Kansas Water Resources Research Institute
Annual Technical Report
FY 2004

Introduction

The Kansas Water Resources Institute is part of a national network of water resource institutes in every state and territory of the U.S. established by law in the Water Resources Research Act of 1964. The network is funded by a combination of federal funds through the U.S. Department of the Interior/Geological Survey (USGS) and non-federal funds from state and other sources. KWRI is administered by the Kansas Center for Agricutlural Resources and the Environment (KCARE) at Kansas State University. An Administrative Council composed of representatives from participating higher education or research institutions, state agencies, and federal agencies assists in policy making.

The Mission of KWRI is to: - Develop and support research on high priority water resource problems and objectives, as identified through the state water planning process; - Facilitate effective communications among water resrouce professionals; - Foster the dissemination and application of research results.

We work towards this mission by: - Providing and facilitating a communications network among professionals working on water resources research and education, through electronic means, newsletters, and conferences; - Supporting research and dissemination of results on high priority topics, as identified by the Kansas State Water Plan, through a competitive grants program.

Research Program

Our mission is partially accomplished through our competitive research program. We encourage the following through the research that we support: interdisciplinary approaches; interagency collaboration; scinetific innovation; support of students and new young scientists; cost-effectiveness; relevance to present and future water resource issues/problems as identified in the State Water Plan; dissemination and interpretation of results to appropriate audiences.

In implementing our research program, KWRI desires to: - Be proactive rather than reactive in addressing water resource problems of the state; - Involve the many water resources stakeholders in identifying research needs and utilize their input to priortize the water resources research needs of the state; - Foster collaboration among state agencies, federal agencies, and institutions of higher education in the state on water resource issues; - Leverage additional financial support from state, private, and other federal sources; - Be recognized in Kansas as a major institution to go to for water resources research.

Reduced Irrigation Allocations in Kansas from Grain Yield -- ET Relationships and Decision Support Model

Basic Information

Title:	Reduced Irrigation Allocations in Kansas from Grain Yield -- ET Relationships and Decision Support Model
Project Number:	2003KS31B
Start Date:	3/1/2003
End Date:	2/28/2004
Funding Source:	104B
Congressional District:	2nd District
Research Category:	Not Applicable
Focus Category:	Irrigation, Water Use, None
Descriptors:	
Principal Investigators:	Norman Klocke, Gary Clark, Troy Dumler, Loyd Stone

Publication

1. Klocke, N.L., G. A. Clark, S. Briggeman, L.R. Stone, and T.J. Dumler. 2004. Crop water allocator for limited irrigation. In Proc. High Plains Groundwater Conference. Lubbock, TX. Dec. 7-9, 2004. 196-206.
2. Klocke, N. L., Schneekloth, J. P., Melvin, S. R., Clark, R. T., and Payero, J. O. 2004. Field scale comparison of limited irrigation strategies. American Society of Agricultural Engineers Paper No. 042280. Aug. 2004.13 pp.
3. Klocke, N.L., Clark, G. A., Briggeman, S., Dumler, T.J., and Stone, L.R. 2004. Crop water allocation program. [abstract] 21st Annual Water and the Future of Kansas Conference. Kansas Water Resources Research Institute. p.19.
4. Melvin, S. R., Payero, J. O., Klocke, N. L. ,and Schneekloth, J. P., 2004. Irrigation management strategies for corn to conserve water. In: Proceedings Central Plains Irrigation Short Course & Exposition Proceedings. Feb. 17-18, 2004. Kearney, NE. pp 37-44.

"Reduced Irrigation Allocations in Kansas from Grain Yield--ET Relationships and Decision Support Model"

Principal Investigators

Dr. Norman L. Klocke, Irrigation Engineer, SW Research Extension Center
Dr. Loyd R. Stone, Soil Physicist, Dept. of Agronomy
Troy J. Dumler, Agricultural Economist, SW Research Extension Center
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Descriptors
Limited irrigation; Decision support; cropping system; Evapotranspiration; Irrigation allocation

Problem and Objectives

Many irrigators in Kansas are facing immediate challenges with declining water yields from their wells. Estimates have been made that 30-50 of irrigation wells in western Kansas are pumping below original capacity. Irrigators in Kansas also face the possibility of shrinking water allocations with changes in water policy or simply enforcement of current water policy. Any of these scenarios will mean more limited irrigation than has been used in the past.

To make these reductions in water use, irrigators will need to consider shifts in cropping patterns. Irrigators who have shrinking water supplies need to know what cropping combinations to select and in what proportions for best water use and profitability. Not every combination of every cropping pattern that an irrigator dreams up can be examined experimentally with research. An agronomic/economic model is needed to predict results for an individual irrigator's situation.

This project is designed to deliver a tool to irrigators for making decisions about allocating scarce water on their land and among their crops. An irrigator's questions might be:

> "I have a limited amount of water, should I put it all on one crop or on two or three crops, how much acreage in each crop, and how much water on each crop?"
>
> "I have a limited amount of water, should I use deficit irrigation on all of my cropped land or should I try to meet the full irrigation needs of my crops on less land?"

The answers to these questions are not straightforward and have many economic and policy-based implications. In order to help agricultural irrigators with these questions and to improve on their beneficial use of our limited water resources, the objectives are:

1. Develop a computerized tool for irrigators to assist in their decisions regarding the best use of limited water supplies or reduced water allocations.
2. Update irrigation and grain yield relationships for corn, wheat, soybean, grain sorghum, and sunflower crops using current varieties and no-till management to support the continued implementation of the decision tool.

Description of Methods

Objective 1:

A computerized model, the crop water allocator (CWA), has been developed to assist in planning cropping patterns and targeting irrigation to those crops. It is an agronomic/economic model that will predict the net returns of possible cropping options. The model uses crop yield and irrigation relationships that were generated from the Kansas Water Budget, a water balance simulation model for western Kansas. The Kansas Water Budget results were based on yield-evapotranspiration relationships for each crop and annual rainfall from 280 to 530 mm across western Kansas as inputs (see Figure 1 for corn results). Crop production costs can be completely controlled by the user with inputs to CWA or the user can rely on default values from Kansas State surveys of typical farming operations in western Kansas.

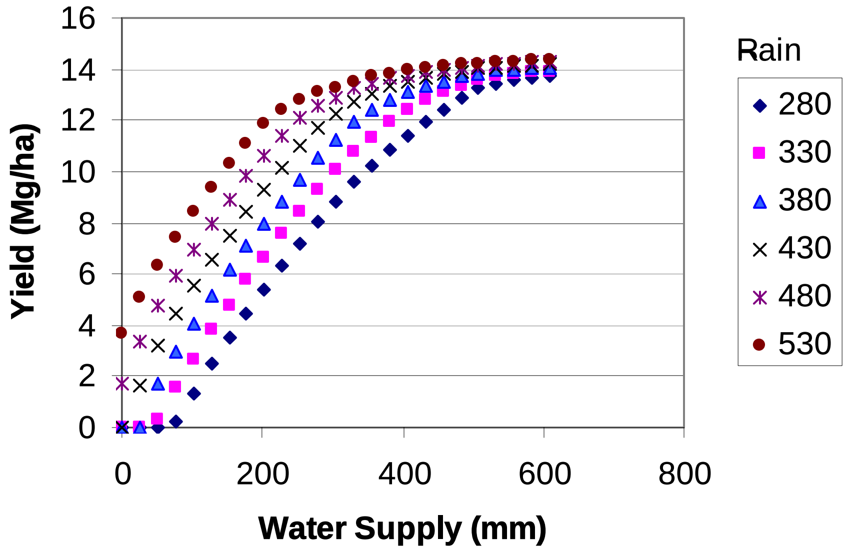


Fig.1. Corn yield in response to irrigation for annual precipitation zones in western Kansas.

The user first selects possible proportions of crops in the land considered in percentages of splits such as: 50-50, 75-25, 33-33-33, 50-25-25, and 25-25-25-25. The crop species, maximum crop yields, irrigation water costs, crop production costs, and maximum water applied for the season are then entered. The program then iterates, by 10% increments of the irrigation amounts, all possible net income solutions over all crop combinations. Multiple runs of the model give the user indications of the sensitivities of net returns to commodity prices, production cost inputs, crop selections, and land allocations.

Objective 2:

The experimental field (8.1 ha) was subdivided into six cropped strips that were irrigated by a 4-span linear move sprinkler irrigation system. Since the cropping strips were not replicated, they were treated as individual experiments statistically. The cropping sequence among the croppin strips was corn-corn-soybean-winter wheat-grain sorghum-sunflower. The soil was a silt loam with a slope of less than 1%. However, soil pH of 8.3 created a challenge for soybean production.

Irrigation amounts were varied within each cropping strip. The six irrigation treatments, replicated four times, ranged from 76 to 458 mm in depth, if needed. Pre-designated amounts of water were applied during vegetative, flowering, and grain fill growth stages. If rainfall was sufficient to fill the soil profile to field capacity, irrigation was not applied. Unused irrigation allocation was rolled over to the next growth stage. If there was unused allocation at the end of the year, it was not carried over to the next year.

Soil water was measured once every two weeks with the neutron attenuation method in increments of 30 cm to a depth of 2.4 m. There was one sampling site per plot. These measurements along with irrigation and rainfall were used to calculate evapotranspiration for each two week period during the season. Irrigation application was calibrated from catch cans, the percent timer, and a totalizing flow meter.

Work Accomplished

Objective 1:
Crop Water Allocator (CWA) was released on the World Wide Web during December 2004 at www.oznet.ksu.edu/mil. It is available to users to download to their individual computers. Training sessions through the KSU Mobile Irrigation Lab will bring more feedback and initial reactions from users. The program was also introduced to Kansas independent crop consultants who may be another avenue for presenting water planning ideas to their clientele. It is too early to determine the usage of this decision tool. Reaction to its introduction at workshops has been very favorable. Individual farmers as users of the program can influence outcomes by their own preferences and strengths. The program is sensitive to commodity prices and maximum yields which will swing results based on user inputs.

Several model simulations were executed to examine the effects of various input factors on net return while annual water allocations were varied from 102 to 610 mm (4 to 24 in). The input factors considered were irrigation costs (85% increase from 2004 costs), commodity prices, and maximum crop yield. Multiple executions of the model with incremental input of one variable can lead to trend analysis (Fig. 2). An example simulation demonstrated that high water allocations led to monoculture corn cropping systems while low water allocations promoted crop rotations. High commodity prices for soybean and lower maximum yields for corn shifted crop choices to soybean and in favor of sunflower in the case of better yield potential for sunflower. All scenarios of over irrigation led to diminishing net returns at the same irrigation amount (410 mm) where the yield-irrigation relation reached a maximum. This is just an example of a multitude of customized scenarios possible.

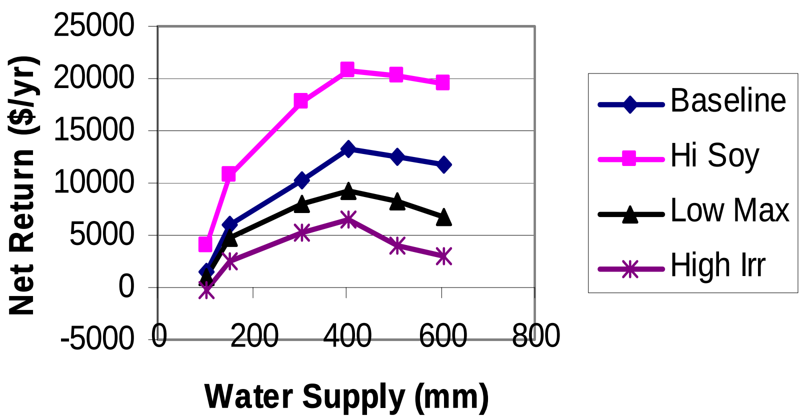


Figure 2. Net return in response to water allocation for irrigation when input variables of high soybean price (Hi Soy), low maximum corn yield (Low Max), high irrigation costs (High Irr).

<u>Objective 2</u>:
Cropping year 2004 had above normal rainfall during May through September (442 mm vs. 314

mm normal). Stone et al., 1995, developed a hydrologic simulation model, the Kansas Water Budget, which was used to generate yield-irrigation relationships for conventional crops in Figure 2. A family of curves was generated (Fig .1) for a range of annual rainfall from 280 to 530 mm. These relationships for corn, grain sorghum, and sunflower were based on yield-ET relationships derived from 1980 to 1990 research data for conventionally grown crops. The simulation results shown in Fig. 3 are based on 530 mm of annual rainfall. The 2004 data points for no-till management are generally above and to the left of the simulated relationships from conventional management. The possible influence of crop residue management and improvements in other management techniques may explain these improved yield-irrigation relationships. More years of data are needed to confirm these early results.

These results are promising. More years of data are needed to confirm the effects of crop residue management. Dry matter harvest results will help understand the trade-offs between using forage for livestock feed or water conservation.

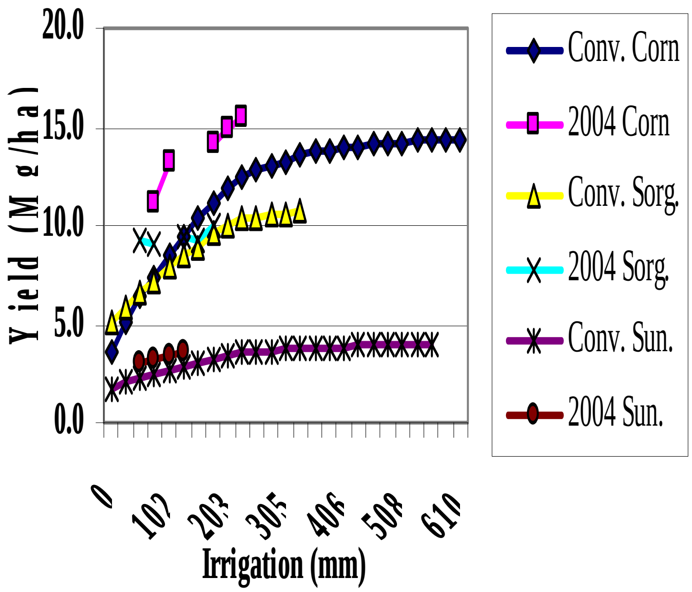


Figure 3. Crop yield responses to 530 mm of annual rainfall with conventional management in western Kansas compared to 2004 no-till management with similar rainfall at the Kansas State University SWREC.

References

Stone, L.R., O.H. Buller, A.J. Schlegel, M.C. Knapp, J.-I. Perng, A.H. Khan, H.L. Manges, and D.H. Rogers. 1995. Description and use of KS Water Budget v. T1 software. Resource Manual, Dep. of Agron., Kansas State Univ., Manhattan, KS.

Publications and presentations:

High Plains Groundwater Resources Conference
Kansas State University—SWREC Field Day
2004 & 2005 Central Plains Irrigation Conference
Kansas State University—SWREC Research Advisory Council Meeting
Groundwater Management District Meeting
Soil Conservation District Board Meeting
Producer meeting at Healy, Kansas
Kansas Water Resources Advisory Meeting
2004 & 2005 Irrigation Technology Seminar, Dodge City
2004 KSU SWREC Research Reviews
Kansas Water Authority Meeting

Klocke, N.L., G. A. Clark, S. Briggeman, L.R. Stone, and T.J. Dumler. 2004. Crop water allocator for limited irrigation. In Proc. High Plains Groundwater Conference. Lubbock, TX. Dec. 7-9, 2004. 196-206.

Klocke, N. L., Schneekloth, J. P., Melvin, S. R., Clark, R. T., and Payero, J. O. 2004. Field scale comparison of limited irrigation strategies. American Society of Agricultural Engineers Paper No. 042280. Aug. 2004.13 pp.

Klocke, N.L., Clark, G. A., Briggeman, S., Dumler, T.J., and Stone, L.R. 2004. Crop water allocation program. [abstract] 21st Annual Water and the Future of Kansas Conference. Kansas Water Resources Research Institute. p.19.

Melvin, S. R., Payero, J. O., Klocke, N. L. ,and Schneekloth, J. P., 2004. Irrigation management strategies for corn to conserve water. In: Proceedings Central Plains Irrigation Short Course & Exposition Proceedings. Feb. 17-18, 2004. Kearney, NE. pp 37-44.

Information transfer

KBUF radio presentations for live 1 hour interviews on three occasions

KSU news release used by High Plains Journal, Kansas Farmer

Klocke, N.L., Clark, G. A., Stone, L.R., Dumler, T.J., and Briggeman, S. 2004. Crop Water Allocator (CWA). [World Wide Web]. Version 1.5. www.oznet.ksu.edu/mil. Kansas State University, AES.

Students Supported

Three college students and two college prep students were supported with part-time employment through this grant. They were exposed to various facets of water resources research from daily planning and coordination of research activities, execution of research protocols, to data processing and data quality control.

A Field Assessment of a Method for Estimation of Ground-Water Consumption By Phreatophytes

Basic Information

Title:	A Field Assessment of a Method for Estimation of Ground-Water Consumption By Phreatophytes
Project Number:	2003KS33B
Start Date:	3/1/2003
End Date:	2/28/2004
Funding Source:	104B
Congressional District:	2nd District
Research Category:	Climate and Hydrologic Processes
Focus Category:	Groundwater, Water Use, None
Descriptors:	
Principal Investigators:	James J. Butler, Gerard J. Kluitenberg

Publication

1. Butler, J.J., Jr., Kluitenberg, G.J., and D.O. Whittemore, A field method for estimation of ground-water consumption by phreatophytes year one (abstract), Proc. 21st Annual Water and the Future of Kansas Conf., p. 27, 2004.
2. Butler, J.J., Jr., Groundwater flow in interconnected stream-aquifer systems: From models to the field, an invited presentation to the Department of Geological and Atmospheric Sciences, Iowa State University, March 12, 2004.
3. Butler, J.J., Jr., Loheide, S.P., II, Kluitenberg, G.J., Bayless, K., Whittemore, D.O., Zhan, X., and C.E. Martin, Groundwater consumption by phreatophytes in a mid-continent stream-aquifer system (abstract), Eos, v. 85, no. 17, Jt. Assem. Suppl., p. JA237, 2004.
4. Loheide, S,P., II, Butler, J.J., Jr., and S.M. Gorelick, A modeling evaluation of a method for estimating groundwater usage by phreatophytes (abstract), GSA 2004 Annual Meeting Abstracts with Program, v. 36, no. 5, p. 390, 2004.
5. Whittemore, D.O., Butler, J.J., Jr., Healey, J.M., McKay, S.E., Aufman, M.S., and R. Brauchler, Seasonal and long-term groundwater quality changes in alluvial aquifer systems (abstract), GSA 2004 Annual Meeting Abstracts with Program, v. 26, no. 5, p. 451, 2004.
6. McKay, S.E., Kluitenberg, G.J., Butler, J.J., Jr., Zhan X., Aufman, M.S., and R. Brauchler, In-situ determination of specific yield using soil moisture and water level changes in the riparian zone of the

Arkansas River, Kansas, Eos, v. 85, no. 47, Fall Meet. Suppl., Abstract H31D-0425, 2004.
7. Loheide, S.P., III, Butler, J.J., Jr., and S.M. Gorelick, Estimation of groundwater consumption by phreatophytes using diurnal water table fluctuations: A saturated-unsaturated flow assessment, Water Resour. Res., in press, 2005.

KWRI PROGRESS REPORT – YEAR TWO

Project Title: A Field Assessment of a Method for Estimation of Groundwater Consumption by Phreatophytes – Year Two
Start Date: March 1, 2004
End Date: February 28, 2005
Investigators and Affiliations: James J. Butler, Jr., Kansas Geological Survey (PI), Gerard J. Kluitenberg, Kansas State University (Co-PI), Donald O. Whittemore, Kansas Geological Survey (Co-PI), Charles J. Barden, Kansas State University (Additional Cooperator), and Craig E. Martin, University of Kansas (Additional Cooperator).
Research Category: Statewide Competitive Grant
Descriptors: phreatophytes, ground water, evapotranspiration, water balance

PROBLEM AND RESEARCH OBJECTIVES

Low streamflows are an increasing problem in Kansas and other areas of the U.S. As a result, smaller amounts of water are available for diversions to water supplies and wetlands, for inflows to reservoirs, for capture by wells in nearby aquifers, for sustaining aquatic wildlife, and for recreation. Stream-aquifer interactions play an important role in the generation and maintenance of low streamflows. Ground-water development in regional aquifers that discharge water to stream corridors and in alluvial aquifers immediately adjacent to streams is often a major factor responsible for low-flow periods. Consumption of ground water by phreatophytes in riparian zones could also be an important factor contributing to periods of reduced streamflow. Reliable estimates of the magnitude of this consumption, however, have not yet been obtained.

In this project, we are developing a method for estimation of the amount of ground water consumed by phreatophytes. This method is being evaluated at a field site of the Kansas Geological Survey at which a great deal of previous work has been performed. The previous work, in conjunction with the additional work to be done as part of this project, enables the methodology development and assessment to be carried out under highly controlled conditions. The end product of this research will be a technique of demonstrated effectiveness for both identifying and quantifying phreatophyte activity. Although the technique will be developed at a site with a mix of phreatophytes common in central Kansas, the approach will be equally viable in areas with different mixes of phreatophytes. The major objectives for this research project are to 1) develop a method for quantifying the consumption of ground water by phreatophytes in hydrologic conditions common to central and western Kansas, 2) evaluate this method at a well-controlled field site, and 3) quantify ground-water consumption by phreatophytes along a portion of the middle reach of the Arkansas River in Kansas. An auxiliary objective of this work is to gather a detailed data set on the major fluxes in stream-aquifer systems that can serve as the basis for research proposals on the quantitative assessment of stream-aquifer interactions in settings common to the Great Plains.

The six specific activities proposed for year two were as follows:

1. Further characterize the Larned Control Volume,

2. Continue monitoring of water and salinity fluxes and phreatophyte activity,
3. Determine phreatophyte water sources by isotopic measurements,
4. Relate water-table fluctuations to phreatophyte activity,
5. Inventory the riparian woodlands of the Arkansas River from Kinsley to Great Bend,
6. Estimate phreatophyte activity along the Arkansas River from Kinsley to Great Bend.

METHODOLOGY

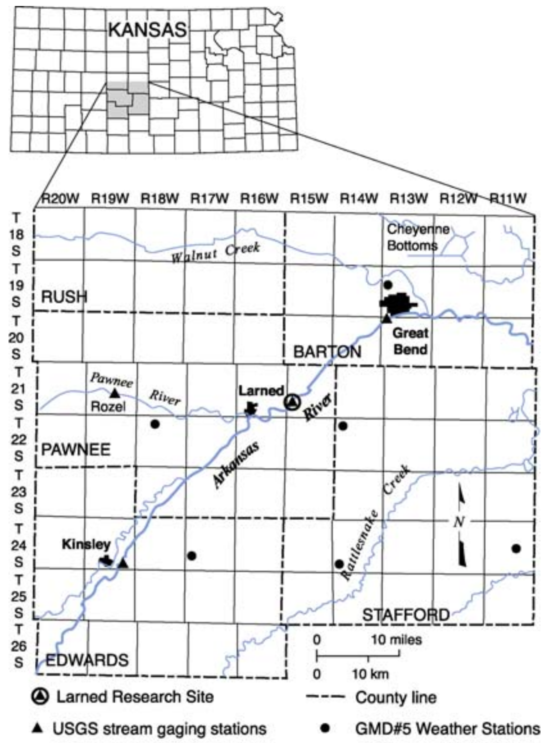


Figure 1

The ultimate objective of this project is to develop a practical approach for quantifying phreatophyte consumption of ground water. This is being done at the Larned Research Site, a field area of the Kansas Geological Survey that is located adjacent to the USGS stream-gaging station on the Arkansas River near Larned in central Kansas (Larned Research Site – Figure 1). Since the late spring of 2001, KGS personnel have done extensive work on stream-aquifer interactions at the Larned site. This previous work enables the tasks of this project to be performed in a controlled field setting.

The methods development that is the focus of this work is being done using the control volume concept. A control volume is essentially a very large lysimeter. Water and salinity fluxes into/out of this volume are determined so that the relationship between phreatophyte activity and water-level fluctuations can be assessed (Figure 2). In the first phase of this project, the Larned Control Volume (LCV) was established in the riparian zone just west of the Arkansas River channel. Wells and vadose-zone monitoring equipment were installed within and adjacent to the LCV in May 2003. Two additional wells were added on the west side of the LCV in June of 2004. Direct-push electrical conductivity logging was used for detailed lithologic characterization prior to well installation.

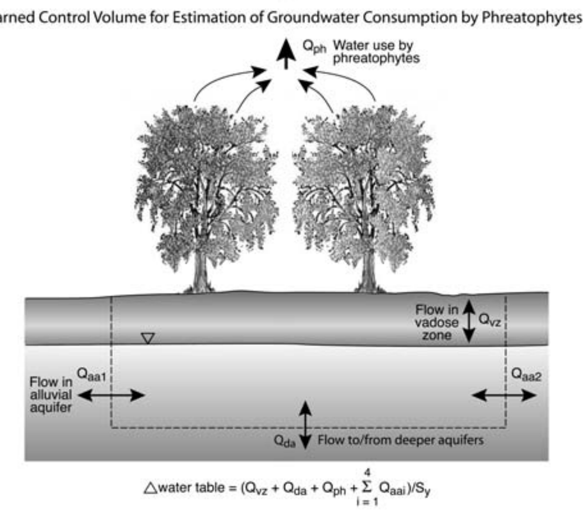


Figure 2

All wells in the LCV are equipped with integrated pressure transducer/datalogger units (In-Situ MiniTroll) that are programmed to take pressure-head readings every 15 minutes. Since the wells in the LCV could be overtopped during periods of high flow, absolute pressure transducers are used instead of the gauge-pressure sensors utilized in most hydrogeologic studies. The absolute-pressure sensors measure the pressure exerted both by the height of the overlying column of water in the well and by the atmosphere. The atmospheric pressure component is removed using data from a barometer at the site. Figure 3 displays records from an absolute-pressure sensor in the riparian zone prior to and after the barometric pressure correction. Manual measurements of water levels in the monitoring wells are taken biweekly during the summer and bimonthly otherwise in order to assess the performance of the pressure sensors and, if necessary, to adjust the calibration parameters.

Additional neutron-probe access tubes were installed adjacent to four of the wells in the LCV in June 2004. The depth of the original access tubes installed in 2003 was 1.83 m. The water table dropped more than anticipated in 2003 so the bottom of those access tubes was a considerable distance above the water table for a portion of the monitoring period. A deeper set of access tubes (3.05 m) was therefore installed in June 2004 to allow monitoring of moisture content over a larger depth range. Measurements in the access tubes were recorded every one to two weeks during the summer with a neutron probe (Model 503 DR Hydroprobe Moisture Depth Gauge; Campbell Pacific Nuclear) using a count duration of 16 s and depth increments of 0.152 m. Standard counts were recorded in the field both prior to and after access tube measurements. The mean standard count for the duration of the study was used to convert each measured count to a count ratio (CR). The soil volumetric water content (m^3 m^{-3}), θ, corresponding to each measured count ratio was calculated with the calibration equation $\theta = 0.2929 \times CR - 0.0117$, which was based on laboratory calibrations and an adjustment for PVC pipe.

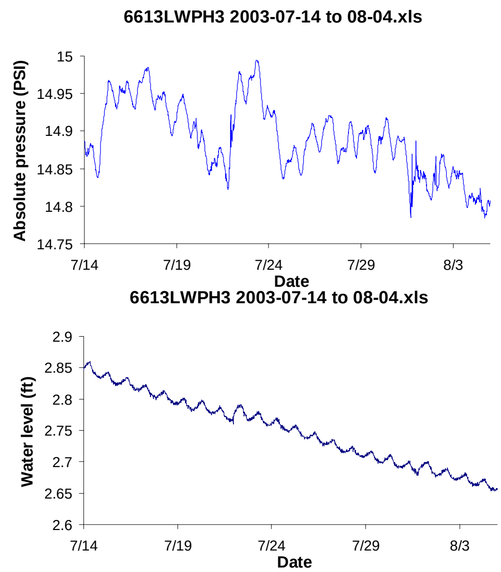


Figure 3

Ground-water samples were collected from all of the shallow wells in the LCV during the spring and early summer, and from a flow event of the Arkansas River, and analyzed for specific conductance and major and minor constituents. Vertical profiles of specific conductance and temperature were measured several times during the summer and monthly to quarterly for the rest of year two in all LCV wells using a YSI Model 30/50 meter and 50 ft cable. Specific conductance and temperature were recorded at the same interval as pressure head in two LCV wells using multiple sensor probes with dataloggers (an In-Situ MP Troll 9000 and a YSI 600SL Sonde).

Transpiration on the leaf scale was measured using a portable photosynthesis system (Li-Cor Li-6400). This machine consists of an infrared gas analyzer (IRGA) that measures the concentration of CO_2 and H_2O in the system air flow. There are two separate IRGA readings, one for the incoming air and one for the air in the sample chamber. A leaf is placed in the sample chamber and sealed inside. The system has its own light source and can control the concentrations of CO_2 and H_2O with the use of soda lime and Drierite, chemicals that scrub the air of CO_2 and H_2O, respectively. For all the measurements taken during this study, the concentration of CO_2 in the sample chamber was 370 PPM. Leaves from cottonwood and mulberry trees were measured under two different light levels and were maintained under conditions approximating ambient during the measurement. The light levels were 1500 μmol photons m^{-2} s^{-1}, which is typical of clear sky light in mid-morning and mid-afternoon during the summer in Kansas, and 300 μmol photons m^{-2} s^{-1}, which is typical for mostly cloudy conditions during the summer. Measurements were taken once a month from June through September 2004. Data were gathered from 7:30 AM to 4:00 PM. Leaves both near the ground and high in the canopy were measured using a cherry picker unit. Data for all of the leaves are in the form of the amount of H_2O transpired per m^2 of leaf area per second at the given light level, temperature and vapor pressure deficit. To extrapolate to the entire canopy, the m^2 leaf tissue per m^2 of ground was estimated using a leaf area index (LAI) sensor. LAI was measured on a biweekly basis during the summer of 2004 between noon and 2 PM. A series of points were selected within the riparian zone and LAI was measured at waist height in the four cardinal directions at each of the points.

Transpiration on the tree scale was measured using sapflow sensors (Thermal Logic [now East 30 Sensors] Model SF18). A sapflow sensor consists of two needles encased in an epoxy head. One needle has an embedded heating element, while the other has three embedded thermocouples. The installation procedure consists of removing a section of bark from the tree, emplacing the needles in the xylem, and covering the exposed xylem and probe with aluminum foil. The heater is turned on for eight seconds every 30 minutes and the temperature at three depths in the xylem above the heater is measured using the thermocouples. Three sensors are equally spaced around the circumference of the tree and remain in the tree for a period of four days. A programmable datalogger (Campbell Scientific 23X) is used to control sensor operation. The velocity of the water flow in the xylem is determined from the time it takes the heat pulse to move past the thermocouples. The volumetric rate of water movement in the trunk is determined from the thickness of the xylem and the velocity measurements. Sapflow measurements were taken every two to three weeks from June to September 2004.

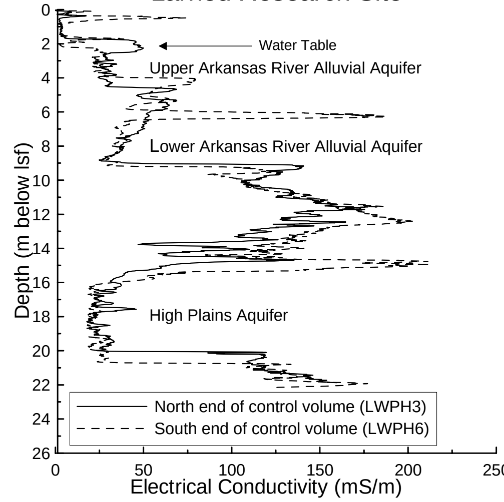
A weather station (Hobo Weather Station logger and sensors, Onset Computer Corp.) was installed within 1600 m of the LCV in June of 2003 and then moved to within 800 m of the LCV in September of 2003. The weather station is equipped with sensors to measure temperature, precipitation, solar radiation, wind speed and direction, and relative humidity. Data are averaged (temperature, solar radiation, wind speed and direction, and relative humidity) or summed (precipitation) and logged at a 15-minute interval. Potential evapotranspiration is calculated from the meteorologic data using the Penman-Monteith equation. The relative humidity sensor was replaced in the summer of 2004 because of damage resulting from a wasp building a nest on the sensor. Fine-mesh netting was placed around the radiation shield to prevent further insect damage.

PRINCIPAL FINDINGS AND SIGNIFICANCE

The principal findings of the second year of the project and their significance will be briefly discussed in the context of the six activities proposed for year two of the project:

Activity 1: Further characterize the Larned Control Volume – two wells and four neutron-access tubes were installed within and adjacent to the LCV. Direct-push electrical conductivity logging was used for detailed lithologic characterization at both well sites. As shown in Figure 4, three aquifer units can be identified in the shallow subsurface within the LCV. The thickness of the sandy silt zone separating the upper and lower portions of the Arkansas River Alluvial Aquifer varies across the site, so the degree of interconnection between these units also varies. The clay and silt zone separating the Arkansas River alluvial aquifer and the High Plains aquifer is consistent across the LCV. Both wells were screened in the upper zone of the Arkansas River alluvial aquifer to the west of the LCV. The purpose of these wells was to provide estimates of the direction and magnitude of lateral flow into the LCV. Slug tests were performed in all water-table wells in the LCV and confirmed the high permeability of the shallow aquifer. Specific yield (S_y) estimates were obtained from an analysis of the neutron logs from both the shallow and deep access tubes. The resulting estimates (S_y=0.19-0.21 for all but one level at the LCV) revealed that specific yield varies relatively little in space. A pumping test performed in the High Plains Aquifer to the west of the LCV in the fall of 2003 was analyzed to provide an estimate of the hydraulic conductivity (2.2×10^{-3} m/d) of the silt and clay zone separating the Arkansas River alluvial aquifer from the High Plains Aquifer.

Figure 4
Electrical Conductivity Logs
Larned Research Site



Activity 2: Continue monitoring of water and salinity fluxes and phreatophyte activity – pressure-head measurements were obtained in all wells in the LCV and adjacent areas at 15-minute intervals beginning in the spring of 2003. These measurements clearly show that prominent diurnal fluctuations in the water table are only observed in the growing season (Figure 5) and are limited to the riparian zone (Figure 6). A professional high-accuracy survey of the horizontal and vertical locations of the casing tops was performed in March of 2004, so gradients can now be calculated from the pressure-head measurements.

Salinity balance in the LCV was originally planned as an approach for estimating ground-water consumption to compare to and

Figure 5
Water Table Fluctuations at Well
LWPH3 Across the Growing Season

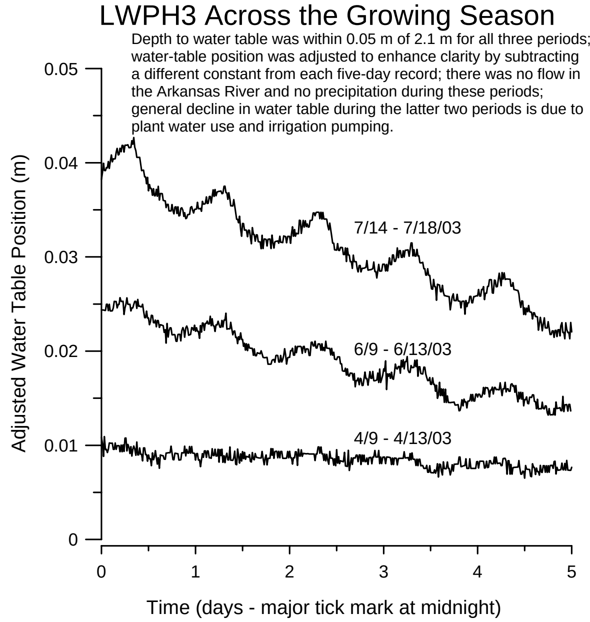
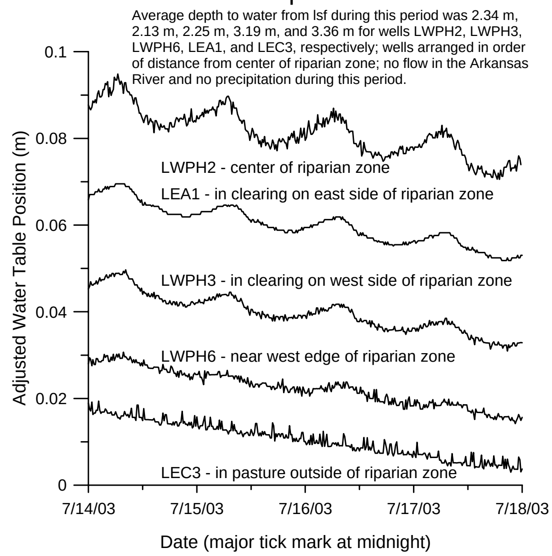


Figure 6
Water Table Fluctuations
Across Riparian Zone



corroborate the water-level fluctuations. The principle for this approach was based on an increase in the total dissolved solids (TDS) content of the water as the trees consumed ground water and left most all of the dissolved solids in the residual water. Results from the study in year one indicated a high degree of heterogeneity in the spatial distribution of TDS (as indicated by water sample analysis and specific conductance data). The attempt to increase the temporal and spatial characterization of the ground-water TDS during year two through both vertical profiling at all LCV wells and continuous conductance recording at two LCV wells showed an even greater level of spatial and temporal heterogeneity than expected. In addition, some of the chemical and conductance data suggest that much of the dissolved solids in the water in the capillary fringe could be precipitated in the unsaturated zone as the water levels dropped. When water levels rise during a river flow event, much of these precipitated salts could be redissolved. The observations indicate that a salinity balance approach to estimating phreatophyte water consumption that is based on ground-water salinity measurements would have too much uncertainty to be valid.

The salinity measurements provided a detailed data set on the major TDS fluxes in the river-aquifer system at Larned that could serve as the basis for research proposals on the quantitative assessment of stream-aquifer interactions – part of the auxiliary objective of the research. The vertical profiles of specific conductance showed the varying influence of flow events in the Arkansas River on the salinity of the ground water in the alluvial aquifer. Figure 7 illustrates the conductance changes at approximately the same elevation in the wells from the late summer 2003 to the fall 2004 during which there were two periods of substantial flow in the Arkansas River. In both instances, the source of the flow was precipitation runoff from the Pawnee River watershed. The figure indicates the large influence that bank storage of the fresher river water had on decreasing the salinity of the shallow ground water. Although there was a general decrease in the influence of the river water on the ground-water conductance with increasing distance from the river for the first flow event (September 2003), there were much more complicated changes in ground-water conductance during and following the second flow event (late June through early July 2004). The data indicate that, although phreatophyte water consumption may cause a general increase in the salinity of the ground water, the salinity changes are controlled more by the movement of different packets of ground water through the heterogeneous alluvial sediments.

The study also discovered that the water-level fluctuations generated by the phreatophytes were sufficient to cause variations in water salinity in the shallow alluvial aquifer during the period of discharge of bank storage input by high river flow, apparently as a result of moving the interface between lower and higher salinity ground water. This is displayed in Figure 8 for a period after the flow event in the Arkansas River of late June to early July 2004. The figure shows that it took a substantial amount of time for the freshest water from the river bank storage to reach the location of well LWPH4A and that this fresher ground water did not move evenly with time to the location. Pronounced oscillations in the conductance in August, which correlated with the water-level fluctuations related to phreatophyte activity, disappeared in late September as the diurnal water-level changes ceased when the phreatophytes became dormant. The substantial spatial and temporal variations in the ground-water salinity based on the vertical profile and continuous observations, and inferred from past river-water quality, have an important bearing on approaches to ground-water sampling for examination of contaminant transport caused by stream-aquifer interactions.

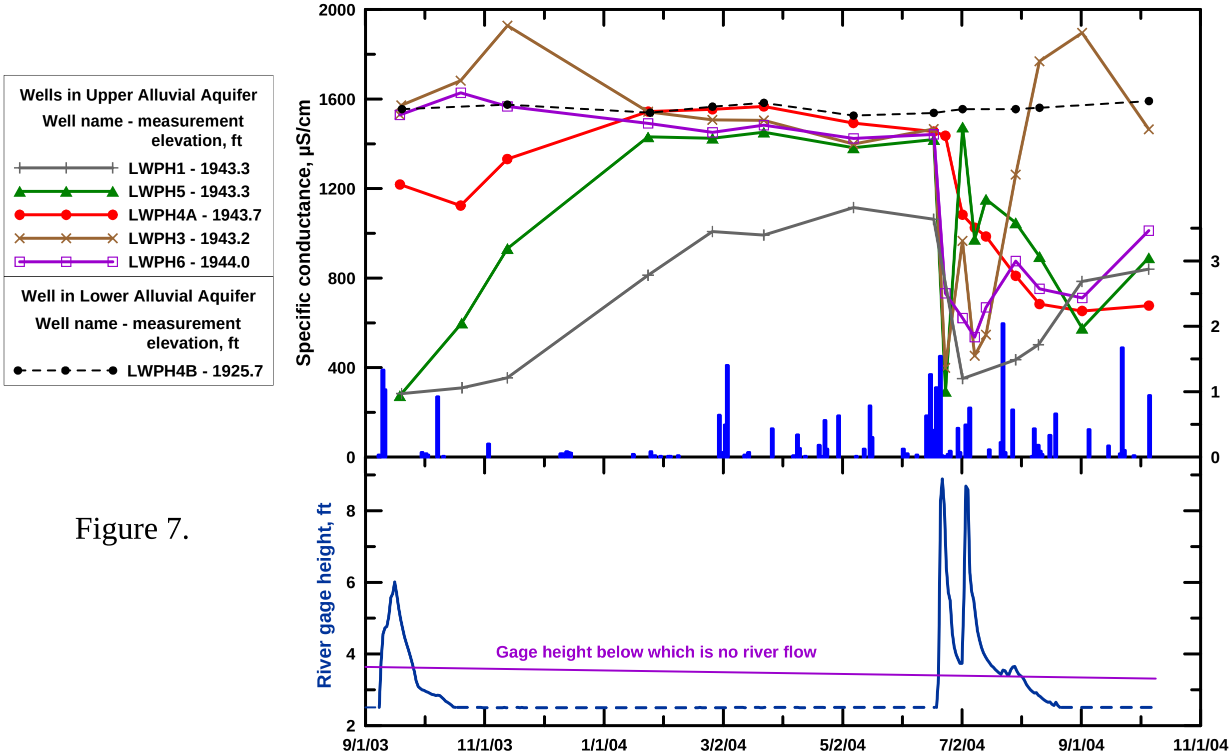


Figure 7.

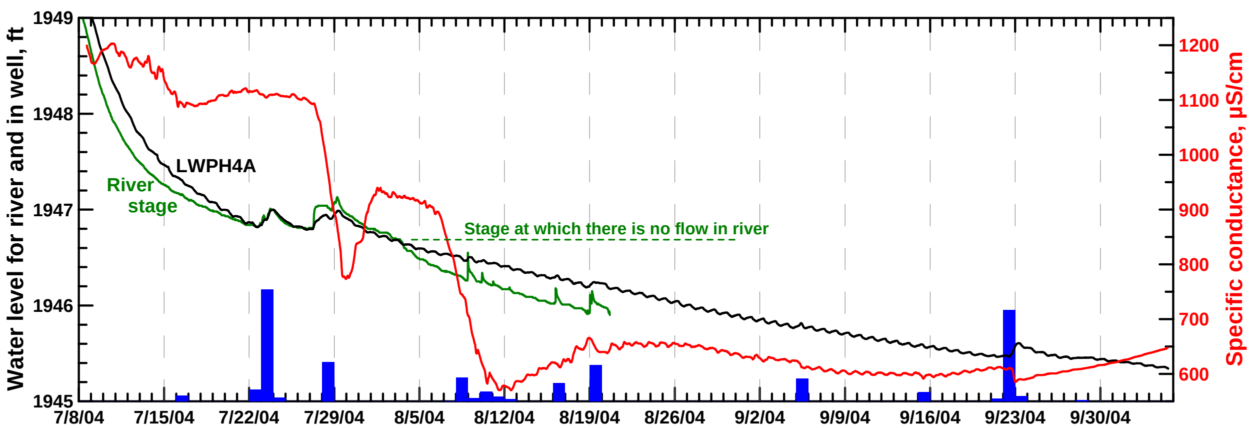


Figure 8. The blue bars are daily precipitation. The highest bar represents 2.04 inches.

Activity 3: Determine phreatophyte water sources by isotopic measurements – water samples have been collected and are awaiting analysis. Those analyses will be performed in year three of this project;

Activity 4: Relate water-table fluctuations to phreatophyte activity – this activity was a major focus of both theoretical and field work in year two. A simulation study of the White method for estimation of ground-water consumption by phreatophytes was completed in year two. In that study, we performed a series of numerical simulations to assess the ramifications of the assumptions underlying the White method and the viability of the resulting estimate of ground-water consumption by phreatophytes. We found that the White method provides reasonable estimates (within 20%) for formations consisting primarily of sands and gravels when the specific yield is defined as the total drainable porosity. However, in finer-grained materials, an estimate of the readily available specific yield must be utilized to obtain reasonable estimates.

In the field, we related sapflow and vadose-zone measurements to the water-table fluctuations to yield new ecohydrologic insights into phreatophyte activity in the LCV. For example, Figure 10a shows plots of the depth to water at well LWPH3 for the same period in late spring of 2003 and 2004. Diurnal fluctuations are imperceptible in the water-level data from June 2004, despite the nearly 50% larger potential for evapotranspiration during that period. The most likely explanation for the absence of fluctuations in the 2004 data is that the water table, which is 0.31 m deeper than in June 2003, is out of reach of the riparian-zone vegetation. Sapflow data collected during these two periods from cottonwoods of similar size and apparent vitality support this explanation, as the 2004 sapflow velocities are greatly reduced relative to those of 2003 (Figure 10b). Neutron-log data from 2004 are consistent with the sapflow and water-level data, as volumetric water content is near the permanent wilting point over most of the vadose zone (not shown). Field notes from a site visit on 6/4/04 by the project PI report yellow leaves on and premature leaf fall from many of the cottonwoods in the riparian zone, indicating that the trees were undergoing stress. The water table was near a historical low in early June 2004, so the most

Figure 10a
Variations in Water-Table Position at Well LWPH3 for Early June of 2003 and 2004

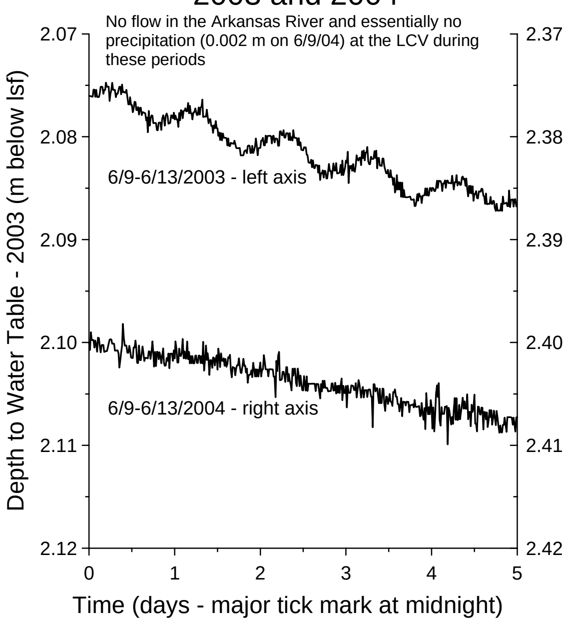
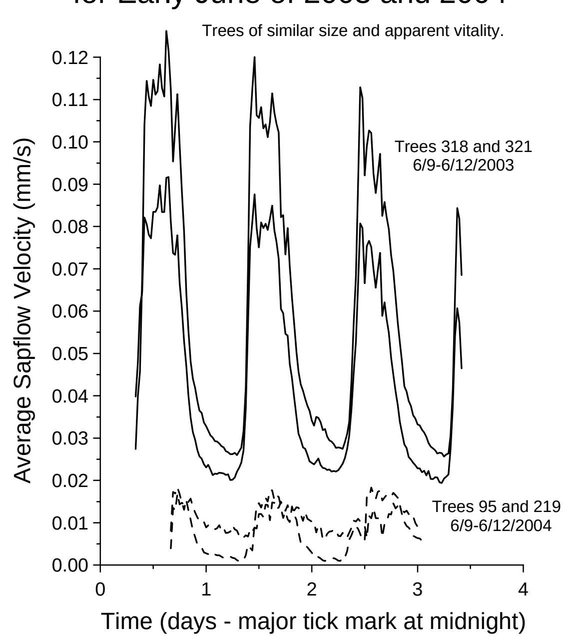


Figure 10b
Variations in Average Sapflow Velocity from LCV Cottonwoods for Early June of 2003 and 2004

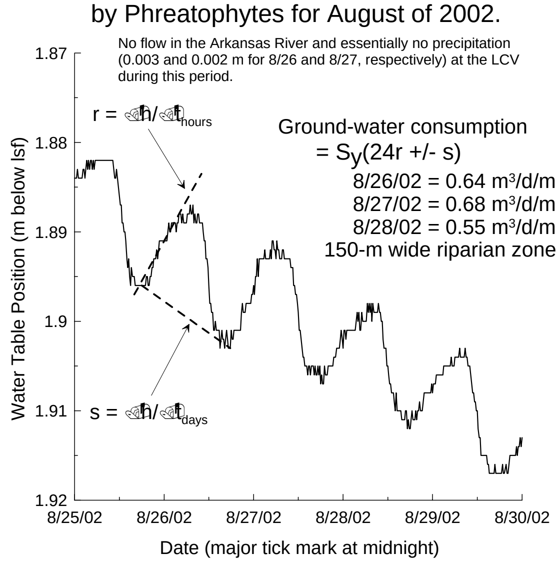


likely explanation for that stress is that the phreatophytes had not had a previous opportunity to develop a root network to extract water from that depth. The phreatophytes at the site do have the capability of drawing water from greater depths, as illustrated by well LEA1 (Figure 6) located on higher ground on the east side of the riparian zone 1.05 m above well LWPH3. However, the trees must have previously developed a root network to extract water from those depths (the water table was also out of reach of vegetation in the vicinity of well LEA1 in early June 2004, but the depth to water from land surface was over a meter greater than at LWPH3). Otherwise, it does not appear that the riparian-zone vegetation in the LCV can adapt quickly enough during the growing season to keep pace with a falling water table induced by regional pumping. The ramifications for the continued existence of the present community of riparian-zone vegetation at the Larned Research Site are significant. If the present riparian-zone vegetation dies out because of an inability to adjust to regional drops in the water table, it will likely be succeeded by invasive species, such as the salt cedar, as has happened in riparian zones throughout semi-arid and arid regions of North America. Further ecohydrologic insights of this type will be developed from the analysis of data in the third year of this project.

Activity 5: Inventory the riparian woodlands of the Arkansas River from Kinsley to Great Bend – the inventory was not done as originally planned because a helicopter inventory of phreatophytes along the Arkansas River corridor was performed by Division of Water Resources personnel. The vegetation patterns resulting from that inventory will be used for the inventory between Kinsley and Great Bend.

Activity 6: Estimate phreatophyte activity along the Arkansas River from Kinsley to Great Bend – an initial estimate of phreatophyte activity was obtained in the latter portions of year two. Data from well LWPH3 were used for this exercise as the fluctuations at that well appear to be representative of the average fluctuations across the LCV (Figure 6). Given an S_Y of 0.20 determined from the analysis of the neutron logs and assuming a riparian zone width of 150 m (a reasonable average for the Arkansas River in this area), the White method was used to obtain an average ground-water consumption of 0.62 m^3/d for 8/26-8/28/02 for a meter-wide strip extending the full width of the riparian zone (Figure 11). This average consumption rate equates to a high-capacity pumping well (defined for this area as a well pumping at 3.79×10^{-2} m^3/s [600 gallons/min]) located every 5.3 km along the river channel. This equivalence should be considered valid only for conditions near the maximum rate of ground-water consumption at the LCV, as the water table was relatively shallow during this period and the amplitude of the fluctuations was relatively large. A complete analysis of the entire data set from the LCV wells will be performed in the third year of this project.

Figure 11
Example Application of White Method for Calculation of Ground-Water Use by Phreatophytes for August of 2002.



PAPERS AND PRESENTATIONS

Butler, J.J., Jr., Kluitenberg, G.J., and D.O. Whittemore, A field method for estimation of ground-water consumption by phreatophytes – year one (abstract), Proc. 21st Annual Water and the Future of Kansas Conf., p. 27, 2004.

Butler, J.J., Jr., Groundwater flow in interconnected stream-aquifer systems: From models to the field, an invited presentation to the Department of Geological and Atmospheric Sciences, Iowa State University, March 12, 2004.

Butler, J.J., Jr., Loheide, S.P., II, Kluitenberg, G.J., Bayless, K., Whittemore, D.O., Zhan, X., and C.E. Martin, Groundwater consumption by phreatophytes in a mid-continent stream-aquifer system (abstract), Eos, v. 85, no. 17, Jt. Assem. Suppl., p. JA237, 2004.

Butler, J.J., Jr., and D.O. Whittemore, Recent Kansas Geological Survey activities at the Larned Research Site, presentation to the Board of Ground Water Management #5, Stafford, KS, September 9, 2004.

Loheide, S,P., II, Butler, J.J., Jr., and S.M. Gorelick, A modeling evaluation of a method for estimating groundwater usage by phreatophytes (abstract), GSA 2004 Annual Meeting Abstracts with Program, v. 36, no. 5, p. 390, 2004.

Whittemore, D.O., Butler, J.J., Jr., Healey, J.M., McKay, S.E., Aufman, M.S., and R. Brauchler, Seasonal and long-term groundwater quality changes in alluvial aquifer systems (abstract), GSA 2004 Annual Meeting Abstracts with Program, v. 26, no. 5, p. 451, 2004.

McKay, S.E., Kluitenberg, G.J., Butler, J.J., Jr., Zhan X., Aufman, M.S., and R. Brauchler, In-situ determination of specific yield using soil moisture and water level changes in the riparian zone of the Arkansas River, Kansas, Eos, v. 85, no. 47, Fall Meet. Suppl., Abstract H31D-0425, 2004.

Loheide, S.P., III, Butler, J.J., Jr., and S.M. Gorelick, Estimation of groundwater consumption by phreatophytes using diurnal water table fluctuations: A saturated-unsaturated flow assessment, Water Resour. Res., in press, 2005.

INFORMATION TRANSFER

Seven presentations concerning this project were presented at various venues both within and outside of Kansas during year two. Two additional abstracts were prepared in year two for presentations early in year three (Water and the Future of Kansas Conference - March 2005, Kansas Academy of Science Conference - March 2005). One manuscript on a modeling assessment of the White method for estimating groundwater consumption by phreatophytes from water-table fluctuations was submitted to the journal Water Resources Research early in year two and was accepted. The paper should be published in the fall of 2003. Work began on a manuscript describing the results of the field investigation of phreatophyte-induced fluctuations in the water table. This manuscript will be completed and submitted to a scientific journal in year three.

STUDENT SUPPORT

Three students participating in the Applied Geohydrology Summer Research Assistantship Program of the Kansas Geological Survey, one KSU graduate student, and one KSU research assistant were partially supported from this grant during the summer of 2004. These students contributed to the aspects of the project involving well and access-tube installation, water-level and vadose-zone monitoring, sapflow sensors, conductance measurements, and weather-station upkeep. Travel, research supplies, and cherry-picker rental were provided for a KU graduate student to perform the leaf-scale transpiration monitoring.

Pharmaceuticals in Surface Water

Basic Information

Title:	Pharmaceuticals in Surface Water
Project Number:	2004KS37B
Start Date:	3/1/2004
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	2nd
Research Category:	Water Quality
Focus Category:	Surface Water, None, None
Descriptors:	
Principal Investigators:	Alok Bhandari

Publication

1. 1. Koch, D.E.; Bhandari, A.; Close, L.; Hunter, R.P. "Azithromycin extraction from municipal wastewater and quantitation using liquid chromatography / mass spectrometry." Journal of Chromatography, A. 1074:17-22. 2005.
2. 2. Xia, K.; Bhandari, A.; Das, K.; Pillar, G. "Occurrence and fate of pharmaceuticals and personal care products (PPCPs) in biosolids." Journal of Environmental Quality. 34:91-104, 2005
3. 3. Bhandari, A.; Close, L.; Koch, D.; Hunter, R. "The occurrence and fate of antimicrobials in municipal wastewater treatment plants - a northeast Kansas perspective." Paper presented at the 39th Midwest Regional Meeting, American Chemical Society, Manhattan, KS, Oct 19-22, 2004.

PROGRESS REPORT

Pharmaceutical Agents in Surface Waters: The Occurrence and Fate of Pharmaceuticals in Northeast Kansas Wastewater Treatment Facilities

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PROJECT TITLE:	Pharmaceutical Agents in Surface Waters: The Occurrence and Fate of Pharmaceuticals in Northeast Kansas Wastewater Treatment Facilities
PROJECT NUMBER:	
START DATE:	March 1, 2003
END DATE:	February 28, 2005
INVESTIGATORS & AFFILIATIONS:	Alok Bhandari, Ph.D., P.E., Associate Professor of Environmental Engineering, Department of Civil Engineering, Kansas State University Robert Hunter, M.S., Ph.D., Assistant Professor of Veterinary Pharmacology, Department of Anatomy and Physiology, Kansas State University
RESEARCH CATEGORY:	Statewide Competitive Grant
FOCUS CATEGORIES:	
DESCRIPTORS:	antibiotics, pharmaceuticals, wastewater, Kansas, occurrence, fate

PROGRESS REPORT

Pharmaceutical Agents in Surface Waters: The Occurrence and Fate of Pharmaceuticals in Northeast Kansas Wastewater Treatment Facilities

Principal Investigators

Alok Bhandari, Ph.D., P.E.
Associate Professor of Environmental Engineering
Department of Civil Engineering, Kansas State University

Robert Hunter, M.S., Ph.D.
Assistant Professor of Veterinary Pharmacology
Department of Anatomy and Physiology, Kansas State University

Problem and Research Objectives

Discharges from municipal wastewater treatment plants (WWTPs) are among the major sources of surface water and groundwater contamination by antibiotics and other pharmaceutical drugs. The presence of antibiotics in surface waters and groundwater is of concern because these chemicals have the potential to perturb microbial ecology, increase the proliferation of antibiotic-resistant pathogens, and pose serious threat to human health. Pharmaceutical chemicals are introduced into municipal wastewater streams from human excreta, which contain large quantities of non-metabolized or partially metabolized medicinal compounds. In order to develop solutions that control the release of antibiotics and other pharmaceutical agents into the environment, it is important to estimate the amounts of these chemicals discharged into surface waters and on land. Recent studies have detected more than 40 different pharmaceutical drugs in environmentally significant quantities in discharges from wastewater treatment facilities in Europe and across the eastern United States. Very few studies, however, have been conducted in the Midwestern United States, and these studies have not correlated the occurrence of target pharmaceuticals to community types or removal in WWTPs to treatment processes and seasonal changes.

The overall objective of proposed project is to evaluate the occurrence and fate of three widely prescribed antibiotics – azithromycin (AZI), sulfamethoxazole (SUL), and ciprofloxacin (CIP) – in raw and treated wastewater, and biosolids at four northeast Kansas wastewater treatment facilities. Information generated from this research will provide critical and timely information about the mass input of these drugs at northeast Kansas WWTPs and extent of environmental release through effluent discharges and biosolids. The proposed work will consist of measuring concentrations of target pharmaceutical drugs in raw and treated wastewater, and biosolids at four northeast Kansas WWTPs. The target antibiotics were selected because they are among the most widely used pharmaceutical drugs in the United States and are commonly detected in municipal wastewaters. The four treatment plants to be evaluated encompass a wide range in the type and size of populations served and the treatment processes employed.

The specific objectives of this research include:

(i) determining the occurrence of the target antimicrobials in the influent, effluent, and biosolids collected from the selected WWTPs;

(ii) determining fate of the antimicrobials as the water is processed in the WWTPs;

(iii) monitoring seasonal changes in antimicrobial concentrations;

(iv) correlating antimicrobial concentrations with the types of treatment processes and raw wastewater characteristics;

(v) conducting a screening evaluation of the water and biosolids samples for a wider variety of pharmaceuticals including methylxanthines (caffeine, theobromine, and theophylline), opioids (morphine, fentanyl, butorphanol, etc.), and acetaminophen;

(vi) conducting hourly and 24-hour composite samples at selected WWTPs to evaluate temporal trends in the mass input and output of pharmaceutical agents at these facilities;

Description of Methods

The four WWTPs selected for this study are located along the Kansas River. The effluent from these treatment facilities is discharged directly into the Kansas River. The four WWTPs were selected because of their proximity to Manhattan, the wide range in the size and type of communities they serve, the wide range of treatment processes employed at these facilities, and our established relationships with the personnel at these municipal plants. Raw wastewater, primary effluent, secondary effluent and sludge samples will be collected at each WWTP and transported to the environmental engineering research laboratory under ice. Sampling at each plant was performed at least once in each of the four seasons: spring (Mar-May), summer (Jun-Aug), fall (Sep-Nov), and winter (Dec-Feb). All water samples will be collected in 1-L pre-washed amber glass bottles and transported to the laboratory under ice. In the laboratory, the wastewater samples were stored at -70ºC until extraction. Sludge samples were collected from the aerators, digesters and dewatering equipment at the four WWTPs. Biosolids were separated from water by centrifugation and freeze-dried before extraction. Samples not extracted immediately were stored at -70ºC.

Extraction and analytical methods were based on the most recent literature as detailed in the original proposal. AZI was extracted by liquid-liquid extraction using MTBE and quantified using LC/MS. SUL and CIP were extracted using mix-mode solid-phase extraction cartridges, eluted with methanol and quantified using HPLC/UV/fluorescence. All samples were subjected to rigid QA/QC protocols during collection, transport, storage, preparation and analysis. Each collected sample was divided into 3 sub-samples. Appropriate surrogate and internal standards were used during extraction and HPLC or LC/MS analyses. External standards and solvent blanks were analyzed at frequent intervals to assure equipment stability. Appropriate statistical methods were used to analyze data and differentiate treatment effects.

Work Accomplished

The accomplishments thus far for this project include sampling at the four different wastewater treatment plants in the Northeast region of Kansas and method development for the analysis of and for the sample preparation of AZI, SUL and CIP in wastewater samples.

A summary of the samples collected at the four WWTPs is presented in Table 1. At least four replicate liquid samples were collected from each plant and at least two replicate solids or slurry samples were collected from clarifiers, digesters, aerators and belt filter presses.

Table 1. Description of samples collected from the WWTPs in May and August 2003.

PLANT I.D.	NUMBERS, TYPES, AND LOCATIONS OF SAMPLES		
	Solid	**Slurry**	**Liquid**
Plant 1	0	4 return line, digester	9 plant influent, plant effluent
Plant 2	2 belt filter press (BFP)	5 nitrification tank, clarifier	19 plant influent, nitrification tank, clarifier effluent, plant effluent, BFP effluent
Plant 3	2 BFP	4 primary clarifier, secondary clarifier	14 plant influent, secondary clarifier effluent, plant effluent
Plant 4	2 BFP	4 primary clarifier, secondary clarifier	17 plant influent, secondary clarifier, BFP effluent, plant effluent

Analytical method development has been completed for sulfamethoxazole, ciprofloxacin and azithromycin. A single isocratic high pressure liquid chromatography (HPLC) method was developed for sulfamethoazole and ciprofloxacin based on a binary gradient method reported by Adams *et al.* (2002). This method utilizes a HPLC with UV/VIS and fluorescence detectors positioned in series. In prior studies, sulfamethoxazole was detected by a UV/VIS detector, (Adams *et al.,* 2002), and ciprofloxacin by fluorescence detection (Golet *et al.* 2001). Solid-phase extraction methods for sulfamethoxazole and ciprofloxacin are currently being developed. These methods are based on those reported by Adams *et al*. (2002), Kolpin *et al*. (2002), and Golet *el at*. (2001) and utilize cation exchange/reverse phase cartridges, MPC (Waters®) or MCX (3M®). A method based on liquid-liquid extraction followed by LC-MS analysis has been developed to quantify azithromycin in water to concentrations as low as 50 ppb. The samples shown below were all extracted from 1 mL of water. The extraction method is as follows: to 1 mL of water, add 100 µL of 0.5 M K_2CO_3, vortex and add 10 mL of methyl-*t*-butyl ether (MTBE). Vortex for 1 minute and centrifuge at ~1,000 ×***g*** for 10 minutes. Transfer supernatant to fresh centrifuge tube and dry using N_2 at 40 °C in a H_2O bath. Reconstitute using 100 µL of mobile phase. Chromatography is performed using a Luna C18(2) (30 × 2 mm) reversed phase column. The mobile phase used is a 24:24:2:50 methanol:H_2O:tetrahydrofuran:acetonitrile with 10 mM ammonium hydroxide.

Analytical results obtained so far indicate that all four treatment plants received raw sewage containing AZI at concentrations ranging from 0.4 to 15 μg/L. No significant change in aqueous AZI concentrations was seen as the wastewater moved through the treatment plants; AZI concentrations in the effluent ranged from 0.8 to 3.8 mg/L. The data showed no discernible seasonal trend for aqueous AZI concentrations. Mass loading of AZI into the Kansas River ranged from 1.5 g/day to 81 g/day.

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Kolpin, D. W.; Furlong, E. T.; Meyer, M. T.; Thurman, E. M.; Zaugg, S. D.; Barber, L. B.; Buxton, H. T. *Environ. Sci. Technol.* 2002, 36, 1202-1211.

Publications and Presentations

1. Close, L.; Koch, D.; Hunter, R; Bhandari, A. "Occurrence and fate of antibiotics in KS wastewater treatment facilities." Invited paper at the 21st Annual Water and the Future of Kansas Conference, Lawrence, KS, Mar 11, 2004.

Information Transfer

1. “K-State Researchers Track Antibiotics in Kansas River Waters” Press release by KSU Research & Extension. Apr 5, 2004
2. “Researchers Track Antibiotics in Kansas River Waters” News article published by About.com (www.about.com), Apr 6, 2004.
3. “Antibiotics in Rivers Raise Concerns” News article published by Harris News Service, Apr 12, 2004.
4. “Water Samples Reveal Presence of Antibiotics” News article published by Topeka Capitol Journal Online, May 4, 2004.

Students Supported

1. Larry Close, MS Candidate, Department of Civil Engineering, KSU
2. Zachary Cook, MS Candidate, Department of Civil Engineering, KSU

Information Transfer Program

Our primary information transfer efforts are through our annual statewide conference, Water and the Future of Kansas. In addition, we have supported a comprehensive website on the High Plains Aquifer. Both are described below.

High Plains Aquifer Information Network

Basic Information

Title:	High Plains Aquifer Information Network
Project Number:	2002KS1B
Start Date:	3/1/2004
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	2nd District
Research Category:	Not Applicable
Focus Category:	Groundwater, Water Supply, Hydrology
Descriptors:	
Principal Investigators:	Margaret A. Townsend, Gary Clark

Publication

HIPLAIN – The High Plains Aquifer Information Network (*www.hiplain.org)*
Final Report for Year 3 (March 1, 2004 – February 28, 2005)

Investigators and Affiliations
Margaret Townsend, Hydrogeologist, Kansas Geological Survey
David Young, Hydrologist, Kansas Geological Survey

Descriptors
High Plains aquifer, Ogallala aquifer, ground water, irrigation, Kansas, Colorado, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, Wyoming, world wide web

Additional Funding
Kansas Water Office - $9,000 for fiscal year 2006

Problem and Research Objectives

The High Plains aquifer spans nearly 111 million acres of the Great Plains. Many communities and agricultural producers rely on the aquifer for groundwater to thrive in the semi-arid region. Uses of the aquifer include municipal, industrial, recreational, and intense agricultural production. Severe water-level declines have occurred in portions of the aquifer due to high-volume pumping of groundwater. Understanding the importance of the aquifer and ensuring its future are critical.

One key to understanding the High Plains aquifer is to have an effective method of sharing information that is practical and applicable to all users of the aquifer. Residential and agricultural users, researchers, consultants, and public policy makers need to have a common source of information to help them acquire the information and knowledge they need to protect this vital resource.

The Internet is an effective method of disseminating data and information. The High Plains Aquifer Information Network (HIPLAIN) establishes an informational site to serve all users of the High Plains aquifer. HIPLAIN focuses on providing information on many aquifer-based issues, including education, agriculture, environmental topics, technical data, and links to organizations that are associated with the aquifer.

HIPLAIN is a one-stop source for a broad group of High Plains aquifer users. By consolidating the available information into one website, individuals are able to find answers and utilize resources with a click of their mouse. HIPLAIN provides opportunities for all potential users to increase their understanding of the region's water resources and provide information to enable better personal and public decisions on water conservation, development, and management.

Description of Methods

- HIPLAIN (www.hiplain.org) was developed in 2002/03 to be a central location for High Plains aquifer resources. Informational categories include About the Aquifer, Agriculture, Education, Environment, Organizations, Pictures, and Technical.
- During the March 2004-February 2005 a major improvement to the website was the addition of a custom designed search engine to permit rapid retrieval of information from the site.
- The site was redesigned and rebuilt to run as an ORACLE database using ColdFusion programming language, making maintenance and updates more efficient, improving site search capabilities, and improving user-friendliness.
- A clickable map was developed for obtaining information housed in the HIPLAIN database on a statewide and regional basis.
- Collaboration with the Ogallala Aquifer Institute and other High Plains states occurred to increase access to public data links;
- Links to the Kansas water-quality data from USGS and the USEPA Storet databases were provided through the site.

- Attempts were made to coordinate work on the HIPLAIN website with the Ogallala Aquifer Initiative consortium of Texas organizations and Kansas State University but no headway was made on this issue

Work Accomplished

Year 3 accomplishments include the following:

- Incorporation of site information into an ORACLE database, improving the efficiency of site maintenance.
- Use of ColdFusion programming language to query the database and generate pages on dynamically.
- Development of a custom search engine for rapid retrieval of information from the ORACLE database.
- Development of clickable map for quick user-friendly access to information on statewide and/or regional basis.
- Updating links to other states for data and information sources.
- Easier access to Kansas water-quality data from USGS and EPA Storet databases;
- Links to High Plains aquifer recharge estimates database developed by Sophocleous (2004).
- Increased links to Agricultural Extension publications that are pertinent to High Plains aquifer issues.

Activities still underway include the following:

- Access to the most up-to-date and newly developed database front ends and data-analysis tools from the KGS website and elsewhere.
- Continued search and posting of relevant links and maintenance.
- Procedures for future data and information dissemination through coordination with the Kansas Water Office, Groundwater Management Districts (GMDs) and other educational and governmental groups.
- Access to legal issues concerning water rights, enforcement, and water-management programs.
- Continued acquisition of additional links to data and information from the other seven states that use the High Plains aquifer.

As the project ends its third year, several enhancements were finalized. Keeping with the idea of increasing user-friendliness, a new layout was designed that incorporated drop-down menus and a clickable map, allowing users to find their section of interest with fewer clicks of their mouse. To reduce the length of the pages, each subcategory of the main sections has a dedicated page, with links back to the main topics or subcategories. This style of website improved visibility of search engines and increase the overall utility of the site.

In addition to providing and improving easy access to Kansas High Plains aquifer information, third-year activities included further acquisition and development of links with all eight High

Plains states concerning water policies and issues, socioeconomic issues, technical information, and access to available datasets for use by the public.

References

Sophocleous, M.A., 2004. Ground-water recharge and water budgets of the Kansas High Plains and related aquifers. Kansas Geological Survey Bulletin 249, 102 p.

Publications and Presentations

Poster session at Water and the Future of Kansas, March 2005.
Groundwater workshop for high school science teachers, July 2004.
Poster presentation at 3i Show, April 2004.

Information Transfer

Access to databases concerning water information, including aquifer water levels, water well construction, and water quality data via the USEPA Storet and USGS NWIS water-quality databases.

Brochures announcing the site were distributed at the Water and the Future of Kansas conferences in 2004 and 2005, and the 3i Show (irrigation, implement, and industry) in April 2005.

A presentation of site was given to junior high and high school teachers during the Ground-water short course in July 2004. Teachers gave feedback on site and comments concerning usefulness for curricula exercises.

Links were added to many organizations, both in Kansas and other states that utilize the aquifer and provide data and services to the public.

Students Supported

None

Water and the Future of Kansas Annual Conference

Basic Information

Title:	Water and the Future of Kansas Annual Conference
Project Number:	2004KS38B
Start Date:	3/1/2004
End Date:	2/28/2005
Funding Source:	104B
Congressional District:	2nd
Research Category:	Not Applicable
Focus Category:	Water Quality, Water Quantity, Water Use
Descriptors:	
Principal Investigators:	Peter Allen MacFarlane, Peter Allen MacFarlane

Publication

Water and the Future of Kansas
Final Report: March 1, 2004 – February 28, 2005

Investigators and Affiliations
Margaret Townsend, Hydrogeologist, Kansas Geological Survey
Al Macfarlane, Hydrologist, Kansas Geological Survey

Descriptors
Water and the Future of Kansas, yearly meeting, USGS funding

Funding: $8,718

Program

The 2004 Water and the Future of Kansas meeting was organized by the Kansas Geological Survey and held at the Lawrence Holidome in Lawrence, Kansas on March 11, 2004.

Description of Methods

- Program theme was voted on by Kansas Water Resources Research advisory group
- Theme selected was Competing Priorities: Resolving Conflicts
- Invited speakers were contacted to see if interested in presenting plenary sessions
- Coordinated with Publications section at KGS to prepare abstract proceedings for meeting
- Coordinated with Jim Jewell, KU Continuing Education at University of Kansas, on the video broadcast of portions of the meeting to attendees in Ulysses, Kansas at the Pioneer Communications facility
- Coordinated with Kansas State University Continuing Education for registration, meal planning, and other logistical efforts at the Lawrence Holidome facility.
- KGS Hydrogeology group, publications personnel, and other groups assisted at the meeting.

Work Accomplished

- Three plenary speakers: Hall Distinguished Professor of American History, University of Kansas; Environmental Lawyer, McKinney & Stringer, Tulsa, OK; and Professor of Fisheries, Purdue University, West Lafayette, IN
- Breakout sessions: Ogallala–Managing the Aquifer: Subunit Protocols; Public Water Supply Water-quality Issues; Urban–Rural Water Issues**;** and Protection of Critical Habitat
- Concurrent afternoon sessions: 23 oral presentations
    - Urban–Rural Water Issues;
    - Impacts of Agriculture on Water Quality;
    - Ogallala Management Issues;
    - Recreation and Public Water Supply Issues;
    - Water Use Issues;
    - Water Quality in Surface Water;
    - Water-use Impacts on Critical Habitat;
    - Covering Water Issues – media discussion session
- Thirty two posters presented
- Luncheon speaker: Roger Welsch

Student Support

Student Support					
Category	Section 104 Base Grant	Section 104 RCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	7	0	0	0	7
Masters	2	0	0	0	2
Ph.D.	1	0	0	0	1
Post-Doc.	0	0	0	0	0
Total	10	0	0	0	10

Notable Awards and Achievements

Publications from Prior Projects

None