq.

## **Appendix B: Project WWW-site posting summary**

First page: Public access index page for the High Plains website, developed for both general and selective distribution and review of data and information.

<http://www.kgs.ukans.edu/Hydro/HPAE/index.html>

Second page: Index page for password-controlled HP AE website for communication among project participants and Coordinating Council.

<http://magellan.kgs.ukans.edu/HighPlains/index.html> (password required for login)

Subsequent pages: Coordinating Council and project participant contact listing—from the website, and illustrative of contact database report products.

<http://magellan.kgs.ukans.edu/HighPlains/council.html> (password required for login)



## High Plains Aquifer Evaluation Project

# High Plains Aquifer Evaluation Project (HPAE)

This is an access-controlled set of pages developed as a convenient means of information exchange and review by the participants in the HPAE. As the project matures and materials are approved for release, appropriate sections of the pages will be transferred into public access pages.

Questions or suggestions? Contact [Robert W. Buddemeier](#), Project Manager.

---

The High Plains Aquifer Evaluation Project is being carried out by the Geohydrology Section of the Kansas Geological Survey (KGS) under a contract with the Kansas Water Office (KWO), with the participation and review of a Coordinating Council made up of representatives of state and local water agencies.

Under the terms of the contract, KGS will provide scientific and technical support and guidance for the Kansas Water Office and other organizations to assist them in setting goals, assessing resources and needs, and evaluating the progress and effects of programs affecting groundwater. The primary focus of the KGS activities will be the quality and quantity of groundwater in the High Plains Aquifer.

### Table of Contents

- [Brief overview of project objectives](#)
- [Agency contact list and members of the HPAE Coordinating Council](#)
- [Project FTP site](#)
- [Participating KGS personnel](#)
- [Info for KGS staff only](#)
- [Info for Agency Personnel](#) (password required)

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[Kansas Geological Survey, Geohydrology Section](#)

Updated May 1999.

Scientific comments to [Robert W. Buddemeier](#)

Web comments to [webadmin@kgs.ukans.edu](mailto:webadmin@kgs.ukans.edu)

The URL for this page is [HTTP://www.kgs.ukans.edu/Hydro/HPAE/index.html](http://www.kgs.ukans.edu/Hydro/HPAE/index.html)



## High Plains Aquifer Evaluation Project (HPAE)

This is an unlisted but publically accessible set of pages developed as a convenient means of information exchange and review by the participants in the HPAE. As the project matures and materials are approved for release, appropriate sections of the pages will be linked to KWO and KGS sites and transferred into listed public access pages.

### Project Personnel

Donald Whittemore - Project Coordinator      Robert Buddemeier - Project Manager

Quantity evaluation: Carl McElwee (Group leader), Allen Macfarlane,  
and Marios Sophocleous

Quality evaluation: Margaret Townsend (Group leader), David Young,  
and Donald Whittemore

Aquifer characterization: Allen Macfarlane (Task leader)

Database management: Jeffrey Schloss      Program assistance: Sharon Vaughn

Questions or suggestions? Contact [Robert W. Buddemeier](#), Project Manager.

Last update 26 April 99.

The High Plains Aquifer Evaluation Project is being carried out by the Geohydrology Section of the Kansas Geological Survey (KGS) under a contract with the Kansas Water Office (KWO), with the participation and review of a Coordinating Council made up of representatives of state and local water agencies.

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### Table of Contents

- [NEW! Draft Water Quality Baseline Definitions for Initial Review/Discussion!](#)
- [NEW! Second Draft of Water Quantity Baseline Definitions \(with original draft/discussion\)](#)
- [Brief overview of project objectives](#)
- [Kansas Water Plan Objectives related to HPAE](#)
- [Agency contact list and members of the HPAE Coordinating Council](#)
- [Project FTP site](#)
- [Participating KGS personnel](#)
- [Preliminary draft 1999-2000 project workplan -- for review and comment](#)
- [Summary of Dec 31 KGS report to KWO on mid-year deliverables](#)
- [Preliminary review of uncertainty in High Plains water level measurements](#)

### [Kansas Geological Survey, Geohydrology Section](#)

Scientific comments to [Robert W. Buddemeier](#)

Web comments to [webadmin@kgs.ukans.edu](mailto:webadmin@kgs.ukans.edu)

The URL for this page is [HTTP://magellan.kgs.ukans.edu/HighPlains/index.html](http://magellan.kgs.ukans.edu/HighPlains/index.html)

**HPAE  
Coordinating Council**High Plains Aquifer Evaluation Project (HPAE), continued

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**Members of the HPAE Coordinating Council**

The Coordinating Council consists of representatives of the major Kansas state and local water agencies. It provides review and advice on project plans and progress, contributes to the definition of goals and products, and facilitates and coordinates acquisition of data and cooperative efforts.

**Al LeDoux (Ex-Officio Chair)**

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**David Pope**

Chief Engineer, Director  
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**KWO Staff****Clark Duffy**

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---

**Participating KGS Staff**

Donald Whittemore - Project Coordinator Robert Buddemeier - Project Manager  
Quantity evaluation: Carl McElwee (Group leader), Allen Macfarlane and Marios Sophocleous  
Quality evaluation: Margaret Townsend (Group leader), David Young and Donald Whittemore  
Aquifer Characterization: Allen Macfarlane (Task leader)  
Database management: Jeffrey Schloss Program assistance: Sharon Vaughn  
Questions or suggestions? Contact Robert W. Buddemeier, Project Manager.

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## **Appendix C: Contact data base**

The contact inventory was assembled first from individual and institutional KGS records, and then checked and expanded by reference to agency WWW pages, directories, etc. Incomplete entries are retained, pending agency review and expressions of interest in database use and maintenance.

The contact database is a useful information tool that will be maintained and updated; a possible long-term product goal would be a web version that would allow agencies and individuals to check and correct their own entries. At present we ask that the personnel listed in the database report please review their information for completeness, accuracy, inform us of any corrections. The report is arranged alphabetically by organization name.

We consider the present form adequate for a stand-alone item, although some individual items need to be checked, corrected, and expanded; when it is linked to the program and data inventory tables, some additions and refinements will undoubtedly be needed. Readers are requested to submit corrections or additions to the compilers of this report.

# CONTACTS DATABASE REPORT

(alphabetically by organization name)

## ORGANIZATION INFORMATION

## PERSONNEL INFORMATION

<i>name</i>	<b>Big Bend GMD No. 5</b>	<input checked="" type="checkbox"/>	Coordinating Council Member	
<i>address1</i>	P.O. Box 7	<i>first/last</i>	<b>Sharon</b>	<b>Falk</b>
<i>address2</i>	125 S Main	<i>title</i>	Manager	
<i>city/state/zip</i>	Stafford KS 67578-0007	<i>unit or division</i>		
<i>office phone/fax</i>	(316) 234-5352 (316) 234-6166	<i>desk phone/fax</i>		
<i>url</i>		<i>email</i>	gmd5@midway.net	

<i>name</i>	<b>Central Kansas Local Environmental Protection Group</b>	<input type="checkbox"/>	Coordinating Council Member	
<i>address1</i>	1803 Kansas Avenue	<i>first/last</i>	<b>Judy</b>	<b>Nuss</b>
<i>address2</i>		<i>title</i>		
<i>city/state/zip</i>	Great Bend KS 67530	<i>unit or division</i>	Barton County Health Department	
<i>office phone/fax</i>	(316) 793-6892	<i>desk phone/fax</i>		
<i>url</i>		<i>email</i>	cklepg@awav.net	

<i>name</i>	<b>Dickinson County Health Department</b>	<input type="checkbox"/>	Coordinating Council Member	
<i>address1</i>	515 NE 10th Street	<i>first/last</i>	<b>Karen</b>	<b>McMillan</b>
<i>address2</i>		<i>title</i>		
<i>city/state/zip</i>	Abilene KS 67410	<i>unit or division</i>		
<i>office phone/fax</i>		<i>desk phone/fax</i>		
<i>url</i>		<i>email</i>		

<i>name</i>	<b>Division of Emergency Management</b>	<input type="checkbox"/>	Coordinating Council Member	
<i>address1</i>	2800 SW Topeka Boulevard	<i>first/last</i>	<b>Lloyd</b>	<b>Krase</b>
<i>address2</i>		<i>title</i>	Deputy Director	
<i>city/state/zip</i>	Topeka KS 66611-1287	<i>unit or division</i>	Adjutant General Department	
<i>office phone/fax</i>	(785) 274-1401	<i>desk phone/fax</i>		
<i>url</i>		<i>email</i>		

<i>name</i>	<b>Ellis County Local Environmental Protection Group</b>	<input type="checkbox"/>	Coordinating Council Member	
<i>address1</i>	601 Main	<i>first/last</i>	<b>Karin</b>	<b>Purvis</b>
<i>address2</i>	Suite C	<i>title</i>		
<i>city/state/zip</i>	Hays KS 67601-4230	<i>unit or division</i>		
<i>office phone/fax</i>	(785) 628-9440 (785) 628-9449	<i>desk phone/fax</i>		
<i>url</i>		<i>email</i>		

<i>name</i>	<b>Ellis County Local Environmental Protection Group</b>	<input type="checkbox"/>	Coordinating Council Member	
<i>address1</i>	601 Main	<i>first/last</i>	<b>Dale</b>	<b>Wing</b>
<i>address2</i>	Suite C	<i>title</i>		
<i>city/state/zip</i>	Hays KS 67601-4230	<i>unit or division</i>		
<i>office phone/fax</i>	(785) 628-9440 (785) 628-9449	<i>desk phone/fax</i>		
<i>url</i>		<i>email</i>		

# CONTACTS DATABASE REPORT

(alphabetically by organization name)

## ORGANIZATION INFORMATION

## PERSONNEL INFORMATION

<i>name</i>	<b>Ellsworth County Local Environmental Protection Group</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Jo Funk</b>
<i>address1</i>	210 N Kansas Avenue		<i>title</i>	
<i>address2</i>			<i>unit or division</i>	
<i>city/state/zip</i>	Ellsworth KS 67439-3118		<i>desk phone/fax</i>	
<i>office phone/fax</i>	(785) 826-6600		<i>email</i>	
<i>url</i>				

<i>name</i>	<b>Equus Beds GMD No. 2</b>	<input checked="" type="checkbox"/>	<i>first/last</i>	<b>Michael Dealy</b>
<i>address1</i>	313 Spruce		<i>title</i>	Manager
<i>address2</i>			<i>unit or division</i>	
<i>city/state/zip</i>	Halstead KS 67056-1925		<i>desk phone/fax</i>	
<i>office phone/fax</i>	(316) 835-2224 (316) 830-2210		<i>email</i>	equusbed@ink.org
<i>url</i>				

<i>name</i>	<b>Ford County Local Environmental Protection Group</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Chris Dunn</b>
<i>address1</i>	106 E Spruce Street		<i>title</i>	
<i>address2</i>			<i>unit or division</i>	Department of Planning, Zoning, and Environmental Heal
<i>city/state/zip</i>	Dodge City KS 67801-4910		<i>desk phone/fax</i>	
<i>office phone/fax</i>	(316) 227-4739		<i>email</i>	zone@pld.com
<i>url</i>				

<i>name</i>	<b>Geary County Health Department</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Mike Houck</b>
<i>address1</i>	P.O. Box 282		<i>title</i>	
<i>address2</i>			<i>unit or division</i>	
<i>city/state/zip</i>	Junction City KS 66441		<i>desk phone/fax</i>	
<i>office phone/fax</i>			<i>email</i>	
<i>url</i>				

<i>name</i>	<b>Harvey County Health Department</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Tim Wagner</b>
<i>address1</i>	316 Oak Street		<i>title</i>	
<i>address2</i>			<i>unit or division</i>	
<i>city/state/zip</i>	Newton KS 67114-3455		<i>desk phone/fax</i>	
<i>office phone/fax</i>	(316) 283-1637 (316) 283-0057		<i>email</i>	
<i>url</i>				

<i>name</i>	<b>Kansas Biological Survey</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Edward Martinko</b>
<i>address1</i>	256 Nichols Hall		<i>title</i>	Director
<i>address2</i>	University of Kansas		<i>unit or division</i>	
<i>city/state/zip</i>	Lawrence KS 66047		<i>desk phone/fax</i>	
<i>office phone/fax</i>	(785) 864-7770		<i>email</i>	
<i>url</i>	www.gemlab.ukans.edu/kbs			

# CONTACTS DATABASE REPORT

(alphabetically by organization name)

## ORGANIZATION INFORMATION

## PERSONNEL INFORMATION

<b>name</b>	<b>Kansas Center for Agricultural Resources and Environmen</b>	<input checked="" type="checkbox"/>	<b>Coordinating Council Member</b>
<b>address1</b>	44 Waters Hall	<b>first/last</b>	<b>William Hargrove</b>
<b>address2</b>	Kansas State University	<b>title</b>	Director
<b>city/state/zip</b>	Manhattan KS 66506-4002	<b>unit or division</b>	
<b>office phone/fax</b>	(785) 532-7103 (785) 532-6563	<b>desk phone/fax</b>	(785) 532-7419
<b>url</b>	www.ksu.edu/kcare	<b>email</b>	bhargrov@oz.oznet.ksu.edu

<b>name</b>	<b>Kansas Conservation Commission</b>	<input type="checkbox"/>	<b>Coordinating Council Member</b>
<b>address1</b>	109 SW 9th Street	<b>first/last</b>	<b>Tracy Streeter</b>
<b>address2</b>	Mills Building, Suite 500	<b>title</b>	Director
<b>city/state/zip</b>	Topeka KS 66612-1299	<b>unit or division</b>	
<b>office phone/fax</b>	(785) 296-3600	<b>desk phone/fax</b>	
<b>url</b>	www.state.ks.us/public/kscce	<b>email</b>	tstreeter@state.ks.us

<b>name</b>	<b>Kansas Conservation Commission</b>	<input checked="" type="checkbox"/>	<b>Coordinating Council Member</b>
<b>address1</b>	109 SW 9th Street	<b>first/last</b>	<b>Blake Henning</b>
<b>address2</b>	Mills Building, Suite 500	<b>title</b>	Assistant Director
<b>city/state/zip</b>	Topeka KS 66612-1299	<b>unit or division</b>	
<b>office phone/fax</b>	(785) 296-3600	<b>desk phone/fax</b>	
<b>url</b>	www.state.ks.us/public/kscce	<b>email</b>	bhenning@scc.state.ks.us

<b>name</b>	<b>Kansas Corporation Commission</b>	<input checked="" type="checkbox"/>	<b>Coordinating Council Member</b>
<b>address1</b>	130 S Market Street	<b>first/last</b>	<b>Maurice Korphage</b>
<b>address2</b>	Suite 2125	<b>title</b>	Director
<b>city/state/zip</b>	Wichita KS 67202-3802	<b>unit or division</b>	Oil and Gas Conservation Division
<b>office phone/fax</b>	(316) 337-6200	<b>desk phone/fax</b>	
<b>url</b>	www.kcc.state.ks.us	<b>email</b>	

<b>name</b>	<b>Kansas Department of Agriculture</b>	<input type="checkbox"/>	<b>Coordinating Council Member</b>
<b>address1</b>	225 S Chestnut	<b>first/last</b>	<b>Marc Anderson</b>
<b>address2</b>		<b>title</b>	
<b>city/state/zip</b>	Lindsborg KS 67451	<b>unit or division</b>	Division of Pesticides, Chemigation Program
<b>office phone/fax</b>	(785) 227-4281	<b>desk phone/fax</b>	
<b>url</b>	www.ink.org/public/kda	<b>email</b>	marca@midusa.net

<b>name</b>	<b>Kansas Department of Agriculture</b>	<input checked="" type="checkbox"/>	<b>Coordinating Council Member</b>
<b>address1</b>	901 S Kansas Avenue	<b>first/last</b>	<b>David Pope</b>
<b>address2</b>	2nd Floor	<b>title</b>	Chief Engineer and Director
<b>city/state/zip</b>	Topeka KS 66612-1281	<b>unit or division</b>	Division of Water Resources
<b>office phone/fax</b>	(785) 296-3717 (785) 296-1176	<b>desk phone/fax</b>	
<b>url</b>	www.ink.org/public/kda	<b>email</b>	

# CONTACTS DATABASE REPORT

(alphabetically by organization name)

## ORGANIZATION INFORMATION

## PERSONNEL INFORMATION

<i>name</i>	<b>Kansas Department of Agriculture</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Dale</b>	<b>Lambley</b>
<i>address1</i>	901 S Kansas Avenue		<i>title</i>		
<i>address2</i>	2nd Floor		<i>unit or division</i>		
<i>city/state/zip</i>	Topeka KS 66612-1281		<i>desk phone/fax</i>	(785) 296-0912	
<i>office phone/fax</i>	(785) 296-3717 (785) 296-1176		<i>email</i>		
<i>url</i>	www.ink.org/public/kda				

<i>name</i>	<b>Kansas Department of Agriculture</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Matt</b>	<b>Scherer</b>
<i>address1</i>	901 S Kansas Avenue		<i>title</i>		
<i>address2</i>	2nd Floor		<i>unit or division</i>	Division of Water Resources	
<i>city/state/zip</i>	Topeka KS 66612-1281		<i>desk phone/fax</i>		
<i>office phone/fax</i>	(785) 296-3717 (785) 296-1176		<i>email</i>		
<i>url</i>	www.ink.org/public/kda				

<i>name</i>	<b>Kansas Department of Agriculture</b>	<input checked="" type="checkbox"/>	<i>first/last</i>	<b>John</b>	<b>Stamer</b>
<i>address1</i>	901 S Kansas Avenue		<i>title</i>	Pesticide Program Manager	
<i>address2</i>	7th Floor		<i>unit or division</i>	Division of Pesticides	
<i>city/state/zip</i>	Topeka KS 66612-1281		<i>desk phone/fax</i>	(785) 296-3786	
<i>office phone/fax</i>	(785) 296-0673		<i>email</i>	jstamer@kda.state.ks.us	
<i>url</i>	www.ink.org/public/kda				

<i>name</i>	<b>Kansas Department of Agriculture</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Tom</b>	<b>Huntzinger</b>
<i>address1</i>	901 S Kansas Avenue		<i>title</i>		
<i>address2</i>	2nd Floor		<i>unit or division</i>	Division of Water Resources	
<i>city/state/zip</i>	Topeka KS 66612-1281		<i>desk phone/fax</i>	(785) 296-4621	
<i>office phone/fax</i>	(785) 296-3717 (785) 296-1176		<i>email</i>	thuntzinger@kda.state.ks.us	
<i>url</i>	www.ink.org/public/kda				

<i>name</i>	<b>Kansas Department of Agriculture</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Brownie</b>	<b>Wilson</b>
<i>address1</i>	901 S Kansas Avenue		<i>title</i>		
<i>address2</i>	2nd Floor		<i>unit or division</i>	Division of Water Resources	
<i>city/state/zip</i>	Topeka KS 66612-1281		<i>desk phone/fax</i>		
<i>office phone/fax</i>	(785) 296-3717 (785) 296-1176		<i>email</i>	bwilson@h20.kda.state.ks.us	
<i>url</i>	www.ink.org/public/kda				

<i>name</i>	<b>Kansas Department of Health and Environment</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Rick</b>	<b>Bean</b>
<i>address1</i>	Forbes Field		<i>title</i>		
<i>address2</i>	Building 740		<i>unit or division</i>	Bureau of Environmental Field Services	
<i>city/state/zip</i>	Topeka KS 66620-0001		<i>desk phone/fax</i>	(785) 296-1675	
<i>office phone/fax</i>			<i>email</i>		
<i>url</i>	www.kdhe.state.ks.us				

# CONTACTS DATABASE REPORT

(alphabetically by organization name)

## ORGANIZATION INFORMATION

## PERSONNEL INFORMATION

<i>name</i>	<b>Kansas Department of Health and Environment</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Debra Baker</b>
<i>address1</i>	Forbes Field		<i>title</i>	
<i>address2</i>	Building 283		<i>unit or division</i>	Local Environmental Protection Program
<i>city/state/zip</i>	Topeka KS 66620-0001		<i>desk phone/fax</i>	(785) 296-1683
<i>office phone/fax</i>			<i>email</i>	
<i>url</i>	www.kdhe.state.ks.us			

<i>name</i>	<b>Kansas Department of Health and Environment</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Marc Duncan</b>
<i>address1</i>	Forbes Field		<i>title</i>	Chief
<i>address2</i>	Building 740		<i>unit or division</i>	Bureau of Waste Management, Ground Water Section
<i>city/state/zip</i>	Topeka KS 66620-0001		<i>desk phone/fax</i>	(785) 296-1614
<i>office phone/fax</i>			<i>email</i>	
<i>url</i>	www.kdhe.state.ks.us			

<i>name</i>	<b>Kansas Department of Health and Environment</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Ron Hammerschmidt</b>
<i>address1</i>	Forbes Field		<i>title</i>	Director of Environment
<i>address2</i>	Building 283		<i>unit or division</i>	
<i>city/state/zip</i>	Topeka KS 66620-0001		<i>desk phone/fax</i>	(785) 296-1535
<i>office phone/fax</i>			<i>email</i>	rhammers@kdhe.state.ks.us
<i>url</i>	www.kdhe.state.ks.us			

<i>name</i>	<b>Kansas Department of Health and Environment</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Brian Bain</b>
<i>address1</i>	Forbes Field		<i>title</i>	
<i>address2</i>	Building 283		<i>unit or division</i>	
<i>city/state/zip</i>	Topeka KS 66620-0001		<i>desk phone/fax</i>	(785) 296-5548
<i>office phone/fax</i>			<i>email</i>	
<i>url</i>	www.kdhe.state.ks.us			

<i>name</i>	<b>Kansas Department of Health and Environment</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Scott Satterthwaite</b>
<i>address1</i>	Forbes Field		<i>title</i>	
<i>address2</i>	Building 283		<i>unit or division</i>	Bureau of Water - Nonpoint Source Section
<i>city/state/zip</i>	Topeka KS 66620-0001		<i>desk phone/fax</i>	(785) 296-5573
<i>office phone/fax</i>			<i>email</i>	
<i>url</i>	www.kdhe.state.ks.us			

<i>name</i>	<b>Kansas Department of Health and Environment</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Pam Chaffee</b>
<i>address1</i>	Forbes Field		<i>title</i>	
<i>address2</i>	Building 740		<i>unit or division</i>	Bureau of Environmental Remediation
<i>city/state/zip</i>	Topeka KS 66620-0001		<i>desk phone/fax</i>	(785) 296-0696
<i>office phone/fax</i>			<i>email</i>	
<i>url</i>	www.kdhe.state.ks.us			

# CONTACTS DATABASE REPORT

(alphabetically by organization name)

## ORGANIZATION INFORMATION

## PERSONNEL INFORMATION

<i>name</i>	<b>Kansas Department of Health and Environment</b>	<input type="checkbox"/>
<i>address1</i>	Forbes Field	<i>first/last</i>
<i>address2</i>	Building 283	<b>Darrel Plummer</b>
<i>city/state/zip</i>	Topeka KS 66620-0001	<i>title</i>
<i>office phone/fax</i>		Bureau of Water - Public Water Supply Section
<i>url</i>	www.kdhe.state.ks.us	<i>desk phone/fax</i>
		(785) 296-5503
		<i>email</i>
		plummer@kdhe.state.ks.us

<i>name</i>	<b>Kansas Department of Health and Environment</b>	<input type="checkbox"/>
<i>address1</i>	Forbes Field	<i>first/last</i>
<i>address2</i>	Building 283	<b>Dave Waldo</b>
<i>city/state/zip</i>	Topeka KS 66620-0001	<i>title</i>
<i>office phone/fax</i>		Bureau of Water - Public Water Supply Section
<i>url</i>	www.kdhe.state.ks.us	<i>desk phone/fax</i>
		(785) 296-5503
		<i>email</i>

<i>name</i>	<b>Kansas Department of Health and Environment</b>	<input type="checkbox"/>
<i>address1</i>	Forbes Field	<i>first/last</i>
<i>address2</i>	Building 283	<b>Steve Page</b>
<i>city/state/zip</i>	Topeka KS 66620-0001	<i>title</i>
<i>office phone/fax</i>		Bureau of Water - Public Water Supply Section
<i>url</i>	www.kdhe.state.ks.us	<i>desk phone/fax</i>
		(785) 296-0189
		<i>email</i>

<i>name</i>	<b>Kansas Department of Wildlife and Parks</b>	<input type="checkbox"/>
<i>address1</i>	900 SW Jackson Street	<i>first/last</i>
<i>address2</i>	Landon Building, Room 502N	<b>Steve Williams</b>
<i>city/state/zip</i>	Topeka KS 66612-1283	<i>title</i>
<i>office phone/fax</i>	(785) 296-2281	Secretary
<i>url</i>	www.kdwp.state.ks.us	<i>desk phone/fax</i>
		<i>email</i>

<i>name</i>	<b>Kansas Forest Service</b>	<input type="checkbox"/>
<i>address1</i>	2610 Claflin Road	<i>first/last</i>
<i>address2</i>	Kansas State University	<b>Raymond Aslin</b>
<i>city/state/zip</i>	Manhattan KS 66502-2798	<i>title</i>
<i>office phone/fax</i>	(785) 532-3300	State Forester
<i>url</i>	www.oznet.ksu.edu/dp_kfs	<i>desk phone/fax</i>
		<i>email</i>

<i>name</i>	<b>Kansas Geological Survey</b>	<input checked="" type="checkbox"/>
<i>address1</i>	1930 Constant Avenue	<i>first/last</i>
<i>address2</i>	University of Kansas	<b>Robert Buddemeier</b>
<i>city/state/zip</i>	Lawrence KS 66047-3726	<i>title</i>
<i>office phone/fax</i>	(785) 864-3965 (785) 864-5317	Senior Scientist
<i>url</i>	www.kgs.ukans.edu	Geohydrology
		ext 329
		<i>email</i>
		buddrw@kgs.ukans.edu

# CONTACTS DATABASE REPORT

(alphabetically by organization name)

## ORGANIZATION INFORMATION

## PERSONNEL INFORMATION

<i>name</i>	<b>Kansas Geological Survey</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Lee</b>	<b>Gerhard</b>
<i>address1</i>	1930 Constant Avenue		<i>title</i>	Director	
<i>address2</i>	University of Kansas		<i>unit or division</i>	Administration	
<i>city/state/zip</i>	Lawrence KS 66047-3726		<i>desk phone/fax</i>	ext 324	
<i>office phone/fax</i>	(785) 864-3965 (785) 864-5317		<i>email</i>	lgerhard@kgs.ukans.edu	
<i>url</i>	www.kgs.ukans.edu				

<i>name</i>	<b>Kansas Geological Survey</b>	<input checked="" type="checkbox"/>	<i>first/last</i>	<b>Don</b>	<b>Whittemore</b>
<i>address1</i>	1930 Constant Avenue		<i>title</i>	Section Chief	
<i>address2</i>	University of Kansas		<i>unit or division</i>	Geohydrology	
<i>city/state/zip</i>	Lawrence KS 66047-3726		<i>desk phone/fax</i>	ext 448	
<i>office phone/fax</i>	(785) 864-3965 (785) 864-5317		<i>email</i>	donwhitt@kgs.ukans.edu	
<i>url</i>	www.kgs.ukans.edu				

<i>name</i>	<b>Kansas Geological Survey</b>	<input type="checkbox"/>	<i>first/last</i>	<b>William</b>	<b>Harrison</b>
<i>address1</i>	1930 Constant Avenue		<i>title</i>		
<i>address2</i>	University of Kansas		<i>unit or division</i>	Administration	
<i>city/state/zip</i>	Lawrence KS 66047-3726		<i>desk phone/fax</i>	ext 445	
<i>office phone/fax</i>	(785) 864-3965 (785) 864-5317		<i>email</i>	harrison@kgs.ukans.edu	
<i>url</i>	www.kgs.ukans.edu				

<i>name</i>	<b>Kansas State University</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Charles</b>	<b>Rice</b>
<i>address1</i>	Department of Agronomy		<i>title</i>		
<i>address2</i>	2004 Throckmorton Hall		<i>unit or division</i>	Department of Agronomy	
<i>city/state/zip</i>	Manhattan KS 66506		<i>desk phone/fax</i>		
<i>office phone/fax</i>	(785) 532-7217 (785) 532-6094		<i>email</i>	cwrice@ksu.edu	
<i>url</i>	www.ksu.edu				

<i>name</i>	<b>Kansas State University</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Morgan</b>	<b>Powell</b>
<i>address1</i>	S231		<i>title</i>		
<i>address2</i>			<i>unit or division</i>	Biological and Agricultural Engineering	
<i>city/state/zip</i>	Manhattan KS 66502		<i>desk phone/fax</i>		
<i>office phone/fax</i>	(785) 532-5813		<i>email</i>		
<i>url</i>	www.ksu.edu				

<i>name</i>	<b>Kansas State University</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Marc</b>	<b>Johnson</b>
<i>address1</i>	Waters Hall		<i>title</i>	Dean	
<i>address2</i>	Kansas State University		<i>unit or division</i>	College of Agriculture	
<i>city/state/zip</i>	Manhattan KS 66506-4002		<i>desk phone/fax</i>		
<i>office phone/fax</i>	(785) 532-6147		<i>email</i>		
<i>url</i>	www.ksu.edu				

# CONTACTS DATABASE REPORT

(alphabetically by organization name)

## ORGANIZATION INFORMATION

## PERSONNEL INFORMATION

<i>name</i>	<b>Kansas Water Authority</b>	<input type="checkbox"/>	Coordinating Council Member	
<i>address1</i>	P.O. Box 69	<i>first/last</i>	<b>Kent</b>	<b>Lamb</b>
<i>address2</i>	RR 1	<i>title</i>	Chairman	
<i>city/state/zip</i>	Macksville KS 67557	<i>unit or division</i>		
<i>office phone/fax</i>	(316) 348-2315	<i>desk phone/fax</i>		
<i>url</i>	www.state.ks.us/public/kwo/authority.html	<i>email</i>		

<i>name</i>	<b>Kansas Water Office</b>	<input type="checkbox"/>	Coordinating Council Member	
<i>address1</i>	109 SW 9th Street	<i>first/last</i>	<b>Darrel</b>	<b>Eklund</b>
<i>address2</i>	Mills Building, Suite 300	<i>title</i>		
<i>city/state/zip</i>	Topeka KS 66612-1249	<i>unit or division</i>		
<i>office phone/fax</i>	(785) 296-0878 (785) 296-0878	<i>desk phone/fax</i>		
<i>url</i>	www.ink.org/public/kwo	<i>email</i>	deklund@kwo.state.ks.us	

<i>name</i>	<b>Kansas Water Office</b>	<input type="checkbox"/>	Coordinating Council Member	
<i>address1</i>	109 SW 9th Street	<i>first/last</i>	<b>Clark</b>	<b>Duffy</b>
<i>address2</i>	Mills Building, Suite 300	<i>title</i>		
<i>city/state/zip</i>	Topeka KS 66612-1249	<i>unit or division</i>		
<i>office phone/fax</i>	(785) 296-0878 (785) 296-0878	<i>desk phone/fax</i>		
<i>url</i>	www.ink.org/public/kwo	<i>email</i>	cduffy@kwo.state.ks.us	

<i>name</i>	<b>Kansas Water Office</b>	<input type="checkbox"/>	Coordinating Council Member	
<i>address1</i>	109 SW 9th Street	<i>first/last</i>	<b>Daljit</b>	<b>Jawa</b>
<i>address2</i>	Mills Building, Suite 300	<i>title</i>		
<i>city/state/zip</i>	Topeka KS 66612-1249	<i>unit or division</i>		
<i>office phone/fax</i>	(785) 296-0878 (785) 296-0878	<i>desk phone/fax</i>		
<i>url</i>	www.ink.org/public/kwo	<i>email</i>	djawa@kwo.state.ks.us	

<i>name</i>	<b>Kansas Water Office</b>	<input checked="" type="checkbox"/>	Coordinating Council Member	
<i>address1</i>	109 SW 9th Street	<i>first/last</i>	<b>Al</b>	<b>LeDoux</b>
<i>address2</i>	Mills Building, Suite 300	<i>title</i>	Director	
<i>city/state/zip</i>	Topeka KS 66612-1249	<i>unit or division</i>		
<i>office phone/fax</i>	(785) 296-0878 (785) 296-0878	<i>desk phone/fax</i>		
<i>url</i>	www.ink.org/public/kwo	<i>email</i>	al@kwo.state.ks.us	

<i>name</i>	<b>Marion County Local Environmental Protection Group</b>	<input type="checkbox"/>	Coordinating Council Member	
<i>address1</i>	230 E Main Street	<i>first/last</i>	<b>Herb</b>	<b>Bartel</b>
<i>address2</i>		<i>title</i>		
<i>city/state/zip</i>	Marion KS 66861-1628	<i>unit or division</i>		
<i>office phone/fax</i>	(316) 382-2550 (316) 382-8823	<i>desk phone/fax</i>		
<i>url</i>		<i>email</i>		

# CONTACTS DATABASE REPORT

(alphabetically by organization name)

## ORGANIZATION INFORMATION

## PERSONNEL INFORMATION

<i>name</i>	<b>McPherson County Health Department</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Steve Johnson</b>
<i>address1</i>	1001 N Main		<i>title</i>	
<i>address2</i>			<i>unit or division</i>	
<i>city/state/zip</i>	McPherson KS 67460-2843		<i>desk phone/fax</i>	
<i>office phone/fax</i>	(316) 241-1775 (316) 241-1756		<i>email</i>	
<i>url</i>				

<i>name</i>	<b>Natural Resources Conservation Service</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Richard Schlepp</b>
<i>address1</i>	760 S Broadway		<i>title</i>	State Soil Scientist
<i>address2</i>			<i>unit or division</i>	
<i>city/state/zip</i>	Salina KS 67401		<i>desk phone/fax</i>	
<i>office phone/fax</i>			<i>email</i>	
<i>url</i>	www.nrcs.usda.gov			

<i>name</i>	<b>Northwest Kansas GMD No. 4</b>	<input checked="" type="checkbox"/>	<i>first/last</i>	<b>Wayne Bossert</b>
<i>address1</i>	P.O. Box 905		<i>title</i>	Manager
<i>address2</i>	1175 S Range		<i>unit or division</i>	
<i>city/state/zip</i>	Colby KS 67701-0905		<i>desk phone/fax</i>	
<i>office phone/fax</i>	(785) 462-3915 (785) 462-2693		<i>email</i>	wbossert@colby.ixks.com
<i>url</i>	colby.ixks.com/~wbossert			

<i>name</i>	<b>Northwest Local Environmental Protection Group</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Dale Brockhausen</b>
<i>address1</i>	350 S Range		<i>title</i>	
<i>address2</i>	Suite 4		<i>unit or division</i>	
<i>city/state/zip</i>	Colby KS 67701		<i>desk phone/fax</i>	
<i>office phone/fax</i>	(785) 462-8636 (785) 462-8637		<i>email</i>	brockhsn@colby.ixks.com
<i>url</i>				

<i>name</i>	<b>Northwest Local Environmental Protection Group</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Mike Balthazor</b>
<i>address1</i>	350 S Range		<i>title</i>	Sanitarian
<i>address2</i>	Suite 4		<i>unit or division</i>	
<i>city/state/zip</i>	Colby KS 67701		<i>desk phone/fax</i>	
<i>office phone/fax</i>	(785) 462-8636 (785) 462-8637		<i>email</i>	
<i>url</i>				

<i>name</i>	<b>Northwest Research Extension Center</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Fred Lamm</b>
<i>address1</i>	P.O. Box 830		<i>title</i>	
<i>address2</i>	RR 3		<i>unit or division</i>	
<i>city/state/zip</i>	Colby KS 78801-1697		<i>desk phone/fax</i>	
<i>office phone/fax</i>			<i>email</i>	
<i>url</i>				

# CONTACTS DATABASE REPORT

(alphabetically by organization name)

ORGANIZATION INFORMATION			PERSONNEL INFORMATION		
<i>name</i>	<b>Phillips County Health Department</b>			Coordinating Council Member <input type="checkbox"/>	
<i>address1</i>	784 6th Street		<i>first/last</i>	<b>Rob Rust</b>	
<i>address2</i>	Courthouse Annex		<i>title</i>		
<i>city/state/zip</i>	Phillipsburg	KS 67662	<i>unit or division</i>		
<i>office phone/fax</i>	(785) 543-6850	(785) 543-6852	<i>desk phone/fax</i>		
<i>url</i>			<i>email</i>	robert@phillipsburg.net	
<i>name</i>	<b>Reno County Local Environmental Protection Group</b>			Coordinating Council Member <input type="checkbox"/>	
<i>address1</i>	209 W 2nd Avenue		<i>first/last</i>	<b>Dan Partridge</b>	
<i>address2</i>			<i>title</i>		
<i>city/state/zip</i>	Hutchinson	KS 67501-5232	<i>unit or division</i>		
<i>office phone/fax</i>	(316) 694-2900		<i>desk phone/fax</i>		
<i>url</i>			<i>email</i>		
<i>name</i>	<b>Reno County Local Environmental Protection Group</b>			Coordinating Council Member <input type="checkbox"/>	
<i>address1</i>	209 W 2nd Avenue		<i>first/last</i>	<b>Peggy Holloway</b>	
<i>address2</i>			<i>title</i>		
<i>city/state/zip</i>	Hutchinson	KS 67501-5232	<i>unit or division</i>		
<i>office phone/fax</i>	(316) 694-2900		<i>desk phone/fax</i>		
<i>url</i>			<i>email</i>		
<i>name</i>	<b>Rice County Health Department</b>			Coordinating Council Member <input type="checkbox"/>	
<i>address1</i>	706 S Miles		<i>first/last</i>	<b>Levi Beaver</b>	
<i>address2</i>			<i>title</i>		
<i>city/state/zip</i>	Lyons	KS 67554-3010	<i>unit or division</i>		
<i>office phone/fax</i>	(316) 257-5331		<i>desk phone/fax</i>		
<i>url</i>			<i>email</i>		
<i>name</i>	<b>Sedgwick County Department of Community Health</b>			Coordinating Council Member <input type="checkbox"/>	
<i>address1</i>	1900 E 9th Street		<i>first/last</i>	<b>Karla Appling</b>	
<i>address2</i>			<i>title</i>		
<i>city/state/zip</i>	Wichita	KS 67214	<i>unit or division</i>		
<i>office phone/fax</i>	(316) 268-8440	(316) 268-8390	<i>desk phone/fax</i>		
<i>url</i>			<i>email</i>		
<i>name</i>	<b>Sedgwick County Department of Community Health</b>			Coordinating Council Member <input type="checkbox"/>	
<i>address1</i>	1900 E 9th Street		<i>first/last</i>	<b>George Huenergardt</b>	
<i>address2</i>			<i>title</i>		
<i>city/state/zip</i>	Wichita	KS 67214	<i>unit or division</i>		
<i>office phone/fax</i>	(316) 268-8440	(316) 268-8390	<i>desk phone/fax</i>		
<i>url</i>			<i>email</i>		

# CONTACTS DATABASE REPORT

(alphabetically by organization name)

## ORGANIZATION INFORMATION

## PERSONNEL INFORMATION

<i>name</i>	<b>Seward County Department of Planning and Zoning</b>	<input type="checkbox"/>	Coordinating Council Member
<i>address1</i>	10 W 15th Street	<i>first/last</i>	Lisa Olson
<i>address2</i>	P.O. Box 1194	<i>title</i>	
<i>city/state/zip</i>	Liberal KS 67905-1194	<i>unit or division</i>	
<i>office phone/fax</i>		<i>desk phone/fax</i>	
<i>url</i>		<i>email</i>	

<i>name</i>	<b>Seward County Local Environmental Protection Group</b>	<input type="checkbox"/>	Coordinating Council Member
<i>address1</i>	103 W 2nd Street	<i>first/last</i>	Lisa Taylor
<i>address2</i>		<i>title</i>	
<i>city/state/zip</i>	Liberal KS 67901-3719	<i>unit or division</i>	
<i>office phone/fax</i>	(316) 626-3266 (316) 626-3312	<i>desk phone/fax</i>	
<i>url</i>		<i>email</i>	

<i>name</i>	<b>South Central Coalition</b>	<input type="checkbox"/>	Coordinating Council Member
<i>address1</i>	P.O. Box 253	<i>first/last</i>	Cyndra Spriggs
<i>address2</i>		<i>title</i>	
<i>city/state/zip</i>	Kiowa KS 67070	<i>unit or division</i>	
<i>office phone/fax</i>		<i>desk phone/fax</i>	
<i>url</i>		<i>email</i>	

<i>name</i>	<b>Southwest Kansas GMD No. 3</b>	<input type="checkbox"/>	Coordinating Council Member
<i>address1</i>	409 Campus Drive	<i>first/last</i>	Diane Coe
<i>address2</i>	Suite 106	<i>title</i>	
<i>city/state/zip</i>	Garden City KS 67846-6158	<i>unit or division</i>	
<i>office phone/fax</i>	(316) 275-7147 (316) 275-1431	<i>desk phone/fax</i>	
<i>url</i>	www.ink.org/public/ksgm/main.html	<i>email</i>	dcoe@midusa.net

<i>name</i>	<b>Southwest Kansas GMD No. 3</b>	<input checked="" type="checkbox"/>	Coordinating Council Member
<i>address1</i>	409 Campus Drive	<i>first/last</i>	Steve Frost
<i>address2</i>	Suite 106	<i>title</i>	Manager
<i>city/state/zip</i>	Garden City KS 67846-6158	<i>unit or division</i>	
<i>office phone/fax</i>	(316) 275-7147 (316) 275-1431	<i>desk phone/fax</i>	
<i>url</i>	www.ink.org/public/ksgm/main.html	<i>email</i>	sfrost@midusa.net

<i>name</i>	<b>Southwest Local Environmental Protection Group</b>	<input type="checkbox"/>	Coordinating Council Member
<i>address1</i>	409 Campus Drive	<i>first/last</i>	Thad Robert
<i>address2</i>	Suite 101	<i>title</i>	
<i>city/state/zip</i>	Garden City KS 67846	<i>unit or division</i>	
<i>office phone/fax</i>		<i>desk phone/fax</i>	
<i>url</i>		<i>email</i>	

# CONTACTS DATABASE REPORT

(alphabetically by organization name)

## ORGANIZATION INFORMATION

## PERSONNEL INFORMATION

<i>name</i>	<b>Southwest Research Extension Center</b>	<i>first/last</i>	<b>Todd Trooien</b>	Coordinating Council Member <input type="checkbox"/>
<i>address1</i>	4500 E Mary	<i>title</i>		
<i>address2</i>	Kansas State University	<i>unit or division</i>		
<i>city/state/zip</i>	Garden City KS 67846-9132	<i>desk phone/fax</i>		
<i>office phone/fax</i>		<i>email</i>		
<i>url</i>				

<i>name</i>	<b>Stevens County Department of Planning and Zoning</b>	<i>first/last</i>	<b>Roger Lynch</b>	Coordinating Council Member <input type="checkbox"/>
<i>address1</i>	200 E 6th	<i>title</i>		
<i>address2</i>		<i>unit or division</i>		
<i>city/state/zip</i>	Hugoton KS 67951	<i>desk phone/fax</i>		
<i>office phone/fax</i>		<i>email</i>		
<i>url</i>				

<i>name</i>	<b>Sumner County Local Environmental Protection Group</b>	<i>first/last</i>	<b>Marvin Simonton</b>	Coordinating Council Member <input type="checkbox"/>
<i>address1</i>	217 W 8th Street	<i>title</i>		
<i>address2</i>		<i>unit or division</i>		
<i>city/state/zip</i>	Wellington KS 67152-3922	<i>desk phone/fax</i>		
<i>office phone/fax</i>	(316) 326-2207	<i>email</i>		
<i>url</i>				

<i>name</i>	<b>U.S. Army Corps of Engineers</b>	<i>first/last</i>	<b>Andy Obrochta</b>	Coordinating Council Member <input type="checkbox"/>
<i>address1</i>		<i>title</i>		
<i>address2</i>		<i>unit or division</i>		
<i>city/state/zip</i>		<i>desk phone/fax</i>	(918) 669-7175	
<i>office phone/fax</i>		<i>email</i>		
<i>url</i>				

<i>name</i>	<b>U.S. Bureau of Reclamation</b>	<i>first/last</i>	<b>Chuck Hunt</b>	Coordinating Council Member <input type="checkbox"/>
<i>address1</i>	300 E 8th Street	<i>title</i>	Program Coordinator	
<i>address2</i>	Room 801	<i>unit or division</i>	Oklahoma-Texas Projects Office	
<i>city/state/zip</i>	Austin TX 78701-3225	<i>desk phone/fax</i>	(512) 916-5646	
<i>office phone/fax</i>	(512) 916-5662	<i>email</i>		
<i>url</i>	www.usbr.gov			

<i>name</i>	<b>U.S. Bureau of Reclamation</b>	<i>first/last</i>	<b>Mike DeFoe</b>	Coordinating Council Member <input type="checkbox"/>
<i>address1</i>	P.O. Box 1607	<i>title</i>		
<i>address2</i>		<i>unit or division</i>		
<i>city/state/zip</i>	Grand Island NE 68802	<i>desk phone/fax</i>	(308) 389-4622	
<i>office phone/fax</i>		<i>email</i>		
<i>url</i>	www.usbr.gov			

# CONTACTS DATABASE REPORT

(alphabetically by organization name)

## ORGANIZATION INFORMATION

## PERSONNEL INFORMATION

<i>name</i>	<b>U.S. Fish and Wildlife Service</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Megan Estep-Johnston</b>
<i>address1</i>	134 Union Boulevard		<i>title</i>	
<i>address2</i>			<i>unit or division</i>	Mountain-Prairie Region
<i>city/state/zip</i>	Lakewood CO 80228-1807		<i>desk phone/fax</i>	
<i>office phone/fax</i>	(303) 236-5322 (303) 236-4224		<i>email</i>	
<i>url</i>				

<i>name</i>	<b>U.S. Fish and Wildlife Service</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Dave Hilley</b>
<i>address1</i>	P.O. Box 48A		<i>title</i>	
<i>address2</i>	RR 3		<i>unit or division</i>	Quivira National Wildlife Refuge
<i>city/state/zip</i>	Stafford KS 67578		<i>desk phone/fax</i>	(316) 486-2393
<i>office phone/fax</i>			<i>email</i>	
<i>url</i>				

<i>name</i>	<b>University of Kansas</b>	<input type="checkbox"/>	<i>first/last</i>	<b>William Johnson</b>
<i>address1</i>	213 Lindley Hall		<i>title</i>	
<i>address2</i>	University of Kansas		<i>unit or division</i>	Department of Geography
<i>city/state/zip</i>	Lawrence KS 66045		<i>desk phone/fax</i>	(785) 864-5548
<i>office phone/fax</i>			<i>email</i>	wcj@ukans.edu
<i>url</i>	www.ukans.edu			

<i>name</i>	<b>unknown</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Barry Brook</b>
<i>address1</i>			<i>title</i>	
<i>address2</i>			<i>unit or division</i>	
<i>city/state/zip</i>			<i>desk phone/fax</i>	
<i>office phone/fax</i>	(785) 296-6506		<i>email</i>	
<i>url</i>				

<i>name</i>	<b>Water Resources Research Institute</b>	<input type="checkbox"/>	<i>first/last</i>	<b>Ernie Angino</b>
<i>address1</i>	1039 Learned		<i>title</i>	
<i>address2</i>	University of Kansas		<i>unit or division</i>	
<i>city/state/zip</i>	Lawrence KS 66045		<i>desk phone/fax</i>	(785) 864-3807
<i>office phone/fax</i>			<i>email</i>	
<i>url</i>				

<i>name</i>	<b>Western Kansas GMD No. 1</b>	<input checked="" type="checkbox"/>	<i>first/last</i>	<b>Keith Lebbin</b>
<i>address1</i>	P.O. Box 604		<i>title</i>	Manager
<i>address2</i>	W Highway 96		<i>unit or division</i>	
<i>city/state/zip</i>	Scott City KS 67871-0604		<i>desk phone/fax</i>	
<i>office phone/fax</i>	(316) 872-5563 (316) 872-7315		<i>email</i>	
<i>url</i>				

## Appendix D: Program data base

*Note: The attached pages are samples of the actual database report, which is more than 100 pp long in the present format. A full copy was previously supplied to KWO (attachment to KGS letter report dated, the material is available in either paper copy or electronic form, and KGS will develop database queries and reports on specific information requests.*

Program information was the most involved and time-consuming to assemble, with approximately 3+ person-months invested to this point. Information was acquired from agency web-sites to the extent that they existed, and was subsequently followed up by e-mail, phone calls, or personal visits, plus use of any published information available from the agency. In the case of organizations without websites (e.g., GMDs other than 4), personal contacts and published information was relied upon. The original sources from which the program information was acquired (see below) had been organized and formatted in a variety of ways. Since some of the information was transferred from word processing tables to spreadsheets and then to Access, there is not complete consistency in the table entries. The fields in the tables were selected as a reasonable basis for sorting and describing the information, but with the recognition that review and experience may dictate some modifications.

In the program inventory, coverage is somewhat variable. At the local level, information is considered reasonably complete for GMDs 2-5, but little or no information has been obtained for GMD1. No serious effort has been made to identify programs at the city or county level except for LEPC, or for districts other than GMDs. State agencies have all been checked, and coverage is considered good for the period 1994-1996. Prior to that, electronic listings are generally not available, and post-1996 updates have been spotty (some information acquired from KWO has been included). State agencies for which coverage is less than adequate are DWR and KSU. Some federal agencies have been checked, including USDA, EPA, Corps of Engineers and USBR, but we are not confident that we have found all of the relevant information for these agencies, and there are others (including USGS) that we have not yet considered. In general, the information assembled gives a reasonable picture of the nature, number, and diversity of the programs, but is far from complete, in spite of the large amounts of time spent and of information assembled (215 database records, compared to 77 contact records, 21 water quality metadata records, and 3 water quantity metadata records). This has resulted in the prioritization decisions mentioned in report section IA3.

### *Comments and observations on programs and the program database:*

1. The number, diversity, and potential overlap of local, state, and federal programs relevant to High Plains water is surprising even to professionals reasonably experienced in working on Kansas groundwater issues.
2. There is no existing listing or description of these programs that crosses the boundaries of agency mission and funding source.
3. The partial lists that do exist vary widely in format, content, and extent of both coverage and information accessibility.
4. From the standpoints of both coordination and assessment of program impacts, such a database seems desirable, and perhaps essential.

5. In view of the substantial effort required to complete and expand such a database, potential uses should be carefully considered, and needs and products prioritized.
6. Responsibility for completion and maintenance (if desired) of the database should be considered. KGS is probably an appropriate entity to structure the database and certainly to link it to the other, project-relevant databases. Whether KGS is most appropriate for further development and/or upkeep is a matter for consideration.

*Comments on database structure an applications:*

Collaboration -- The program data table contains entries that are specifically identified as "cooperative agreements" (usually in the "program objectives" field); however, a much larger number of programs have multiple agencies identified in the "organizations" and/or the "funding" fields. The database can be queried for multiple-agency participation.

Geographic location -- The program data table has location entries for county, basin, GMD, and other, all of which are searchable. Eventually these data and searches will probably be handled in a GIS database; for the time being, input on the probable applications and search needs of the users will be solicited (see below) in order to determine what refinements to the field and query structures might be needed. A major issue is that all of the categories are partially but not perfectly overlapping (e.g., GMDs contain parts of basins and parts of counties, and vice versa), so the design of data included and search criteria both need to be tailored to expected applications.

**PROGRAM** Local environmental protection program

ORGANIZATIONS	FUNDING SOURCES	LOCATIONS
KDHE	KS General fund	Other SC KS LEPG
SCC	Water Plan	County
KWO		Basin
		GMD
	Begin 1996	
	End	

LOCAL, STATE, or FEDERAL state

**PROGRAM OBJECTIVES**  
 Provides grants to local entities to develop and implement sanitary codes, conduct public education, support data mgmt., solid waste planning, wellhead protection, and non-point source pollution mgmt.

**PROGRAM** Local environmental protection program

ORGANIZATIONS	FUNDING SOURCES	LOCATIONS
KDHE	KS General fund	Other SW KS LEPG
SCC	Water Plan	County
KWO		Basin
		GMD
	Begin 1996	
	End	

LOCAL, STATE, or FEDERAL state

**PROGRAM OBJECTIVES**  
 Provides grants to local entities to develop and implement sanitary codes, conduct public education, support data mgmt., solid waste planning, wellhead protection, and non-point source pollution mgmt.

<b>PROGRAM</b> Agricultural Extension program			
<b>ORGANIZATIONS</b>	<b>FUNDING SOURCES</b>	<b>LOCATIONS</b>	
KSU		Other Southwest Kansas	
		County	
		Basin	
		GMD	
	Begin		
	End		
		LOCAL, STATE, or FEDERAL	local
<b>PROGRAM OBJECTIVES</b>			
Education; efficiency of water use, drought tolerant crops			

<b>PROGRAM</b> Oil and gas protection program			
<b>ORGANIZATIONS</b>	<b>FUNDING SOURCES</b>	<b>LOCATIONS</b>	
KCC	Water Plan	Other Southwest Kansas	
		County	
		Basin	
		GMD	
	Begin		
	End		
		LOCAL, STATE, or FEDERAL	local
<b>PROGRAM OBJECTIVES</b>			
Prevent contamination by brines			

**PROGRAM** Experiment station programs

ORGANIZATIONS	FUNDING SOURCES	LOCATIONS
KSU	Water Plan	Other ?
	KS General fund	County
		Basin
		GMD
	Begin ?	
	End ?	

LOCAL, STATE, or FEDERAL local

**PROGRAM OBJECTIVES**

Conservation / irrigation

**PROGRAM** Water Supply Program

ORGANIZATIONS	FUNDING SOURCES	LOCATIONS
SWKS LEPP	Water Plan	Other
	KDHE	County
		Basin
		GMD GMD3
	Begin 1991	
	End present	

LOCAL, STATE, or FEDERAL local

**PROGRAM OBJECTIVES**

Objectives are to: (1) Sample private water wells to screen for water quality problems in drinking water. (2) Analyze the collected samples for bacteria, nitrate and selected other constituents, such as lead. (3) Conduct on-site evaluations of well construction and location with respect to potential sources of contamination. (4) Make suggestions to well owners about ways to improve water quality based on the on-site evaluations.

<b>PROGRAM</b> Public information/education		
<b>ORGANIZATIONS</b>	<b>FUNDING SOURCES</b>	<b>LOCATIONS</b>
GMD3	KWO	Other
	KS Geographic Alliance	County
		Basin
		GMD GMD3
	Begin 1995	
	End 1996	LOCAL, STATE, or FEDERAL local
<b>PROGRAM OBJECTIVES</b>		
<p>Title: "Conservation Education and Technical Assistance To Water Users In Southwest Kansas Groundwater Management District No. 3." Implement public outreach and educational programs for water users, the general public, and students K-12. Provide technical assistance to water users. Notify irrigators about availability of free technical assistance for well flow rate testing and water meter installation evaluation. Provide assistance with irrigation system design and operation evaluations to effect water conservation and optimum economic production. Implement a pilot "Conservation Mgmt. Service" program for additional technical assistance to irrigators. Initiate an accounting system for pilot "Flex Appropriation Mgmt." program to assist irrigators and DWR in monitoring water appropriation use and compliance in Arkansas River Intensive Groundwater Use Control Area of the District. Hire an education specialist.</p>		

<b>PROGRAM</b> Public information/education		
<b>ORGANIZATIONS</b>	<b>FUNDING SOURCES</b>	<b>LOCATIONS</b>
GMD3	KWO	Other
	KS Geographic Alliance	County
		Basin
		GMD GMD3
	Begin 1997	
	End 1998	LOCAL, STATE, or FEDERAL local
<b>PROGRAM OBJECTIVES</b>		
<p>KWO contract 98-129 ??</p>		

**PROGRAM** GMD2 Management Program

ORGANIZATIONS	FUNDING SOURCES	LOCATIONS
GMD2	GMD2	Other
		County
		Basin
		GMD
	Begin 1975	GMD2
	End present	
		LOCAL, STATE, or FEDERAL
		local

**PROGRAM OBJECTIVES**

Aquifer safe yield principle, groundwater quality principle, balance groundwater withdrawals with annual recharge, remediate groundwater contamination, public education, monitor groundwater quality and quantity, study aquifer characteristics, investigate alternative sources of water, encourage reclamation or recycling of waste water, investigate ways to improve recharge and prevent its deterioration, support legislative changes which enhance good groundwater mgmt. practices, cooperate with appropriate local, state and federal agencies and organizations.

**PROGRAM** McPherson Intensive Groundwater Use Control Area

ORGANIZATIONS	FUNDING SOURCES	LOCATIONS
DWR	DWR	Other
GMD2		County
		Basin
		GMD
	Begin 1980	Extreme northern portion GMD2
	End present	
		LOCAL, STATE, or FEDERAL
		local

**PROGRAM OBJECTIVES**

Reduce Water level declines, close area to further groundwater development, require installation of meters, establish system for monitoring water levels, rainfall and groundwater withdrawals, encourage use of alternative sources of water supplies.