PROJECT SUMMARY
KANSAS WATER RESOURCES INSTITUTE

Project Title: Assessment of deteriorating water quality in the Ogallala Aquifer and its effect on crops in western Kansas

Personnel:
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Goals and Objectives:
The overall goal of this project is to establish baseline information on the status of water quality of the Ogallala Aquifer as it relates to the major agricultural crops in the region. The project objectives will be to: 1) quantify the spatial extent of water quality deterioration in areas underlain by the Ogallala Aquifer2) evaluate the effect of varying concentrations of specific chemical constituents primarily chloride and sulfate on crop growth; and 3) encourage participation of a student into the field of water resources.

Introduction
Literature Review: The Arkansas River in southwest Kansas, one of the most saline rivers in the United States (US), could have sulfate and chloride concentrations as high as 2,700 mg/L and 300mg/L, respectively. This is the main source of these contaminants to groundwater in the alluvial and High Plains aquifers along the Arkansas River (Whittemore, 2000). Buddemeier et al. (2003) noted that with the irrigation efficiency improvements compared with flood irrigation there is still uncertainty as to the rate of contamination to the aquifer in the next decades and whether the water quality will sustain the water demands in the area. In addition, there might be other sources of these contaminants since the proliferation of PVC retrofits extends outside the Arkansas River corridor. This is probably the best time to revisit the water quality status of the Ogallala Aquifer and link this issue with the irrigated crops in the region.

Over the past couple of years, there have been an increasing number of center pivot (CP) irrigation systems in southwest Kansas that were retrofitted/underslung with PVC. According to several personnel from irrigation industries, the main driver for this increase was the deteriorating water quality being pumped out of the aquifer that was causing corrosion inside the main steel lateral pipes. Personnel from GMDs, Soil Water Conservation Districts, and county extension offices, and farmers corroborate industry perceptions. This adaption has been previously observed in areas with saline water especially in the alluvial aquifers adjacent to Arkansas River (Whittemore, 2010). Recently, it has been observed that even those center pivots that are farther away from the Arkansas River corridor have been retrofitted with PVC. This indicates

a knowledge gap regarding salinity hazard in the irrigation water being pumped from the Ogallala as well as the spatial extent of the affected areas.

Water quality is a major concern for irrigators because it could entail major investments either to prevent the deterioration of their irrigation systems, or to prevent undue damage to their crops and topsoil. Identifying the problem before it becomes prevalent is important information for producers, water resource managers and policy makers.

Justification: This proposed project will quantify the concentration of chemical constituents in the irrigation water and also determine the spatial extent of water quality deterioration in southwest Kansas. It is hypothesized that with the decline of water levels in the Ogallala Aquifer, there is a corresponding deterioration in water quality, especially with increased agricultural activity (Chaudhuri, 2012). This is an emerging concern in the region because as the Ogallala Aquifer water declines, limited irrigation management practices are being promoted in the Ogallala region. However, without adequate rainfall especially during off-cropping season, there is essentially no leaching process occurring. Thus, there is a tendency to exacerbate salinity problems in the root zone eventually leading to accumulation of salts in the soil profile. Producers on the other hand are concerned about the effects salinity on crop productivity and yield. The main focus of the project is to conduct baseline information on the water quality problem and to generate guidance for irrigators on the effect of salts on their crops. With this information, proactive actions could be undertaken to inform irrigators, policy makers, and resource managers about this emerging issue.

Procedures

The approach would be to conduct survey, laboratory analysis, spatial analysis, and plant testing in the area of southwest Kansas (see Table 1). A bi-annual (pre- and post-cropping season) water quality survey would be conducted by collecting water samples at strategic distances from the Arkansas River and targeted areas dominated by wells tapping only the Ogallala Aquifer. In coordination with the Groundwater Management Districts, we will contact irrigation well owners within the sampling grid to request permission to take water samples from their wells. This step is essential in order to identify the current extent of salinity problem emanating from the alluvial aquifer. The water samples will be sent to private independent laboratories, such as Servi-Tech, for irrigation water quality analysis. The water analysis will quantify specific chemical constituents present, primarily sulfate and chloride and also other salts such as NO^{-}_{3}, Ca^{++}, and Na^{+}. Geo-statistical and spatial analyses using ArcGIS will be performed based on the water quality parameters and location of the samples. Interpolation of the point samples will be performed to provide a more holistic view of the issue. Maps will be produced to show the concentration of pollutants in the region.

Once the range of pollutants, represented in the form of electro conductivity (EC), has been established, equal percent intervals of EC (e.g. 20% interval for up to 150% of maximum EC), will be applied as irrigation water to the major crops in the region such as corn and sorghum. The response of the crops, such as emergence, physiological responses and yield, to salinity will be documented. This experiment will be done in a greenhouse, located at K-State SWREC in Garden City, to remove the interactions of other complicating variables. However, we will use representative soil types in the field in the experiment set-up to capture

the current status of soil chemistry. Models such as Root Zone Water Quality Model (RZWQM) (Hanson et al. 1998) could be applied to verify the dynamics of the system.

An undergraduate student will be hired to conduct several aspects of the study. Ideally, the undergraduate student with familiarity in irrigated agriculture from southwest Kansas will be supported for at least during the two summers of the project. The student will assist in water sampling, care and maintenance of plants, and plant monitoring and sampling, and will also be involved in some data collection and analysis. The student will be encouraged to participate together with other investigators in presenting the results of the project, such as during K-State field days and Governor's Conference on Water and the Future of Kansas. Similar to the funding goal of the grant program, the project hopes to influence and encourage at least a student in the realm of water resources research. The principal investigators and an agricultural technician will assume the rest of the activities especially when the student is attending classes.

Table 1. Time frame of major activities.

Major Activities	**Year 1**				**Year 2**			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Planning and Survey								
Water Sampling and Analysis								
Plant Testing								
Mapping and Geo-statistical Analysis								
Reporting and Publication								

Methods of Technology Transfer: The results of the project will be presented at technical and professional scientific meetings, as well as published in peer-reviewed journals. The information derived from this study will be shared in extension education meetings, experiment station field days and tours. The interpreted research results will be delivered to farmers, breeders, and other related public and private audiences in the form of practical seminars and bulletins. Producers, policy makers, and water resource managers in the region will be apprised of the significant results in this study using different communication avenues.

Expected Outcome

There are at least three major outcomes expected from this project, (1) to gain knowledge on the water quality status of the Ogallala Aquifer, (2) to provide information to the irrigated producers on the effect of salinity to crops, and (3) to engage students in the science of water resource. Specific outputs would include maps that will show the extent and magnitude of pollutant concentrations in the western region of Kansas. This is very important information for producers, water resource managers (e.g. GMDs), and policy makers. Equally important are the technical bulletins that will be produced from this project identifying the effect of salinity on crops with the range of pollutant concentration in the irrigation water. This information will be instrumental in the conceptualization of policies and other research studies in the region.

It is also expected that the results of this study will be pivotal information in future research initiatives regarding the water quality of the Ogallala Aquifer.

Qualifications of Investigators:

Jonathan Aguilar: The PI is an extension Water Resource Specialist of K-State SW Research Extension Center in Garden City with an area of responsibility covering roughly the western half of the state. He has a BS and MS in Agricultural Engineering with major focus on soil and water resources, and a PhD in Biological and Agricultural Engineering with emphasis on watershed modeling. Prior to his current job, he was a postdoc Agricultural Scientist at US Department of Agriculture- Agricultural Research Service (USDA-ARS) who worked within an interdisciplinary team studying spatial and temporal analysis of crop diversity indices for the contiguous U.S., and have done some research on remote sensing to quantify crop residue in the field in relation to water conservation and carbon sequestration. At present stage of his career, he has produced four manuscripts in refereed journals, at least 20 technical presentations five of which were invited, three proceedings, seven published abstracts, and five technical reports. Other than extension activities, his background also include working with GIS, remote sensing, database management, soil and water conservation, watershed modeling, hydrology, water quality, lithology, and well drilling.

Isaya Kisekka: Dr. Isaya Kisekka is an Assistant Professor of Irrigation Engineering at Kansas State University (KSU). Dr. Kisekka received his Ph.D. in Agricultural and Biological Engineering from University of Florida. His research at KSU focuses on water management in irrigated cropping systems. His goal is to develop management strategies and technologies that optimize economic crop yields, enhance water conservation and preserves water quality. His responsibility on this project will be to evaluate physiological and yield responses of selected crops to different levels of salinity (EC). He will also offer support to other components of the project as needed.

Aleksey Sheshukov: Dr. Aleksey Sheshukov is an Assistant Professor in the Department of Biological & Agricultural Engineering of Kansas State University. Dr. Sheshukov's expertise lies in hydrologic and watershed modeling with emphasis on assessing areas of non-point source pollution and developing watershed plans to improve water-quality in Kansas watersheds. Dr. Sheshukov has multiple peer-reviewed publications at the edge of GIScience and watershed hydrology, and was a principal investigator on several federal projects sponsored by NSF, USDA, and EPA including two ongoing projects with USDA on gaining a better understanding of erosion sources on cultivated croplands, specifically the ephemeral gully erosion. His major responsibility is on GIS analysis and modeling activities.

Danny Rogers: Dr. Danny Rogers is a licensed engineer with BS and MS degrees from Kansas State University and a Ph.D. for Oklahoma State University. Dan is a professor and extension agricultural engineer for Kansas State University Research and Extension with over thirty-five years of experience. His primary program responsibility is water resources management, with primary emphasis on irrigated agricultural production; including irrigation development, irrigation systems, water management and energy for irrigation. He will be responsible for providing technical guidance on sampling and water quality analysis.

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