Kansas Water Resources Institute Funded Projects for 2020-2021

Submitted to the Kansas Water Authority
by
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USGS State Base Projects
Total Kansas USGS Funds Committed: $250,000
Total University Matching Funds Committed: $500,000

1) **Title: Simulating the Effects of Reservoir Management Strategies on In-Stream Sediment Load, Streambank Stability, and Water Quality**
   Tony Layzell, KGS, Andrea Brookfield, KU, and Erin Seybold, KU.

PROJECT GOALS AND OBJECTIVES – The objective of the proposed work is to develop and demonstrate the importance of reservoir management on streambank stability and in-stream sediment loads using a model capable of simulating both surface water operations and streambank erosion. In addition, the implications of sediment loading from eroding streambanks on downstream water quality will be assessed. This objective will be met through: (1) further development of an existing reservoir management model to simulate streambank stability; (2) demonstration of this model through characterization of a reservoir-controlled basin in Kansas; and (3) collection and interpretation of water quality data. The goal is to show the importance of evaluating water management strategies on not only their ability to meet downstream water demands and reduce water shortages, but also their ability to restrict sediment loading, streambank erosion, and maintain water quality.

Despite the connections between (1) reservoir management and sediment transport, and (2) sediment transport and water quality, very little research has investigated the influence of reservoir management on downstream sediment loads, streambank stability, and water quality. Existing models are available to independently simulate sediment transport and optimize reservoir operations for water use, however, there are currently no frameworks available to consider the interactions between these two systems. This proposed work will address this research gap by developing and demonstrating a modeling framework that can optimize reservoir management, predict the effect on streambank stability, and infer the effects of changing sediment loads on water quality.

2) **Title: A New Statewide System for Tracking and Forecasting Drought**
   Andres Patrignani, KSU and Christopher Redmond, KSU

PROJECT GOALS AND OBJECTIVES - The overall goal of this project is to develop a web-based system for tracking and generating short-term forecasts of drought conditions across the state of Kansas. This new system will provide fine temporal (daily) and spatial (field scale) soil moisture resolution currently unavailable from other drought monitoring tools (e.g. U.S. Drought Monitor and the Seasonal Drought Outlook). This new tracking system will enable timely and accurate identification of drought-vulnerable regions and communities across Kansas.

Specific Goal 1. Generate a new database of soil properties for the stations of the Kansas Mesonet. We will visit each station of the Kansas Mesonet to collect undisturbed soil cores at each soil moisture sensor depth for subsequent laboratory determination of soil physical properties. This step is essential to develop accurate drought indices based on Plant Available Water (PAW).
Specific Goal 2. Integrate soil moisture observations from the Kansas Mesonet with soil moisture predictions using gridded rainfall, soil, and vegetation products. Soil moisture maps generated from the

Kansas Mesonet will be combined with independent soil moisture maps generated using a modeling approach that takes into account existing soil databases (e.g. USDA-NRCS Soil Survey), gridded rainfall products (e.g. NOAA River Forecast Center), and remote sensing vegetation products (e.g. NASA MODIS). The resulting soil moisture maps will be the result of a merger between in-situ and modeled daily estimates of root-zone soil moisture. Root-zone plant available water and fraction of available water capacity (FAW) will be used as soil moisture-based drought-indicators.
Specific Goal 3. Validate the generated map of soil moisture and plant available water created in Goal 2. We will use an innovative cosmic-ray neutron detector capable of non-invasively measuring field-scale soil moisture on-the-go while driving on county roads. Validation surveys will span the entire state to capture soil moisture conditions across the different Kansas climate divisions.

3) **Title: Improving Irrigation Water Use Efficiency Using Novel Root Sensors**
   Colby Moorberg, KSU, Dorivar Ruiz Diaz, KSU, Gerard Kluitenberg, KSU, Naiqian Zhang, KSU and Yuqi Song, KSU

PROJECT GOALS AND OBJECTIVES - The focus of this study is to improve water use efficiency in irrigated agriculture by continuing development of a root sensor system. This root sensor system will facilitate the collection, analysis, and use of root data in near-real time in order to improve in-season management decisions by farmers to increase water use efficiency in irrigated systems. Our primary goal is to apply and test a root sensor that can automate the determination of rooting depth and root distribution by depth. The research objectives required to achieve the primary goal are to 1) instrument a corn (Zea mays L.) field with RhizoPi camera systems, 2) determine daily rooting depth of corn and weekly plant-available water content by depth, and 3) adjust irrigation scheduling based on the rooting depth and soil moisture in order to maximize irrigation water use efficiency.

4) **Title: Experimental and Modeling Investigation of Fluid-Fluid and Rock-Fluid Compatibility Between Arbuckle and Lansing Kansas City Formations with the Purpose of Produced Water-Exchange Between the Two Formations to Reduce Both Fresh Water Usage and Water Disposal Problems**
   Reza Barati (KU), Justin Hutchison (KU) and Edward Peltier (KU)

PROJECT GOALS AND OBJECTIVES - To demonstrate the potential of brine exchange between geological formations as a method for reusing oil and gas industry wastewater (produced water) in Kansas for further oil production. Increasing produced water reuse simultaneously addresses two issues of importance to state water resources by reducing the necessity for produced water disposal, which has known environmental and seismic impacts, and by reducing the need for freshwater use in oil production. This study will generate laboratory-scale data and an economic feasibility model that will guide the development of a pilot-scale test study of brine exchange by KS oil and gas producers. The scientific merit of this proposal is a determination of the stability of the Lansing-Kansas City (LKC) brine in the presence of brine from the Arbuckle formation, the development of geochemical models to predict scale-formation potential in the mixed systems, and a preliminary economic and environmental analysis of the exchange process. The broader impacts of this research include the training of a graduate student in Environmental Engineering, the incorporation of new educational materials in a Water Management and Reuse course, and the support of an early career faculty member (Dr. Hutchison).
Objectives:
1) Evaluate the interaction of LKC formation cores in the presence of Arbuckle formation brines and determine the composition of any resulting precipitates,
2) Provide data that can be used to model complex surface interactions between the geological formation and the injected brine to understand the scaling potential of the brine-rock interactions,
3) Estimate the preliminary economic and environmental tradeoffs of brine exchange versus business-as usual disposal processes.

4) Provide guidance for a future pilot-scale test of produced water reuse in a brine-exchange process.

5) **Title: Benthic Cyanobacterial Mats: A Potential Source of Harmful and Nuisance Compounds to Kansas Streams**
Admin Husic (KU), Ted Harris (KU) and Belinda Sturm (KU)

PROJECT GOALS AND OBJECTIVES - Few long-term studies exist aimed at understanding benthic cyanobacterial mat proliferation and toxin production. Physical disturbances and biogeochemical conditions are identified as important, but their interconnected relations with mat production and/or degradation are not well understood. Thus, we develop three goals:

1. Search for and study mat formation and toxicity in multiple Kansas streams
2. Correlate mat location and toxicity with parameters from *in situ* high-frequency sensor measurements and discrete sampling
3. Develop predictive models for mat occurrence and toxicity

To achieve these goals, we aim to complete the following specific objectives:

1. Search for benthic cyanobacterial mats in three streams of rapidly growing Johnson County, KS including the highly urbanized Indian Creek (98.3% urbanization), the mixed land use Mill Creek (67.4% urbanization), and the agriculturally dominated Blue River (20.8% urbanization).
2. Integrate spatially discrete data in the three streams over the course of two years to assess temporal variability in mat growth, decay, and toxin-release rates.
3. Relate temporal spot sampling of benthic cyanobacterial mats and cyanotoxins with *in situ* high-frequency sensor data of turbidity, chlorophyll (Chl-a), phycocyanin (PC), fluorescent dissolved organic matter (fDOM), and nitrate.
4. Compare explanatory variable signals within our tributary streams to the signal at the Kansas River (at DeSoto) to discern whether toxins are originating from benthic mats or reservoir releases.

6) **Spatial variability and subsurface controls of groundwater recharge and nutrient mobilization in dry streams**
Erin Seybold (KGS), Samuel C Zipper (KGS) and Chi Zhang (KU)

PROJECT GOALS AND OBJECTIVES - The overarching goal of this proposal is to understand the influence of intermittent and ephemeral rivers, streams, and ditches (herein referred to as 'dry streams') on water quantity and quality in Kansas in support of two guiding principles in the Kansas Water Plan. To address this goal, we propose two objectives: 1) quantify the quantity and variability of groundwater (GW) recharge and the physical controls on recharge in dry streams (supporting the principle of 'Conserving and Extending the High Plains Aquifer'), and 2) quantify the solute load from dry streams to receiving ecosystems (supporting the principle of 'Improving Our State's Water Quality'). We will accomplish this via synoptic physical and biogeochemical measurements at 10 sites and detailed geophysical surveys and long-term monitoring at three core sites, leveraging existing long-term data and instrumentation. Specific outcomes of this project will include: (i) multiple peer-reviewed publications documenting hydrogeological and biogeochemical findings; (ii) improved parameterizations of dry streams in future groundwater modeling efforts for the High Plains Aquifer; (iii) the development of a project team, methods, and instrumentation approach which will form the basis of future collaborative funding proposals (e.g., NSF); and (iv) education of at least 4 undergraduate students through an Applied Geohydrology Internship Program based at the KGS.

National USGS Competitive Grant
USGS Funds Committed: $250,000 University Funds Committed: $250,000

Title: Interbasin Water Transfers, Hydrologic Modeling, Water Budget, Water Supply and Demand
Landon Marston (KSU) and others

The primary goal of the proposed work is to advance understanding of the role Interbasin water transfers (IBTs) play in shaping water availability across the nation and the corresponding implications to the environment and society. This overarching goal will be achieved through three key objectives. Objective 1 is to produce a comprehensive and publicly available national inventory of interbasin water transfers. In creating a standardized IBT data product, we will work with USGS Co-PIs to leverage USGS's existing network of local, state, and federal stakeholders that maintain data onIBTs. Next, objective 2 is to generate models to estimate, predict, and gap fill IBT conveyance volumes. These data-driven models will help us uncover new knowledge buried with the data and enable prediction through applications of statistical, machine learning, and processed-based approaches. Finally, objective 3 we will determine the collective impact of IBTs under current and historical conditions, as well as under different water supply/demand and climate scenarios.