Kansas Water Resources Research Institute
Annual Technical Report
FY 2017

Introduction

The Kansas Water Resources Institute (KWRI) is part of a national network of water resources research 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 Agricultural Resources and the Environment (KCARE) at Kansas State University. An Administrative Council comprised of representatives from participating higher education or research institutions, state agencies, and federal agencies assists in policy making.

The mission of KWRI is to: 1) develop and support research on high priority water resource problems and objectives, as identified through the state water planning process; 2) facilitate effective communications among water resource professionals; and 3) foster the dissemination and application of research results.

We work towards this mission by: 1) providing and facilitating a communications network among professionals working on water resources research and education, through electronic means, newsletters, and conferences; and 2) 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 Introduction

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

In implementing our research program, KWRI desires to: 1) be proactive rather that reactive in addressing water resource problems of the state; 2) involve the many water resources stakeholders in identifying and prioritizing the water resource research needs of the state; 3) foster collaboration among state agencies, federal agencies, and institutions of higher education in the state on water resource issues; 4) leverage additional financial support from state, private, and other federal sources; and 5) be recognized in Kansas as a major institution to go to for water resources research.

Quantifying Ephermeral Gully Erosion and Evaluating Mitigation Strategies with Field Monitoring and Computer Modeling

Basic Information

Title:	Quantifying Ephermeral Gully Erosion and Evaluating Mitigation Strategies with Field Monitoring and Computer Modeling
Project Number:	2016KS185B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	KS-001
Research Category:	Water Quality
Focus Categories:	Sediments, Models, Water Quality
Descriptors:	None
Principal Investigators:	Aleksey Sheshukov

Publications

1. Bandara, C., A. Sheshukov, W. Boyer, 2016. Evaluating Soil Loss from Ephemeral Gullies with Photogrammetry and Computer Modeling. Governor s Conference on the Future of Water in Kansas. Nov. 2016. Manhattan, KS.
2. Karimov, V., A.Y. Sheshukov. 2016. Reservoirs sedimentation in Central Kansas: Aspect of soil erodibility due to subsurface and surface flows. Poster presentation at the Governor s Conference on the Future of Water in Kansas. Nov. 2016. Manhattan, KS
3. Bandara, C., A. Sheshukov, W. Boyer (2017). Evaluating Soil Loss from Ephemeral Gullies with Photogrammetry and Computer Modeling. Governor s Conference on the Future of Water in Kansas. Nov. 2017. Manhattan, KS.
4. Karimov, V., A.Y. Sheshukov (2017). Integrated process-based modeling of channelized flow and soil erosion in small watersheds. International ASABE Meeting. Spokane, WA, 16-19 July, 2017. ASABE Paper 1700566.
5. Bandara, C., A.Y. Sheshukov (2017). Quantifying Ephemeral Gully Erosion with Photogrammetry Surveying. International ASABE Meeting. Spokane, WA, 16-19 July, 2017. ASABE Paper 1700474.
6. Karimov, V.R., A.Y. Sheshukov (2017) Effects of Intra-storm Soil Moisture and Runoff Characteristics on Ephemeral Gully Development: Evidence from a No-till Field Study. In special issue: Streambank Erosion: Monitoring, Modeling and Management. Water. 9(10): 742.

KWRRI Annual Progress Report

Title: Quantifying Ephemeral Gully Erosion and Evaluating Mitigation Strategies with Field Monitoring and Computer Modeling

Research category: Water Quality

Focus Category: Sediments, Models, Water Quality

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Reporting Period: 3/1/2017 – 2/28/2018

1. Rationale and objectives

Soil erosion causes severe soil degradation and significantly contributes to total soil loss in agricultural fields. Sheet, rill and ephemeral gully (EG) erosion are the main mechanisms that highly contribute to total soil loss in agricultural fields. This project focuses on understanding mechanisms related to EG formation, location, geomorphological properties related to storm characteristics, and quantifying the amounts of soil losses from EG erosion in Kansas. The objectives of the project are:

1. To assess EG-driven soil erosion by monitoring soil loss from EGs on several no-till fields in Kansas.
2. To evaluate factors that majorly contribute to soil loss along concentrated flow paths with a physically-based predictive model, and
3. To analyze a set of agricultural BMPs for effective mitigation of EG erosion.

2. Study area

A no-till field at Pillsbury crossing area near the city of Manhattan in Riley County, Kansas was selected for field measurements (Figure 1). The field had area of 9.4 ha, elevation range from 330 m to 346 m with an average slope of 1.7%. Soil was silty clay loam of hydrologic group C. The field was under no-till management with summer crops of grain sorghum planted in 2016 followed by soybeans in 2017. A diversion terrace was built on the south side of the field, preventing flow from adjacent areas on the south to flow into the field.

Table 1. Catchment characteristics of three gullies.

	Gully 1	Gully 2	Gully 3
Drainage area (m^2)	390	12,700	4,270
Length of longest flow path (m)	33	242	140
Average slope of the longest flow path (%)	0.6	0.8	0.6

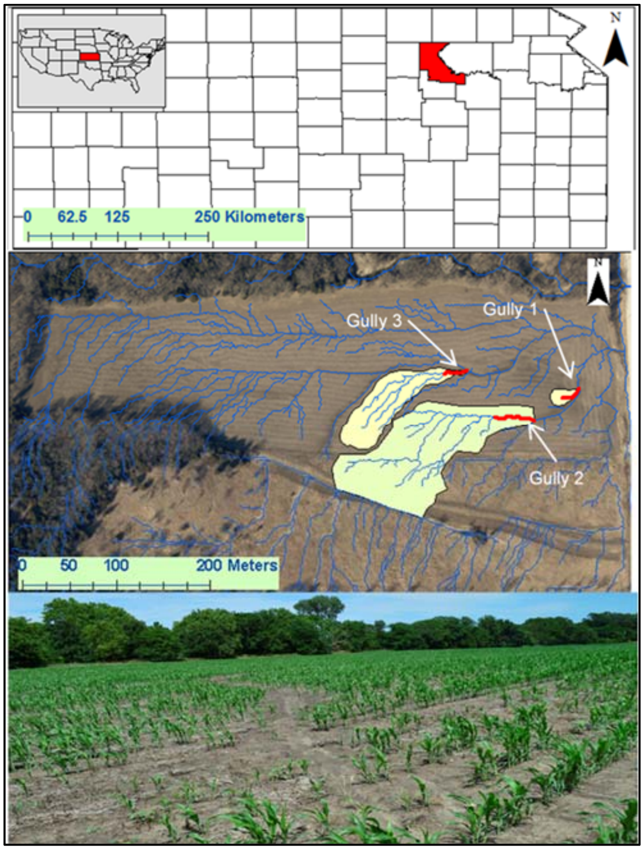

Figure 1. Map of the field, three studied gullies and their contributing areas.

Upon visual inspection during field visits in spring 2016, the field had visible ephemeral channels present. Channels on the north side of the field had drainage from the south-west side and were eliminated from consideration. After thorough inspection and preliminary GIS modeling of the field, three gullies were selected for detailed soil loss monitoring (Table 1). The gullies had contributing drainage areas embedded within the field, which eliminated inflows from areas outside of the field with unknown runoff characteristics. In addition, a tipping bucket type rain gauge was installed near the field to continuously measure rainfall rates.

The gullies were frequently surveyed during summer growing seasons and the changes in surface elevation were evaluated with photogrammetry technique.

3. Field surveys and data analysis

In the second year, we continued surveying three gullies for elevation changes and monitored weather conditions. We used photogrammetry technique to detect soil elevation and calculate the changes between field visits and elevation measurements. The photogrammetry technique is described below.

3.1. Photogrammetry method

Photogrammetry is based on the analysis of multiple photographs taken of the same area and creating a 3-D elevation model. To geospatially reference the 3-D model and assure the accurate scale, several reference points within the observation area were established. We drove 10 cm long plastic survey stakes into the soil around a gully for X, Y, and Z reference. Each stake was surveyed by the total station prior to the use in photogrammetry software. We placed on average 2 stakes per square meter of an area. We purchased a full frame camera, Sony Alpha a7, with 50 mm prime lens, and designed and self-manufactured a backpack frame to mount the camera during field surveys. The camera was mounted on the frame at the height of 3 meters above the ground with 5 degree tilt away from the operator. The frame was attached to a backpack that was worn by the operator. The images were captured wirelessly through Wi-Fi technology invoked the shot from a tablet while walking along the gully. The imaging required six overlapping photographs to cover one square meter of ground surface and two consecutive photographs with at least 30% overlap.

The photogrammetry processing software, Photomodeler Scanner by Eos Systems Inc. (Vancouver, British Columbia, Canada) was purchased for image processing and building of 3-D elevation point clouds. The created point cloud datasets were geospatially referenced and scaled using the reference points. Final elevation data points were exported into ArcGIS software (http://desktop.arcgis.com/en/arcmap/) and desktop environment, where they were converted into digital elevation models (DEM).

Each gully was surveyed from headcut to end of channel areas during every field visit and point clouds were created. Variations in soil elevation between surveys were calculated as differences in point values. The total soil loss was obtained as an elevation difference multiplied by the pixel size for each point.

3.2. Results

In 2017, we conducted six surveys: from April 19 to December 6. Data for three gullies was processed in Photomodeler software, ESRI's ArcMap software, and Matlab, and the following products were developed:

- Elevation maps for each survey (Fig. 2),
- Soil losses or gains between each two surveys (Fig. 3),
- Advancement rate of a headcut, width, and depth (Fig. 4),
- Surface area of a gully (Fig. 3),
- Width/depth at selected cross-sections of a gully,
- Depth along gully thalweg,
- Gully representation by a rectangular cross-section form for computer modeling.

Hourly weather data including rainfall and temperature, and bi-weekly NDVI index are presented in Fig. 5. Major rainfall events were present during late summer 2016 and spring 2017. Soil loss was also detected within gullies during those two periods (3 and 8). Details of each survey period are summarized in Table 2.

All gullies showed cumulative soil loss including gully deepening and widening over the entire observation period in 2016. Each gully thalweg showed average loss of 10 to 15 cm of soil depth with gully surface area increasing by 2.5 m^2 (Fig. 3). Gully shape was converted from actual 3-D elevation model to multi-segment rectangular shape for its representation in gully modeling. Each gully segment had width, depth and length calculated from each survey data.

While few rainfall events were responsible for gully advancement, some events brought sediment that was deposited at the bed of the gully channel (Fig. 2). This contrasts with sheet and rill erosion, which has soil movement detected for each event.

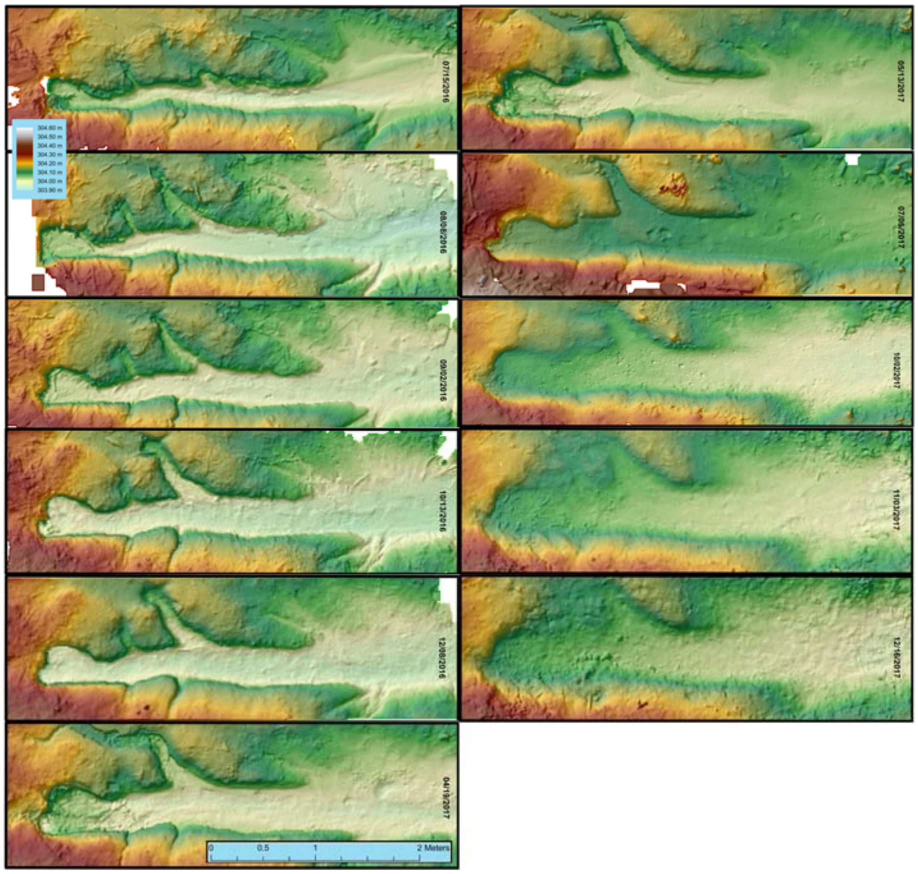

Figure 2. Digital elevation models for 11 field surveys of Gully 1.

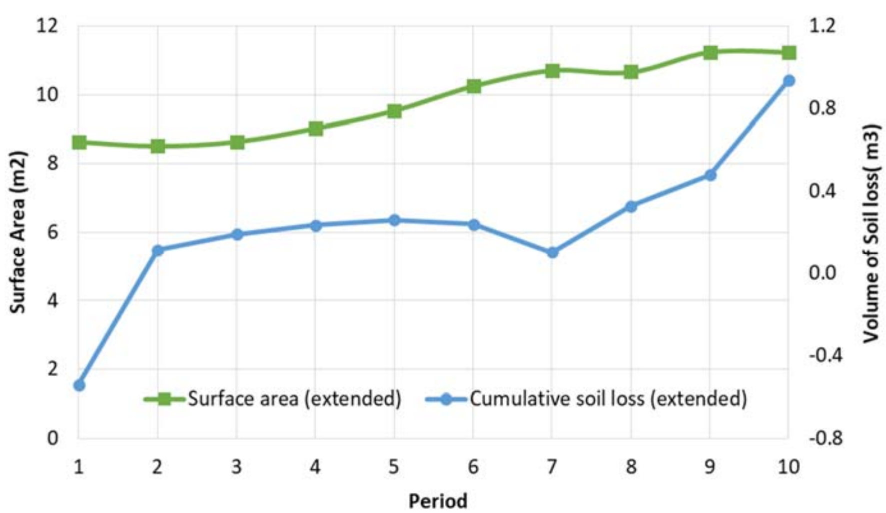

Figure 3. Changes in surface area and volume of soil lost/gained for periods between consecutive surveys.

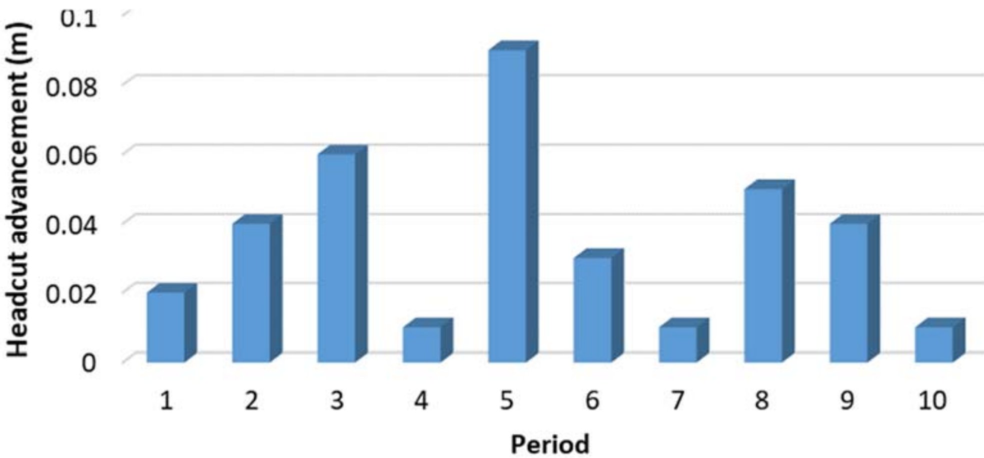

Figure 4. Rate of headcut migration for Gully 1. Each period is determined between two consecutive surveys.

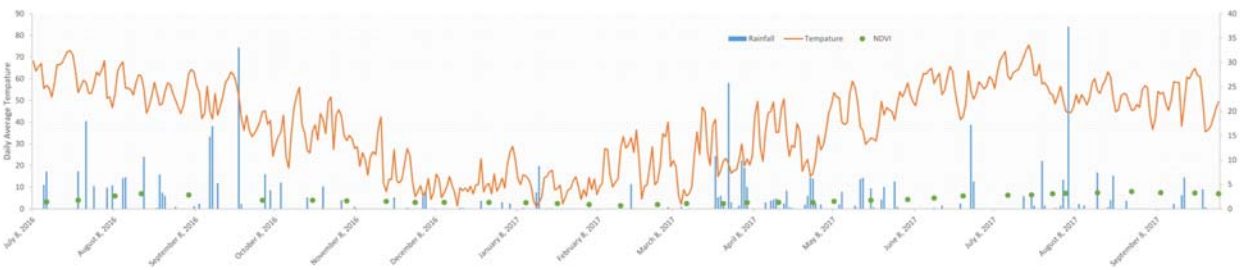

Figure 5. Average daily temperature, precipitation, and NDVI during study periods of 2016 and 2017.

Table 2. Main characteristics for periods between surveys.

Survey Period	No. Days	No. Wet Days	No. Rainfall Events	Peak P (mm/h)	Total P (mm)	Average NDVI	Total Soil Loss (m^3/ha)		
							Gully 1	Gully 2	Gully 3
7/13/2016-7/15/2016	3	1	2	16	17	0.6	59.0	68.7	92.3
7/15/2016-8/08/2016	24	6	29	20	90	0.8	90.2	96.9	74.1
8/08/2016-9/02/2016	25	8	24	12	84	0.7	93.2	100.4	88.2
9/02/2016-10/13/2016	41	11	45	42	201	0.4	125.0	158.8	98.7
10/13/2016-12/08/2016	56	8	33	6	41	0.3	-70.0	-63.2	-68.4
12/08/2016-4/19/2017	132	36	149	11	224	0.2	74.3	65.1	82.7
4/19/2017-5/13/2017	24	11	61	7	63	0.6	14.2	8.5	9.3
5/13/2017-7/05/2017	53	15	49	13	124	0.8	14.8	9.0	9.7
7/05/2017-10/02/2017	88	23	75	35	216	0.7	-7.0	5.2	-1.8

4. Integrated ephemeral gully modeling

4.1. Model framework

A physically-based predictive model was developed for ephemeral gully soil loss estimations. The model combines hillslope hydraulic and erosion modeling by the WEPP model and modified Foster-Lane model for channel erosion (Fig. 6). The hillslope event-based model takes soil type, rainfall depth, representative pathway, and management practices as inputs among other parameters, and calculates output hydrograph and sediment loads at the end of hillslope pathway. These flow characteristics are used as inputs into a headcut segment of the gully. Within the channelized part of the gully, channel flow is routed downslope with a kinematic wave modeling approach, sediment is transported according to sediment transport equation and limited by transport capacity, while channel cross-sections are adjusted for channel flow shear stress and eroded downward and sideway within each time step. The model is developed for a single event with a dynamic time-step.

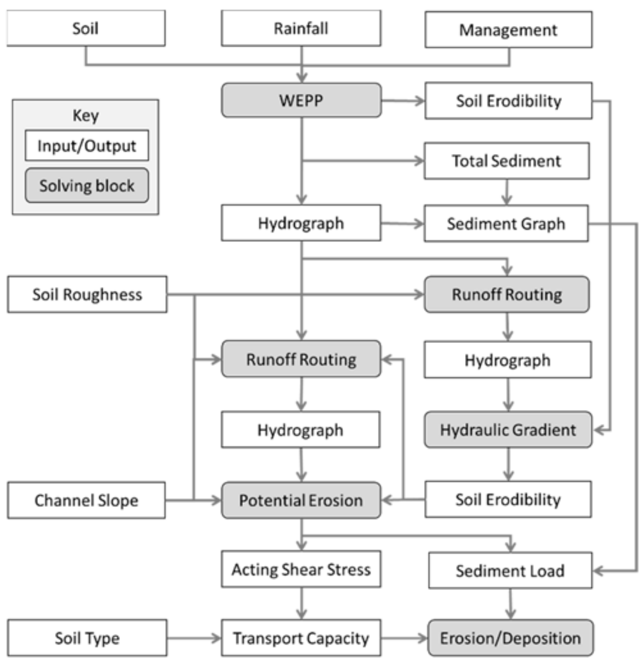

Figure 6. Flowchart of the integrated hillslope-gully erosion model. Shaded boxes represent main solving modules of the integrated gully model.

Changes in rectangular channel shape (or channel erosion) occur due to soil detachment at channel walls, channel bed erosion and/or sediment deposition. Soil erosion or accumulation depends on multiple factors: overland flow rate, sediment loads from headcut and side catchments, and channel present shape. While these conditions regulate the amount of soil potentially leaving each channel segment for each time step, actual erosion depends on transport capacity. If it is exceeded, soil deposition occurs. The potential channel erosion is computed based on the modified Foster and Lane model (Foster & Lane, 1983) with an assumption of the infinite transport capacity. Widening and deepening rates depend on the distribution of the acting shear stress over the wetted perimeter of the channel. Channel initially adjusts the width and forces downward movement of the bottom.

Once the non-erodible layer is reached, widening begins at a decreasing rate accounting for distribution of the acting shear stress. Dynamic behavior of downward and widening rates depends on unsteady hydrograph of channel flow with potential multi-tier channel cross-sectional profile. More details on the integrated erosion model can be found at Karimov and Sheshukov (2017) and Karimov (2017; Chapter 6).

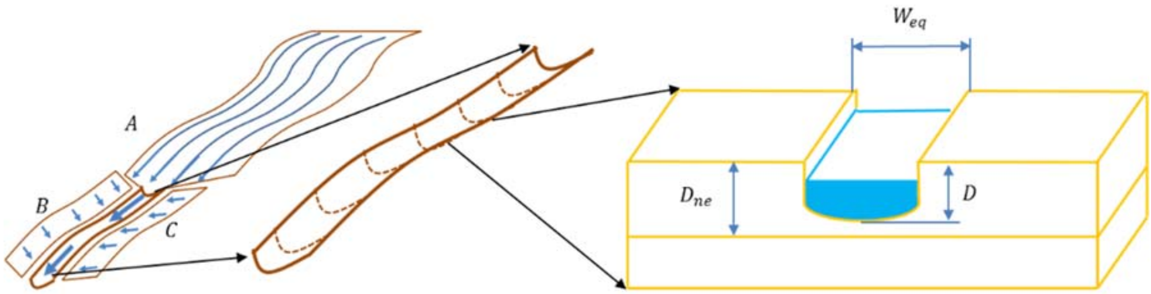

Figure 7. Schematic representation of hillslope headcut drainage area (A), sideway drainage area (B, C), ephemeral gully segments, and channel cross-section.

4.2. Results

The integrated channel erosion model was applied to observed ephemeral gully development. Seven rainfall events with return periods of 1, 2, 5, 10, 25, 50, and 100 years were simulated with WEPP built-in weather component. All events had duration of 4 hours, maximum rainfall intensity of 307.3 (mm/hr), time to peak of 30%, and precipitation amount of 70, 82, 102, 119, 145, 166, and 188 mm that were respective to the corresponding return periods of 1, 2, 5, 10, 25, 50, and 100 years. Each rainfall simulation had baseline (conventional tillage) and two implemented BMPs: no-till and conversion to CRP. Parameters used in WEPP are presented in Table 3.

Table 3. Input parameters to the hillslope model for three BMP scenarios.

Parameter	units	Management scenario		
		Till	No-till	CRP
Plant	-	Corn	Corn	Bluestem
Bulk density after last tillage	g/cm3	1.3	1.3	1.3
Initial canopy cover (0-100%)	%	90	90	90
Days since last tillage	days	60	420	20000
Days since the last harvest	days	270	720	20000
Initial frost depth	cm	0	0	0
Initial interrill cover (0-100%)	%	50	90	56
Cumulative rainfall since last tillage	mm	150	1700	500
Initial ridge height after last tillage	cm	2	2	1.7
Initial rill cover (0-100%)	%	50	90	61
Initial roughness after last tillage	cm	2	2	0.8
Depth of secondary tillage layer	cm	10	10	10
Depth of primary tillage layer	cm	20	20	20
Initial rill width	cm	0	0	0
Initial total dead root mass	kg/m2	0.5	0.4	0.2
Initial total submerged residue mass	kg/m2	0.2	0.1	0

The results of baseline and two BMP scenarios are presented in a form of total soil loss from the catchment as a combination of sheet-and-rill erosion and ephemeral gully erosion. Total soil loss and ephemeral gully-only soil losses are plotted in Figure 8 versus precipitation for three scenarios and two antecedent soil moisture conditions.

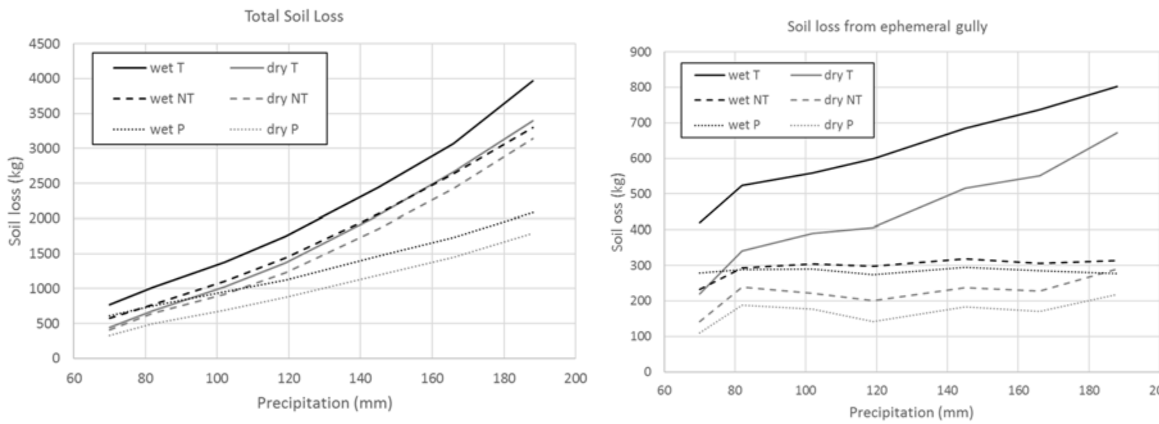

Figure 8. (a) Total (hillslope and gully) and (b) ephemeral gully-only soil loss for three BMPs and two antecedent soil moisture conditions (T-tillage; NT-no-till; P-CRP).

The results show an increase of soil loss with the increase of precipitation. For all managements and all rainfalls, dry initial condition produced less erosion than wet condition. As expected, an application of no-tillage and conversion to CRP significantly reduced total erosion rates compared to conventional tillage. Interestingly, conversion to CRP has a larger impact for higher precipitation events as compared no-till scenario.

Similarly to total sediment loss, soil erosion from ephemeral gully for conventional tillage baseline increases with the precipitation increase. Also, low antecedent soil moisture condition produces less erosion than soils with higher initial soil moisture content. In addition, ephemeral gully erosion for two BMP scenarios levels off at a certain erosion rate and does not depend on the amount of precipitation for either soil moisture condition.

Additional testing of the integrated channel erosion model is needed to fully understand the intricate details of soil losses associated with ephemeral gully erosion, hillslope erosion, and overland flow.

5. Future work

In years 1 and 2, we established field measurements and collected continuous and survey data for three gullies. The elevation, runoff, and elevation datasets will allow us to restore the dynamics of runoff events for computer model calibration. In year 2, we developed a framework for integrated channel erosion model and tested it on a collection of rainfall events applied to studied gully. In year 3, the computer model will be applied to more rainfall and runoff events specific to gully 1, 2 and 3 developments between selected consecutive surveys. We will also finalize data analysis from gully surveys.

Monitoring the Effectiveness of Streambank Stabilization Projects in Northeast Kansas

Basic Information

Title:	Monitoring the Effectiveness of Streambank Stabilization Projects in Northeast Kansas
Project Number:	2016KS186B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	KS-001
Research Category:	Water Quality
Focus Categories:	Sediments, Water Quantity, None
Descriptors:	None
Principal Investigators:	Charles J Barden

Publications

There are no publications.

KWRRI Annual Progress Report

Title: Monitoring the Effectiveness of Streambank Stabilization Projects in Northeast Kansas

Research category: Water Quality

Focus Category: Sediments, Water Quality

Primary PI: Charles J. Barden, Horticulture and Natural Resources, Kansas State University, 1712 Claflin Road, Throckmorton 2021, Manhattan,KS 66506, cbarden@ksu.edu, (785) 532-1444

Reporting Period: 3/1/2017 – 2/28/2018

Project Goals and Objectives

The project goal is to quantify the environmental benefits of government-sponsored streambank stabilization and restoration projects in northeastern Kansas, with a focus on sites within the Kickapoo Tribe in Kansas and Prairie Band Potawatomi Nation Indian Reservations. Specific objectives are to:

1) Document the erosion and deposition rates of existing streambank stabilization sites;
2) Compare the performance of cedar revetment and rock vein and weir projects;
3) Conduct bio-assessment surveys to document aquatic organism presence at stabilized sites compared to nearby unstabilized reaches.

Field Data Collection

Stream bioassessments with macro invertebrates sampling were conducted twice on two sites in the past year on the Delaware River and Plum Creek, both on the Kickapoo reservation (Figure 1). The sampling was conducted in May and June 2017. Sample areas on the Delaware River were sites with rock weirs and riparian buffer plantings. Control sites were unstabilized reaches immediately downstream. The Plum Creek site had a redcedar revetment installed in 2013, and the control site was immediately downstream. The classification of biodiversity indices to water quality ratings are shown in Table 1. Data from those assessments are shown in Tables 2 and 3.

The team visited long-term streambank monitoring sites to search for bank pins on a site near Axtel in Nemaha county (installed March 2007), and on Little Soldier Creek on the Prairie Band Potawatomi Nation (installed March 2000). Only one pin was found, on the Little Soldier Creek Site.

Site Selection for New Cedar Revetments

Several sites were examined on the Kickapoo reservation for installing new revetments as part of this project. Also, several sites were nominated by the Delaware River Wraps coordinator and Kansas Forest Service staff. Two sites were selected for installation in the spring of 2017, on Little Grasshopper Creek (March) in Atchison county and Wolfley Creek (April) in Nemaha county, both within the Delaware WRAPS area. Substantial sediment (154 cubic yards) was trapped by the Little Grasshopper Creek revetment (Figure 2), and the Wolfley Creek revetment trapped 62 cubic yards from high stream flows.

Outreach and Technology Transfer

The two watershed foresters with the Kansas Forest Service were involved in the planning and installation of the cedar revetments, and viewed several previously treated and potential project sites.

In May 2017, the study sites on the Potawatomi and Kickapoo reservations were included on a field tour for the North Central Extension Water Summit "Building Collaboration Between State Land Grant Universities and Tribal Colleges". There were 35 participants from several state universities and tribal colleges across the region, along with several state and federal agencies. Also the PI presented about the current study at the summit.

A project poster was presented at the Governor’s Water Conference in November in Manhattan.

Project staff helped organize an Earth Day celebration and lessons at the Kickapoo Nation School on April 20, 2017.

Graduate training

One MS graduate student, Denisse Benitez Nassar, was partially supported by this project, and began her program in January 2017 in the Horticulture and Natural Resources department. She plans to complete her studies in December 2018. An intern, Ricardo Choriego, worked on the project from January – April 2018, from Zamorano University in Honduras.

Future Work in Year 3

Research

A set of bank pins were inserted above stabilized and unstabilized reaches at both sites, and they will be monitored for erosion over the coming months.

We will repeat the macroinvertebrate sampling with the assistance of Haskell students on the Kickapoo sites in May and June 2018. Data collection should be complete by the end of August, 2018, with analysis and results complete by December 2018.

Outreach

A research poster will be presented at the Society of American Foresters national convention in October, 2018, in Portland, Oregon**.**

Figure 1. Haskell Indian Nations University students assisted K-State researchers in conducting the bioassessment by sampling macro invertebrates on the Delaware River

Table 1 Biotic Index table to estimate water quality rating

Biotic Index	Water Quality Rating
0.00-3.75	Excellent
3.76-4.25	Very Good
4.26-5.00	Good
5.01-5.75	Fair
5.76-6.50	Fairly poor
6.51-7.25	Poor
7.26-10.00	Very poor

Table 2. Delaware River macroinvertebrates biodiversity indices results from May 15 and June 15, 2017 sampling.

	Delaware			Delaware Control		
Channel Unit	Riffle	Cut Bank	Pool	Riffle	Cut Bank	Pool
Biotic Index	2.00	4.53	4.58	3.99	4.91	5.5
Shannon	3.14	1.03	1.13	2.74	1.94	0.64
Simpson	85%	63%	61%	76%	77%	38%

Table 3. Plum Creek macroinvertebrates biodiversity indices results from May 15 and June 15, 2017 sampling.

	Plum			Plum Control		
Channel Unit	Riffle	Cut Bank	Pool	Riffle	Cut Bank	Pool
Biotic Index	4.35	4.47	4.37	4.91	4.88	4.53
Shannon	1.74	8.40	0.62	19.26	1.40	1.05
Simpson	85%	81%	68%	81%	48%	70%

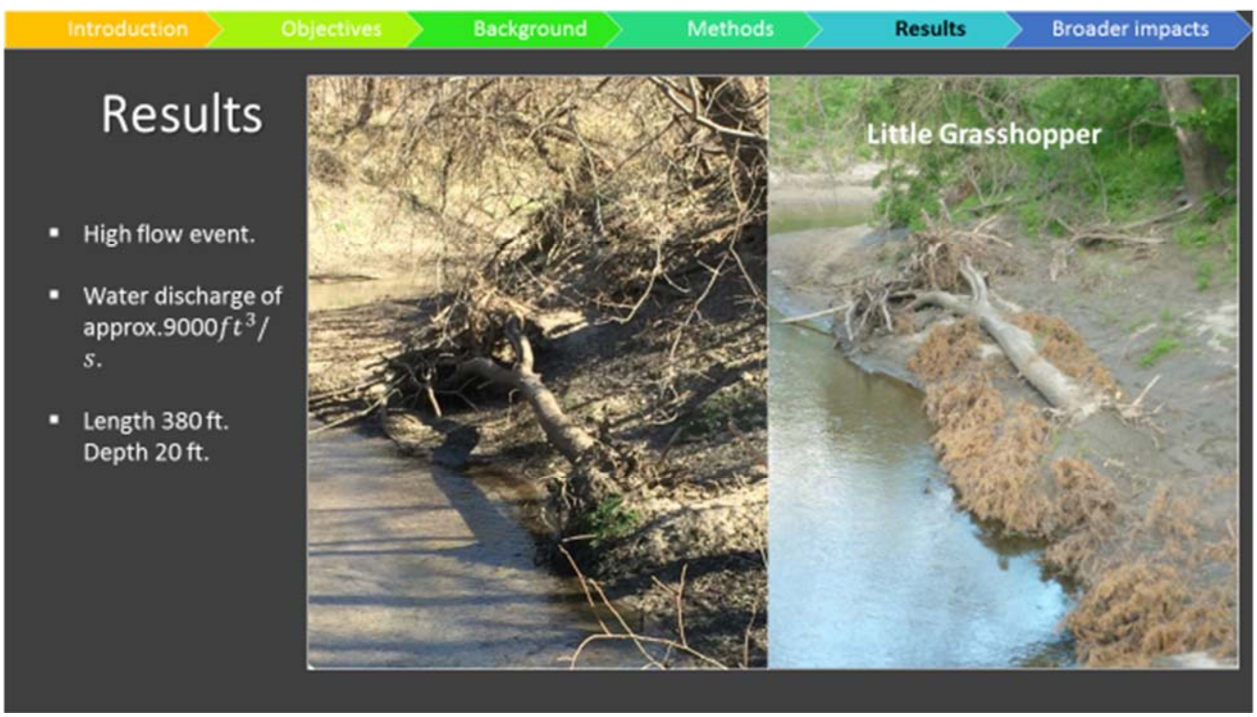

Figure 2. Before and after redcedar revetment installation on Little Grasshopper Creek in Atchison County. An estimated 154 cubic yards of sediment were trapped by the revetment.

Assessing the impact of constructed wetlands on nitrogen transformation and release from tile outlet terraces (TOTs) in Kansas

Basic Information

Title:	Assessing the impact of constructed wetlands on nitrogen transformation and release from tile outlet terraces (TOTs) in Kansas
Project Number:	2016KS187B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	KS-001
Research Category:	Water Quality
Focus Categories:	Wetlands, Sediments, None
Descriptors:	None
Principal Investigators:	Pamela Sullivan, Ted Peltier

Publications

There are no publications.

Title: Assessing the impact of constructed wetlands on nitrogen transformation and release from tile outlet terraces (TOTs) in Kansas.

Research Category: Nutrient Transport and Transformation

Focus Category: Nitrogen

Primary PI: Pamela L. Sullivan, University of Kansas (KU), Department of Geography and Atmospheric Science, Lawrence KS, plsullivan@ku.edu, (785)-864-6561

CO-PI: Edward Peltier, University of Kansas (KU), Civil and Environmental and Architectural Engineering, Lawrence KS, epeltier@ku.edu, (785)-864-2941

Abstract

The goal of this work was to determine the influence of tile outlet terrace (TOT) croplands that are connected to constructed wetlands on fluxes of nitrogen and sediment. Work on this research commenced in June 2016 and will continue through through December 2018. In this report we focus on the data from 2017 from three TOT fields where tiles are drained to constructed wetlands. During this period we measured water fluxes and water chemistry into and out of the wetlands. Rainfall, water velocity and water levels were measured continuously, while automated samplers facilitated the collection of water chemistry during storm events and grab samples were collected weekly/biweekly from within the wetlands to understand wetland water chemistry variability. Over the next year we will continue with water sampling collection, collecting soil water in fields using lysimeters and finish bulk chemical analysis of soil. We will use these data together to separate storm hydrographs to event and pre-event water, determine the sources and interactions of pre-event water and develop a conceptual model of N transformation and flux for TOT systems.

Introduction

Nitrogen (N) contamination of water bodies pose serious risks to human health and ecological services. Enhanced applications of N fertilizer over the past ~60 years have also been concomitant with increases in bicarbonate (HCO_3^-), metals and metalloid concentrations in some of our largest river systems (Raymond and Cole, 2003; Stets et al., 2014). The transformation of N is sensitive to the availability of oxygen (O_2): NH_4^+ produces NO_3^- and protons (H^+) through nitrification by autotrophic bacteria in the presence of O_2, while NO_3^- can be reduced by denitrification in the absence of O_2, consuming protons. These processes can take place at roughly the same time depending on the soils O_2 availability (Reddy et al., 1976), but the overall production of H^+ drives soil acidification and chemical weathering, which releases metal and metalloids into solution (Semhi et al., 2000).

Unfortunately, while research efforts have focused on developing BMPs for fertilizer application, N contamination to surface water and more recently shallow and deep groundwater remains a real threat (Burow et al. 2010; Gurdak and Qi, 2012). For example, groundwater in the Central Plains has been highlighted to have some of the highest groundwater NO_3^- concentrations. In Kansas, roughly 0.03 to 0.12 t ha^{-1} of N fertilizer is applied annually for agriculture, and long term studies of N fertilizer purchase suggests the rate of consumption has increased at ~8% over the last decade (EPA, 2015). Thus, questions still remain as to the transformation, transport and fate of N under varying agricultural practices and its influence of metal and metalloid transport.

One runoff control practice that has been employed for the last century is tile outlet terraces. Here, the goal is to reduce surface runoff (and associated erosion) by effectively creating a sewer drainage system within an agriculture landscape. As such, the hydrology of the landscape is transformed, water is allowed to pool in depressions on the landscape before entering surface pipes where it is transmitted in the subsurface to the outlet drainage system (ditch or stream). While a larger proportion of water is lost through the tile drains this re-routing of water alters natural subsurface flow paths to increase infiltration, lateral vadose zone water flow and soil-water interaction, and thus enhances adsorption/desorption processes and colloid mobility. Until recently these systems emptied directly into adjacent streams, enhancing the transport of dissolved nutrients between the agricultural fields and streams. New BMPs that create wetland intermediaries to capture nutrients from the outflow are now being tested. The development of these tile outlet terrace systems and constructed wetland systems begs the questions: *how have these modification altered water flow across the system and the transformation and fate of N?* and *what is the effect of wetland design on nutrient capture effectiveness?*

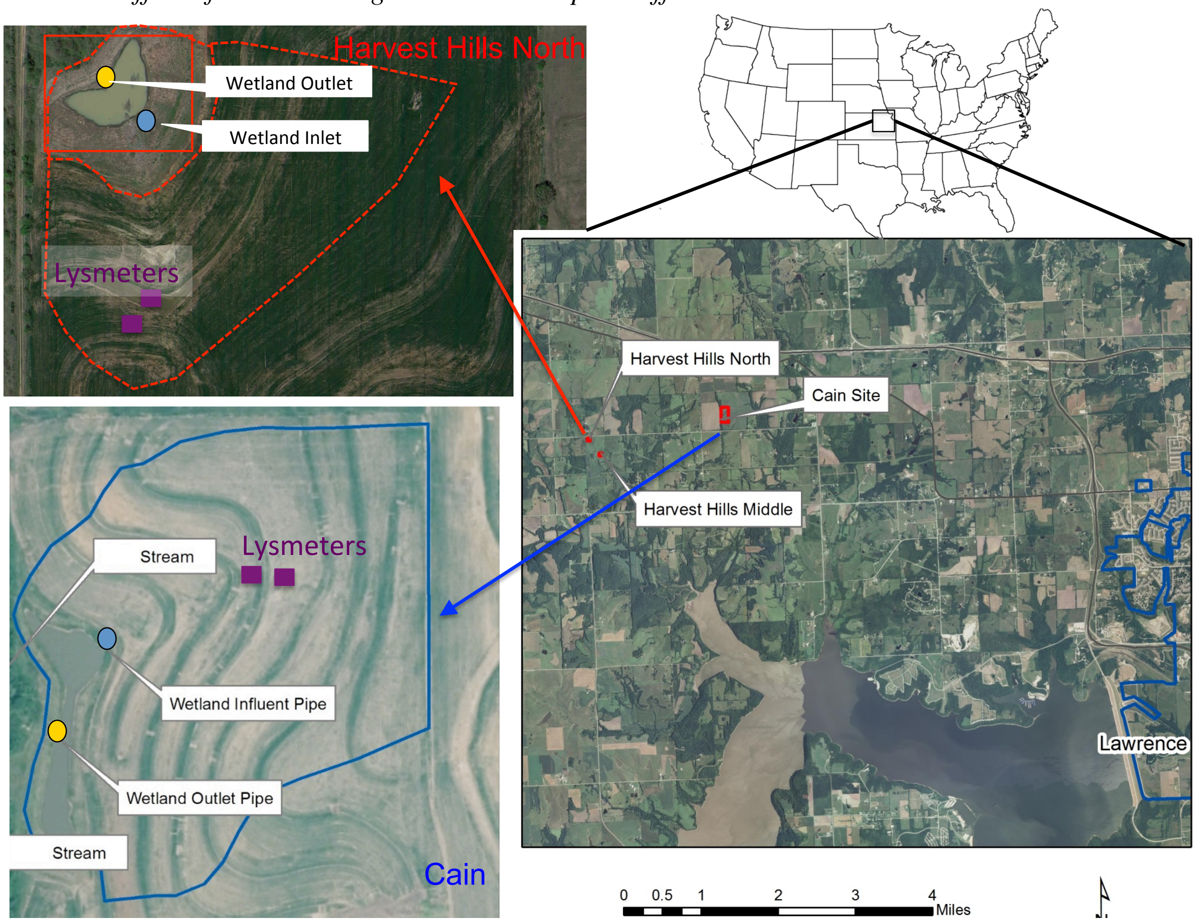

Fig. 1 Two tile outlet terraces (TOTs) with constructed wetlands at the outlet were monitored in 2016. These fields are located in the Wakarusa Watershed and drain to Clinton Lake, main drinking water supply for the city of Lawrence. Water from the inlet and outlet pipes as well as soil water was collected and measured over this period.

Study Area: In 2017 three tile terraced cropland systems located within the Wakarusa Watershed in Douglas County, KS, and drain to Clinton Lake were examined for this project (Fig. 1): Harvest Hills North (HHN) *(*38°59'05.5"N, 95°27'19.0"W), Harvest Hills Middle (38°58'57.5"N 95°27'12.3"W) and Cain (38°59'21.9"N, 95°25'19.9"W). All sites are (Fig. 2): 1) terraced and consist of slight ridges and depressions across the landscape, 2) have perforated standpipes, located in the depressions, connect to the tiles helping to drain depressions, and 3) have tiles that discharge to constructed wetland ponds (built between 2008-2011), which eventually discharge to nearby intermittent streams through a weir box. The streams drain into the Clinton Lake, a main drinking water supply to the city of Lawrence (KS).

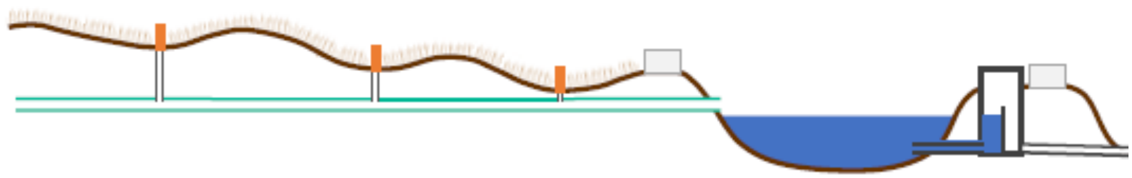

Fig. 2 Diagram of tile outlet terraces and associated wetlands for the Harvest Hills North, Harvest Hills Middle and Cain fields. The orange boxes represent the perforated standpipes, located in depressions, that connect to the tiles below the surface.

Harvest Hills North and Harvest Hills Middle drains ~ 10.6 ha and consists of seven terraces (HHN = 7, HHM = 3), while Cain drains ~ 16.6 ha and consists of six terraces. In 2017, Harvest Hills North and Harvest Hills Middle was planted with soy, while Cain was planted with soy on the four upland terraces and corn on the lower two terraces.

The agricultural research sites are located about 20 km west of Lawrence, and are separated by ~3.2 km. The general lithology of Douglas county (which encompasses the research sites), consists of limestone, shale, and sandstone. The local climate of Lawrence and extending areas are continental and the growing season spans ~196 days. The average annual temperature according to NOAA (1981-2010 Normals; https://www.ncdc.noaa.gov) is 12.4 °C and ranges from 30.3 °C in the summer to -6.3 °C in the winter. The average annual precipitation is 1013 mm with ~70% of the total precipitation falling in the spring and summer months.

Methods

Water Flux Measurements and Water Sample Collect From Tile Outlet and Wetland

The water flux and sample collection methods were configured the same for the HHN, HHN and Cain outlets. Here, the tile outlet, the pipe that connects to the drainage tiles from field to the wetland, was equipped with a velocity area meter (Model 750, ISCO) to determine water flux (discharge, m^3/s) from the pipe into the wetland and automated water sampler (ISCO Model 6712 Full-Size Portable Samplers) to collect samples. The velocity area meter records both velocity and depth of water. Discharge (m^3/s) is the product of the velocity (m/s) and the filled water area (m^2) in the pipe. The area (A) is solved using the following equation

$$A = \frac{R^2}{2}(\theta - sin\theta)$$

where R is the radius of the circle and θ is the central angle in radians.

At the wetland outlet two configurations were used: at HHN and HHM, the outlet pipe that drained the wetland went to a weir box that was outfitted with a pressure transducer (Model 720, ISCO) and automated water sampler (ISCO Model 6712 Full-Size Portable Samplers) to collect samples, while at Cain, a culvert directly drained the wetland and water levels were determined at the mouth of the culvert using a pressure transducer (Model 720, ISCO) and water samples were collected from inside the culvert using an automated water sampler (ISCO Model 6712 Full-Size Portable Samplers). The outlet discharge (Q, ft^3) from the HHN and HHM sites was calculated using a stage-discharge relationship:

$$Q = 3.33 \times L \times H^{1.5}$$

where L is the width across the weir and H is the height of water above the weir crest. For the Cain outlet a rating curve was employed

$$Q = 1.511 \times S^2 - 3116.195 \times S + 1606117.046$$

where Q, discharge (ft^3) is related to S, stage (ft, elevation). Discharge values where then converted from ft^3 to m^3.

All data collected from the tile outlet is referred to as *Inlet* data (e.g., HHN_Inlet, HHM_Inlet, and Cain_Inlet), while data collected from the wetland outlets is referred to as *Outlet* data (e.g., HHN_Outlet, HHM_Outlet, and Cain_Outlet). At all automated sensors (velocity meters and pressure transducers) collected data at a 1-minute frequency, while water samples were collected every 30 minutes per storm event once flow was detected at the velocity meters at the inlet sites or once a specific water height surpassed for the outlets sites. Water then was collected for the 12 hours following the rain event given velocity and water levels were large enough to produce flow into or out of the wetland. Within one day of the rain event, water samples were collected from ISCOs. In addition, to tile outlet velocity, precipitation was also measured at the inlets using a standard rain gauge tipping bucket (674 Tipping Rain, ISCO). Rain measurements were also collected at a 1-minute interval. In 2017, inlet and outlet sites were outfitted with equipment at the HHN, HHM and Cain in May 2017 and were removed at the end of November 2017. Grab water samples were also collected weekly to bi-weekly from the wetlands to quantify changes in the wetland water chemistry between rain and flow events.

Soil Water Sampling from Suction-Cup Lysimeters

In March 2017, nested suction-cup lysimeters (SK20, Decagon) were installed at 30, 60, and 90 cm in to the soil using an auger specific to the diameter of the suction-cups. Soil samples were collected from the auger every 10 cm for bulk geochemical analysis. Nested lysimeters were installed at a ridgetop and depression couplet of one terrace at each of the field sites to quantify nutrient transformation with depth under more (ridgetop) and less (depression) drained conditions. A hand held pump was used to apply suction to the lysimeters, lysimeters were vacuumed to ~100 PSI. Water samples were collected weekly from lysimeters given water availability.

Water Chemistry Measurements

All water samples were immediately brought back to the lab, aliquoted for appropriate chemical analysis (unfiltered, filtered with 0.8 μm filter, and filtered with 0.45 μm filter) and then stored in a refrigerator at 4°C. Unfiltered samples were analyzed for total nitrogen (TN) and phosphorus (TP). Water was then filtered through a 0.8 μm filter for total dissolved nitrogen (TDN) and phosphorus (TDP) analyses. TN and TDN were prepared for analysis using alkaline-persulfate digestion that oxidizes inorganic and organic nitrogenous compounds to nitrate (Reschke et al., 2014). TP and TDP were prepared for analysis acidic persulfate digestion that oxidizes organo-phosphates to inorganic ortho-phosphate (v). A Shimadzu 1650-PC UV/Visible light spectrophotometer was then used to determine the concentrations of TN, TDN, TP and TDP. Suspended load in the water samples was determined by weight change on the 0.8 μm filters, filters were dried and weighed prior to filtration and then dried and weight post filtration, given ample water was collected 250 ml of sample was filtered. Finally, the water underwent a second filtration using 0.45 μm nylon filters, this water was analyzed for major anions and cations (preserved with HCL) using a Dionex IC-1600. Anion analysis included measurements of chloride (Cl-), nitrate (NO_3^-), and sulfate (SO_4^-) while cation analysis included measurements of sodium (Na^+), potassium (K^+), magnesium (Mg^{2+}), ammonium (NH_4^+) and calcium (Ca^{2+}).

Results from 2017 and Future Analysis

Hydrology

During the 2017 monitoring period (~114 days), there were 40, 20 and 40 rain events recorded at the Cain, HHN and HHM, respectively. Rainfall events averaged 1.18, 1.42 and 0.52 cm for Cain, HHN and HHM, respectively (Fig. 3). A minimum threshold of flow, 0.1 m/s, was necessary for water sampling collection to take place, given this restriction, we collected 6 of the 13 flow events that produced enough flow for sample collection at the inlets of HHN, HHM, and Cain, respectively (Fig. 3). Overall the magnitude for velocity and water level responses at Cain inlet was greater than that of HHN and HHM, which is not surprising given the Cain field is nearly triple the size of the HHN field and five times the HHN field.

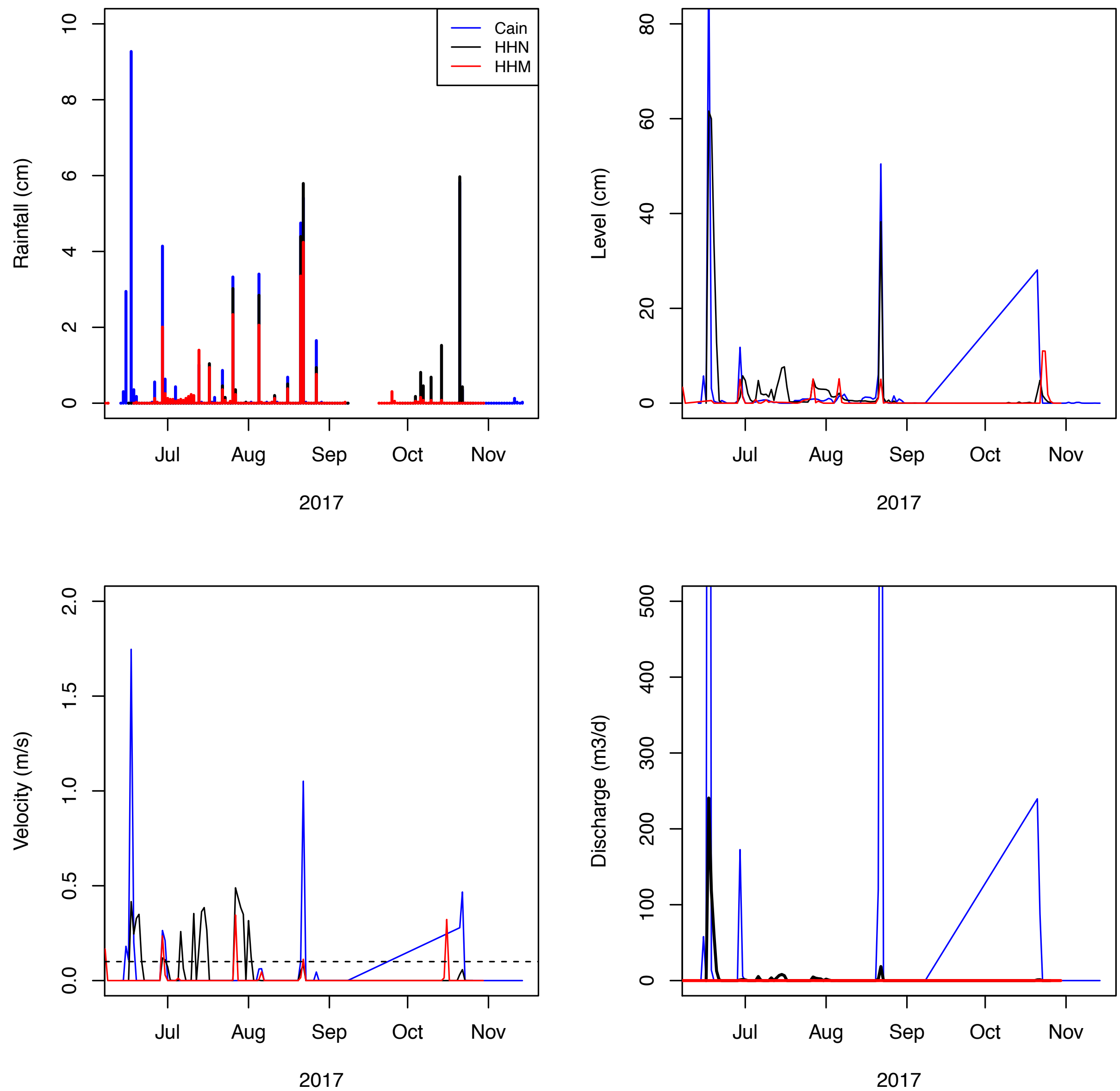

Figure 3. Rainfall (top left), water level (top right), velocity (bottom left) and discharge (Q, bottom right) for Cain (blue), HHN (black), and HHM (red) inlets for 2017. Dotted line indicates minimum velocity needed for samples to be collected.

Hydrograph responses at the inlets differed in terms of duration, frequency of events, and rising-falling limb dynamics (Fig 4). Flow events at Cain were much longer in duration and size compared to HHN, while the smallest flow events and duration of events was observed at HHM. In addition, the response of the discharge curve following rain events differed for all sites with a much longer recession curve observed at the Cain site compared to HHN and HHM. We will be analyzing these curves in terms of the number of dry days prior to the flow event to determine how potential soil moisture conditions govern the hydrograph response at these different sites and the impact on the concentration and fluxes leaving each location.

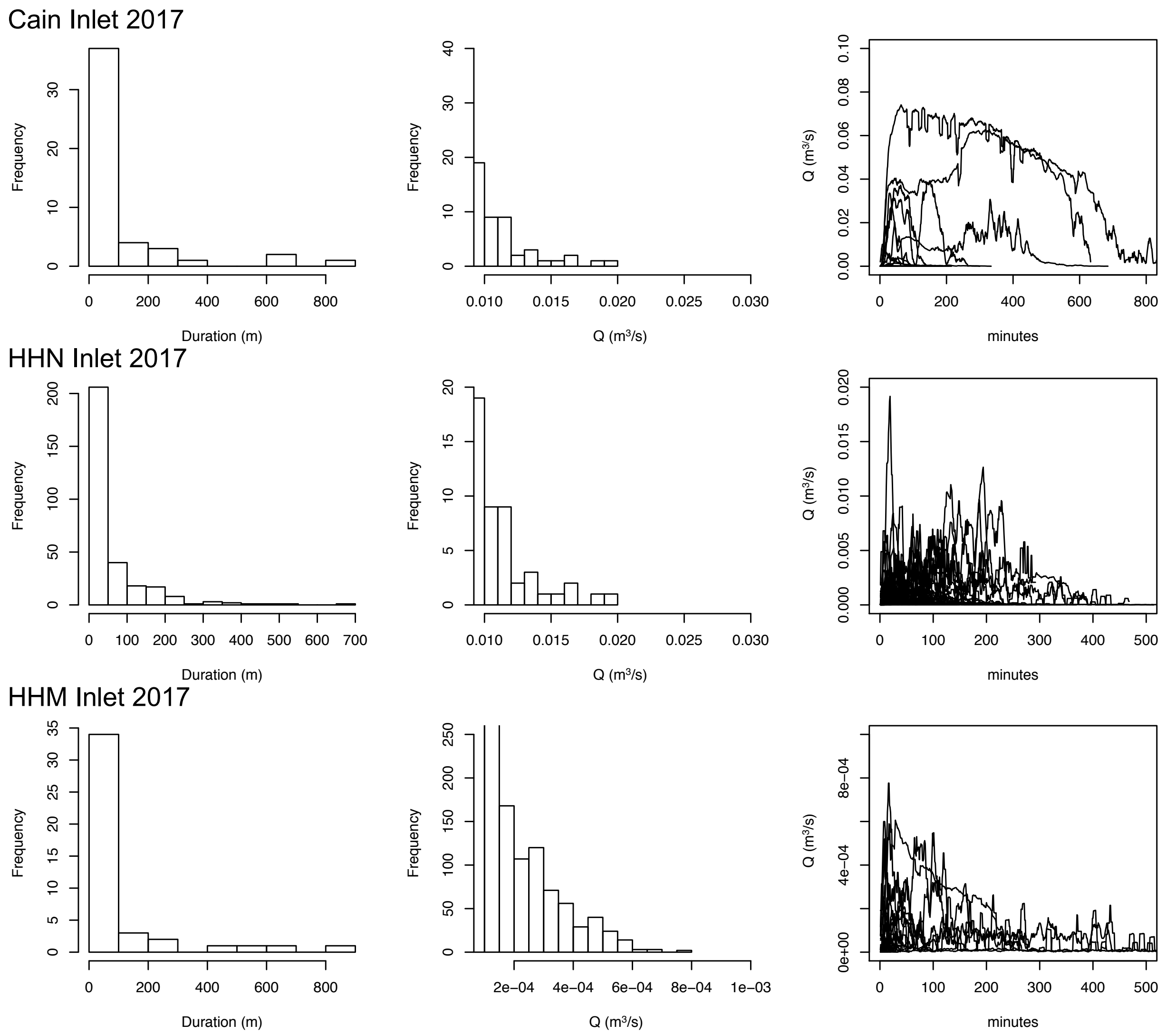

Figure 4. Flow patterns at Cain (top), HHN (middle) and HHM (bottom) for the 2017 monitoring period. Flow duration (left), distribution of discharge (Q) events (center) and shape of Q events (right) differed amongst the sites.

Water Chemistry

Multiple approaches were used to monitor water chemistry at the inlet, within the wetland and from the outlet over the study period. Cation analysis is still on going for many of the samples and will be presented with the final report. Here, we report back on concentration of total nitrogen (TN), total phosphorus (TP), total dissolved N (TDN), total dissolved P (TDP), total suspended solids (TSS), nitrate (NO_3^-), chloride (Cl^-) and sulfate (SO_4^{2-}).

WETLAND CHEMISTRY

For the wetlands themselves, grab samples were collected weekly to biweekly to monitor variability over the growing season and early fall (Fig. 5). Compared to inlet averages, concentrations were generally lower in wetlands compared to the inlet water for most measured constituents. A larger fraction of the total phosphorus in the wetlands was in the dissolved form compared to the inlet. Site specific analysis for the wetlands is still on going.

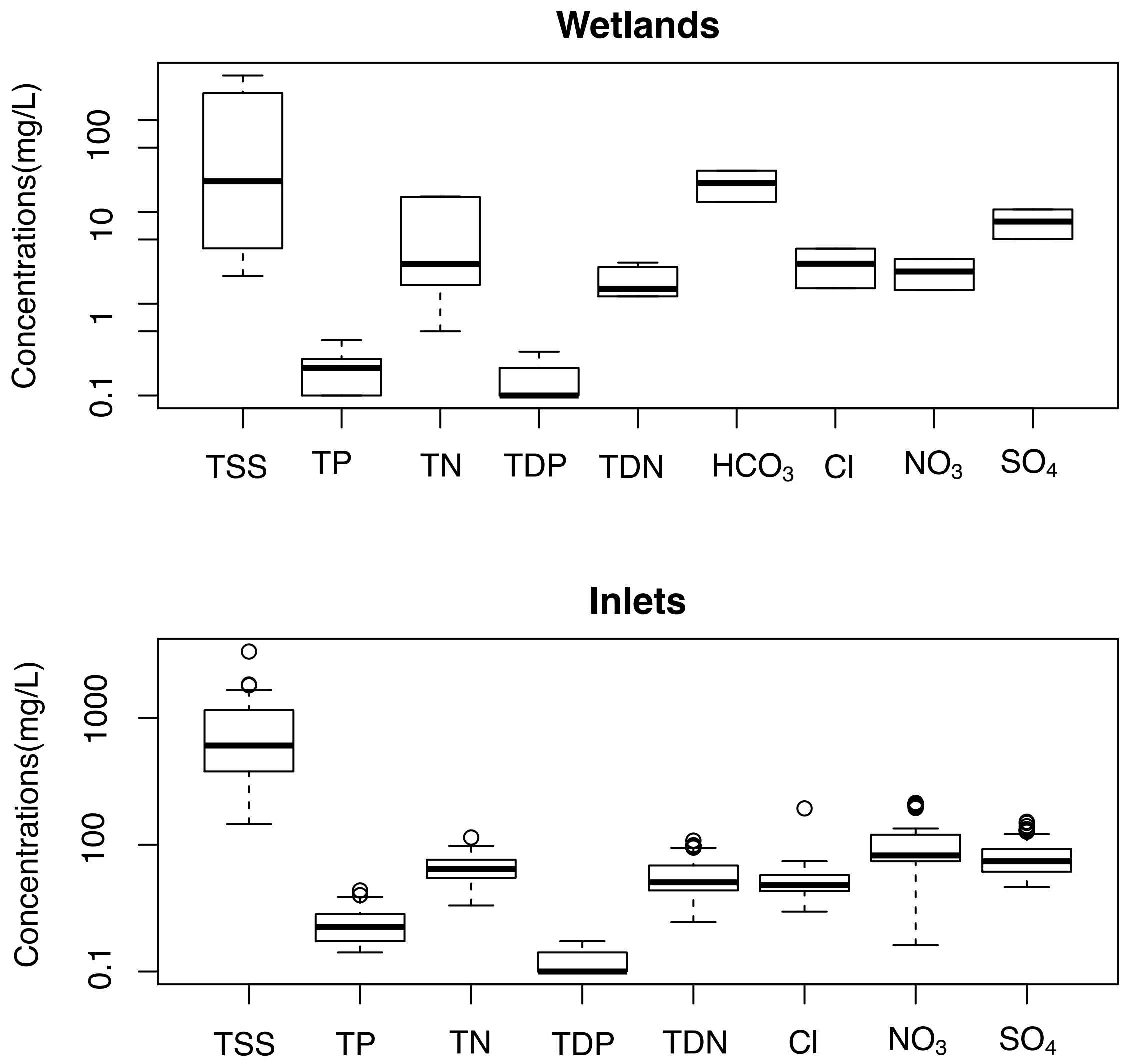

Figure 5. Wetland (top) and inlet (bottom) water chemistry from 2017(left to right): total suspended sediment (TSS), total phosphorus (TP), total nitrogen (TN), total dissolved phosphorus (TDP), total dissolved nitrogen (TDN), alkalinity (HCO_3, only wetlands) chloride (Cl), nitrate (NO_3), and sulfate (SO_4).

STORM EVENT WATER CHEMSITRY

In 2017, six storm events were collected from the inlet locations (Cain_inlet = 2, HHN_inlet = 3, HHM_inlet = 1), outlet events were not collected during these same inlet events because water levels in the wetlands were too low. In Figs 6-10 we present the concentrations compared to the discharge for these events and focus on the total suspended solids (TSS), total phosphorus (TP), total dissolved phosphorus (TDP), total nitrogen (TN), total dissolved nitrogen (TDN), chloride (Cl^-), nitrate (NO_3^-) and sulfate (SO_4^{2-}). The response of chemical species differs per storm events but large changes in the concentrations of Cl^- and SO_4^{2-} over each event suggests that different portions of the landscape are likely contributing solutes over each event, while the reduced response of variability in the total and dissolved nitrogen and phosphorus suggests these nutrients are amply abundance across the landscape. We anticipate that the cation analysis for these samples will be completed within the next two months and that we will start to explor mixing model options and concentration-discharge hysteresis patterns.

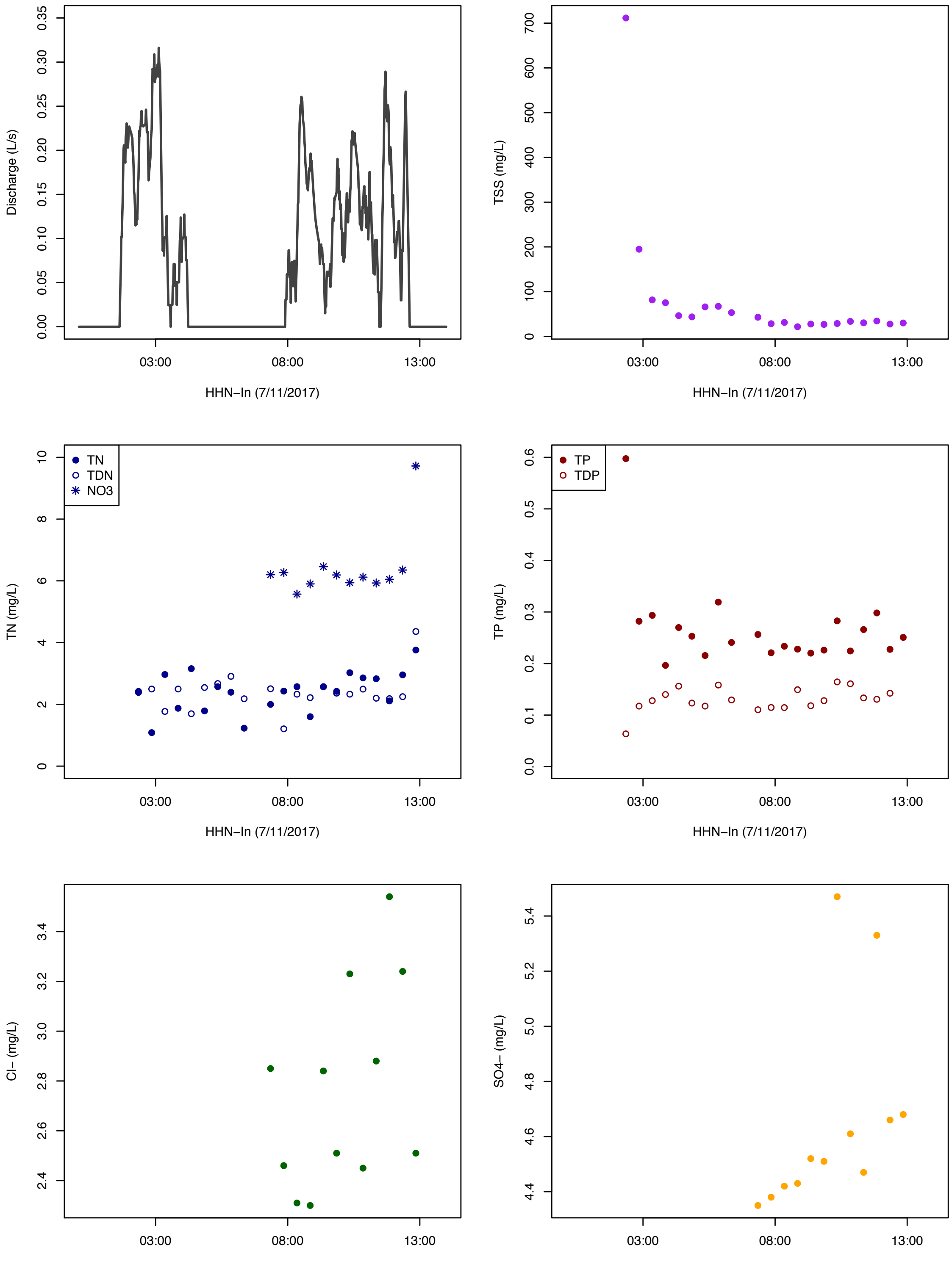

Figure 6. Hydrograph (top left) and water chemistry for the HHN inlet on 7/11/2017.

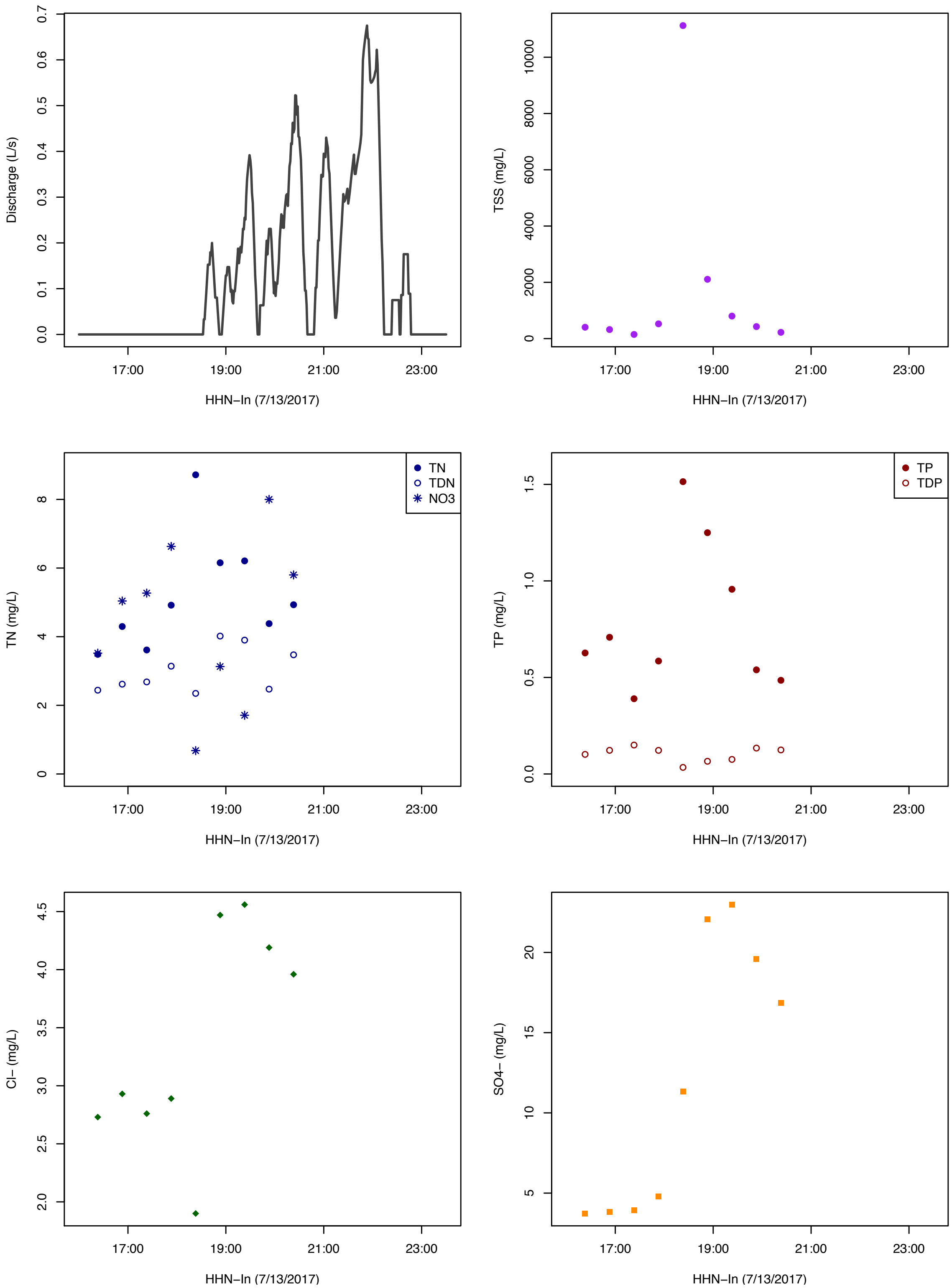

Figure 7. Hydrograph (top left) and water chemistry for the HHN inlet on 7/26/2017.

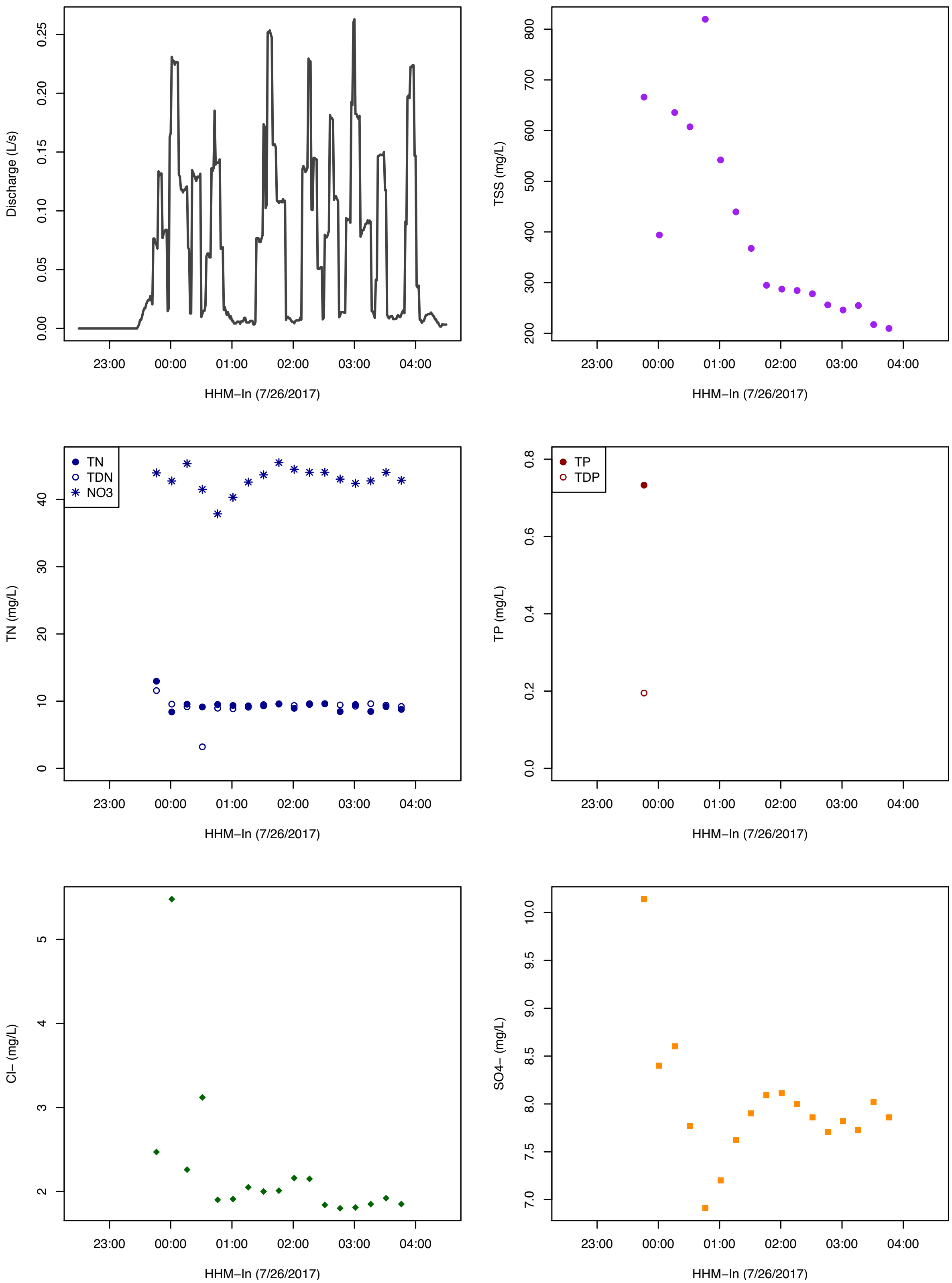

Figure 8. Hydrograph (top left) and water chemistry for the HHM inlet on 7/26/2017.

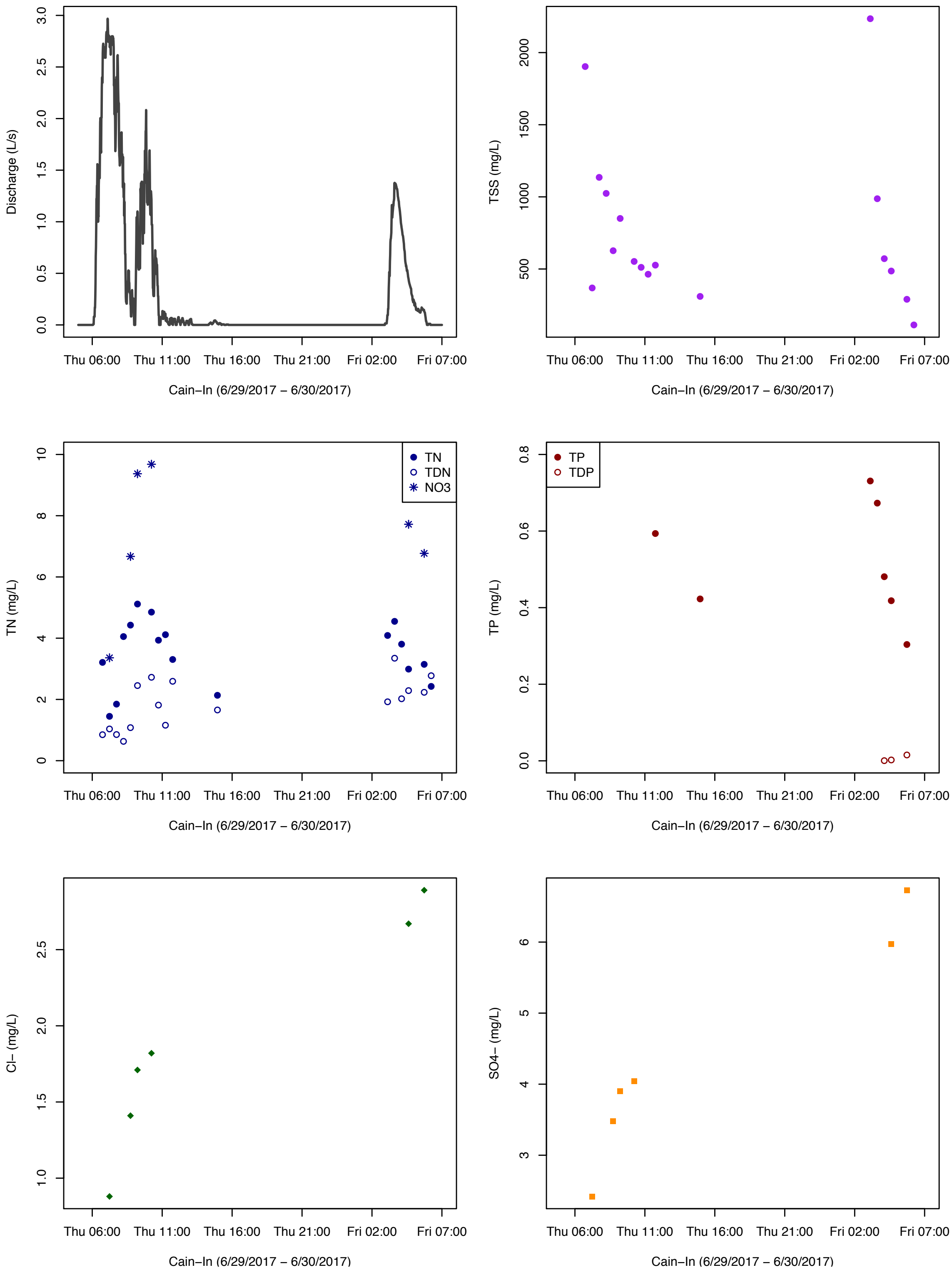

Figure 9. Hydrograph (top left) and water chemistry for the Cain inlet on 6/30/2017.

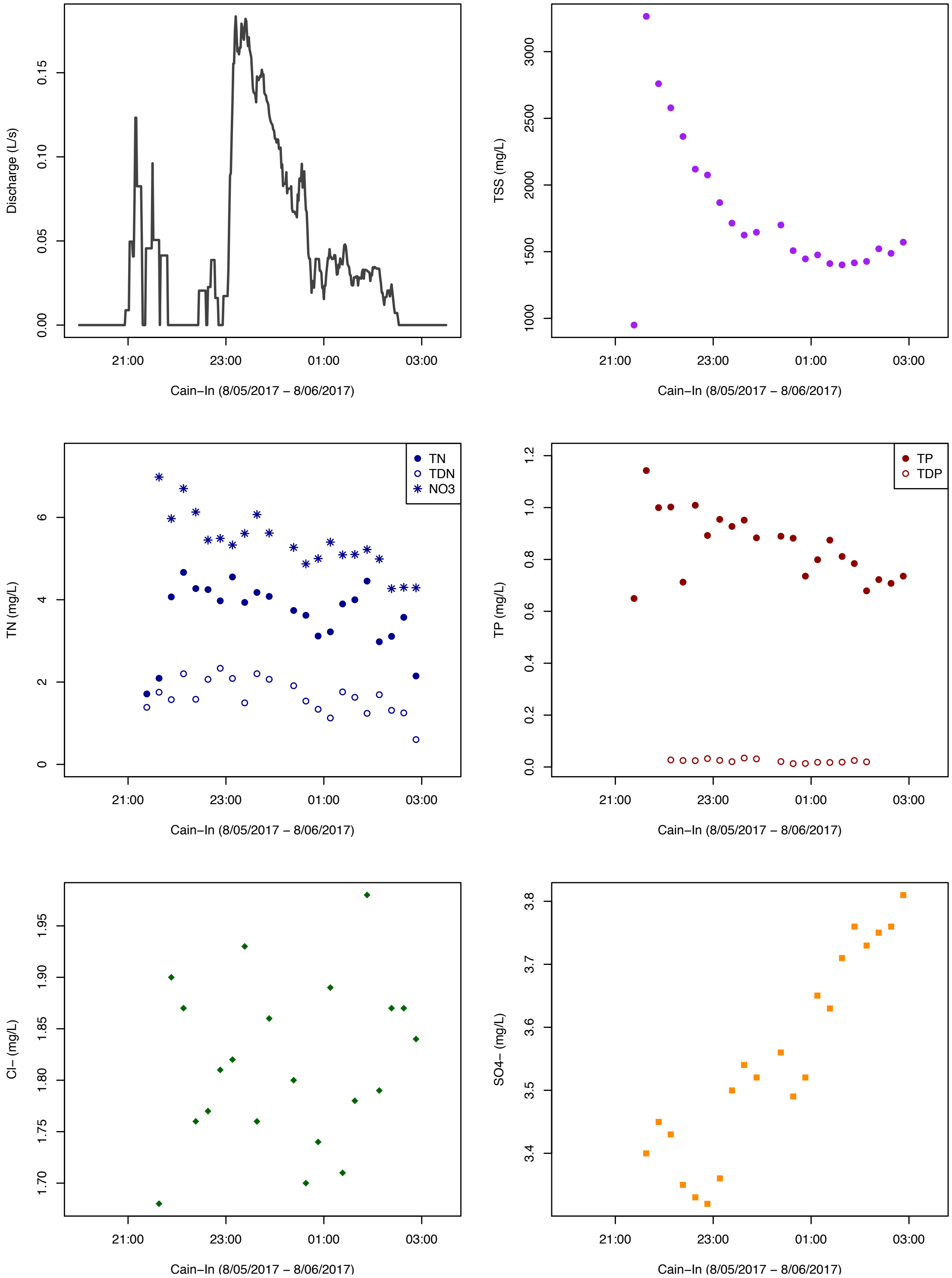

Figure 10. Hydrograph (top left) and water chemistry for the Cain inlet on 8/05/2017.

LYSIMTER WATER CHEMISTRY

Soil water was collected using lysimeters at three depths 30, 60 and 90 cm at “ridgetop” and “depression” positions on the landscape. Anion analysis (HCO_3^- Cl^-, NO_3^-, and SO_4^{2-}) of soil water chemistry is presented in Fig 11. In general, HCO_3^- and SO_4^{2-} increased with increasing depth, except at HHN_B where it was elevated at all depths. Cl^- had the highest observed concentrations at the mid depth position (60 cm) but values at all depths spanned the entire range (1-82 mg/L). Across sites the most elevated concentrations of Cl^- were observed in the HHN sites, while the lowest values were generally observed in the depressions at Cain and HHM. The concentrations of NO_3^- in the soil water had a similar pattern to that of the Cl^-, spanning a large range in concentrations at all depths, but here NO_3^- was generally elevated at the surface and decreased with depth. Across the sites HHN generally had the most elevated NO_3^- concentrations, while Cain had the lowest. These differences between Cain and HHN, suggests differences in the rate of soil water flushing between the two locations, with a greater degree of flushing occurring at Cain compared to HHN.

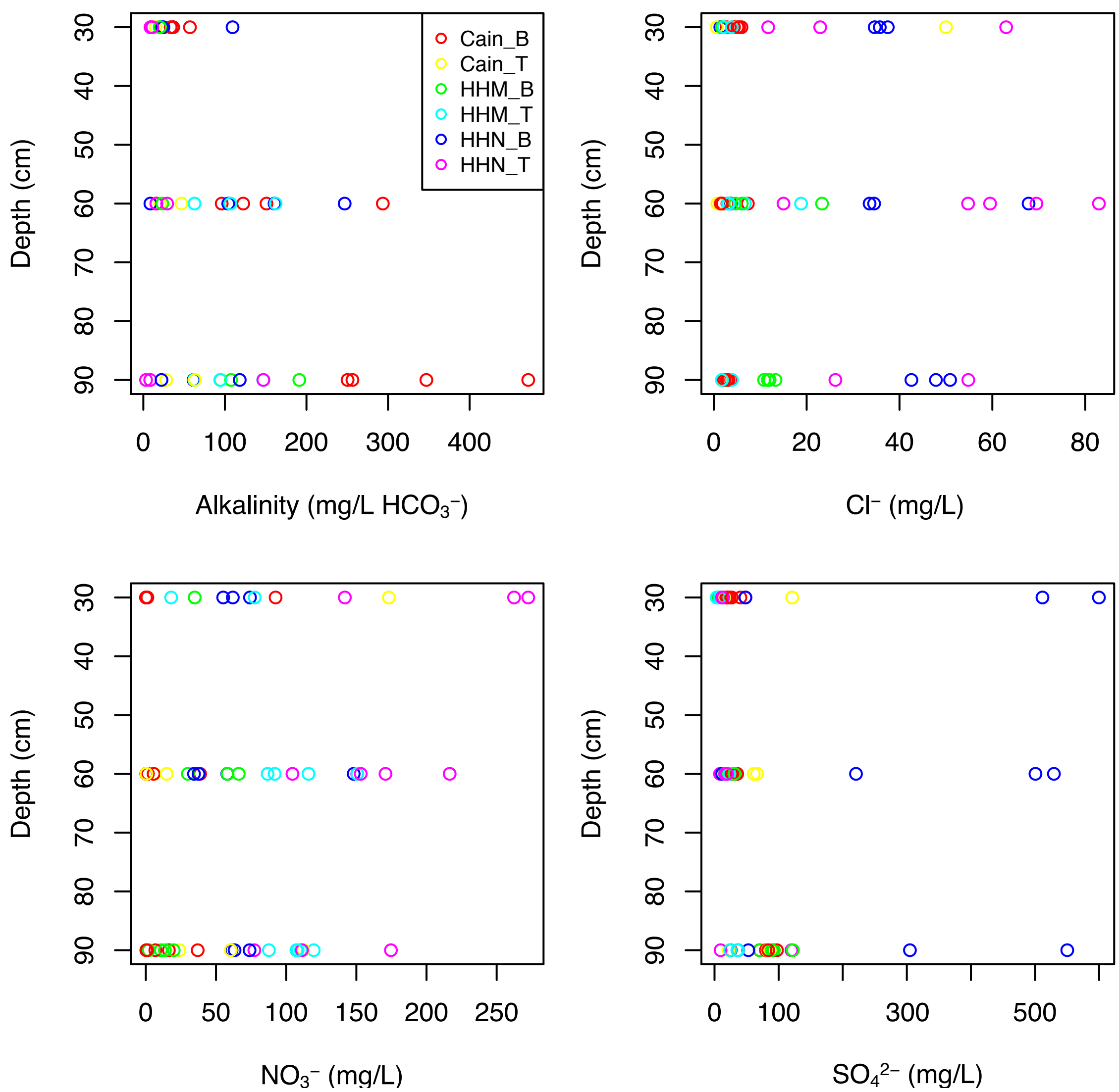

Figure 11. Soil water anion chemistry (alkalinity, Cl^-, NO_3^-, and SO_4^{2-}) from three Cain, HHN and HHM at the ridgetop (T) and depressions (B) in the terraced landscape for depths of 30, 60 and 90 cm.

S

ampling and Analysis in 2018

All water measurements will continue in 2018. In addition, wetland soil samples will be collected in May 2018 and October 2018. Hydrograph analysis will continue and mixing models will be developed to elucidate chemical fluxes through the inlet. Finally, overall effectiveness of the wetlands will be established by comparing inlet and outlet chemical fluxes.

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Contaminant Barriers or Pathways? Hydraulic and chemical methods to improve characterization of shallow aquitards.

Basic Information

Title:	Contaminant Barriers or Pathways? Hydraulic and chemical methods to improve characterization of shallow aquitards.
Project Number:	2016KS188B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	KS-001
Research Category:	Water Quality
Focus Categories:	Groundwater, Water Quality, None
Descriptors:	None
Principal Investigators:	Jordi Batlle-Aguilar, James J Butler

Publications

There are no publications.

Project number: 2016KS188B –progress report year 2.

Project Title: **Contaminant barriers or pathways? Hydraulic and chemical methods to improve characterization of shallow aquitards**

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1 Introduction and project goals

Shallow aquifers are heavily exploited for drinking-water and irrigation supplies. These aquifers are often part of multi-layered systems where confining layers (aquitards) play a paramount role in "isolating" an aquifer from overlying or underlying units with poorer quality waters. The "isolating" capability of an aquitard - i.e., its ability to serve as a protective barrier to point (e.g., accidental spillage) or diffuse (e.g., agricultural fertilizer, manure, and pesticides) contamination - is commonly characterized using the vertical component of hydraulic conductivity (K_Z). This parameter, which in a simplistic fashion is often assumed to be 0.1 of its horizontal component (K_H), requires more confident estimates when it comes to protecting groundwater used, directly or indirectly, for human supply. The vertical hydraulic conductivity of an aquitard can be estimated using hydraulic or chemical methods; each method represents specific spatial and temporal scales and is based on a certain set of assumptions. The key questions commonly faced by practicing hydrogeologists are what method is the most appropriate for a particular application, and how much uncertainty is associated with the method selected.

The main goal of this research project is to explore the variability of K_Z estimates on shallow aquitards using different methods. The first field site chosen for this project is the Geohydrologic Experimental and Monitoring Site 2 (GEMS2). This progress report presents the project results we have obtained from GEMS2.

2 Field site location and hydrogeology

The Geohydrologic Experimental and Monitoring Site 2 (GEMS2), a Kansas Geological Survey (KGS) research site, was selected as a representative shallow clay aquitard with a confined alluvial aquifer underneath. The site is located northeast of Lawrence, Kansas, in the alluvial plain of the Kansas River, at 30 meters distance from Mud Creek (Figure 2). Previous Electrical Conductivity (EC) direct push logging performed on the site suggested that overlying the confined aquifer are 7 m of clay and 2 m of silt at the surface. The sandy-gravel confined aquifer, approximately 11 m thick, is bounded underneath by low permeability bedrock (Liu et al., 2012).

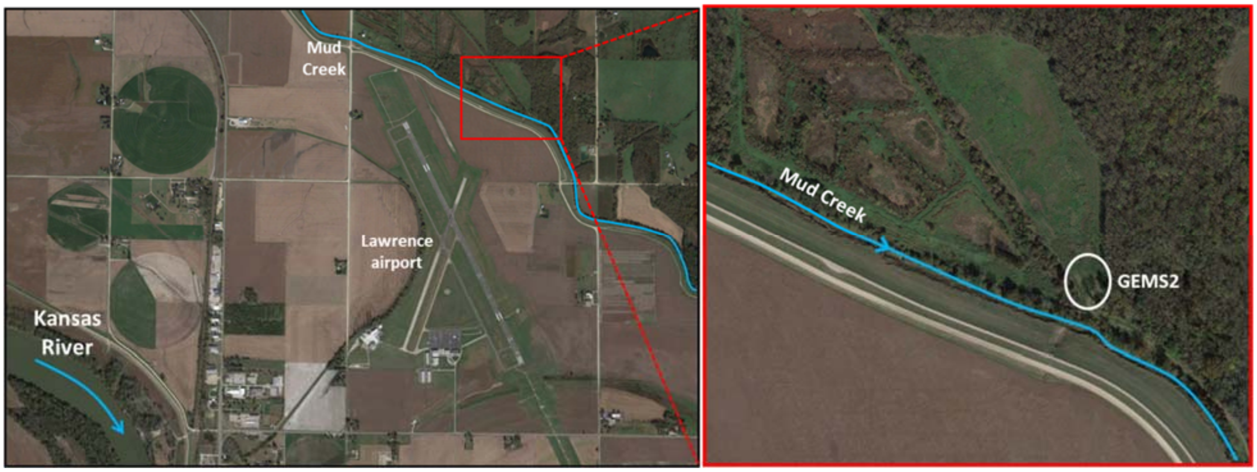

Figure 1. Location of the study site GEMS2 (Geohydrologic Experimental and Monitoring Site 2) (source: Google Earth).

3 Materials and methods

3.1 Drilling, coring and instrumentation

The aquitard at GEMS2 was equipped with four aquitard piezometers and two vibrating wire piezometers (VWP). Screen depths for the aquitard piezometers and VWPs were selected based on a direct-push EC profile performed at the study site in August 2016 (Figure 2). Drilling and equipment installation were performed between August 2016 and April 2017. Four aquitard piezometers were drilled with a maximum intake zone of 1 m, at increasing depths (in meters below ground): G2J1 (3.8–4.0 m), G2J2 (5.0–6.0 m), G2J3 (6.0–7.0 m), and G2J4 (7.0–8.0 m). Two vibrating wire piezometers, VWP1 and VWP2, were installed at 5.5 m and 7.5 m depths, respectively, with their pressure-sensitive diaphragm located at 5.7 m and 7.7 m.

Each of the four aquitard piezometers was drilled using a dual-rod system (8.25 cm outer diameter [OD] with a shoe 8.78 cm OD) using the KGS Geoprobe® 7822DT. Both inner and outer rods were simultaneously driven to the depth where the top of the screen would be located. There, the inner rods and attached drive point were removed from inside the outer rods. A thin-walled sample barrel (5.3 cm OD × 4.6 cm inner diameter [ID]) with attached cutting shoe (5.4 cm OD) and a plastic liner (4.2 cm ID) with core catcher inside were then lowered back inside the cased hole. The entire outer rod string, along with the sample barrel and liner installed inside at the lower end, was advanced for half a meter. After a 0.5 m soil core was sampled into the plastic liner, rod advancement ceased, and the sample barrel was retrieved. This process was repeated once more, obtaining a total of two cores for each intake zone. Given the plasticity of the clay, each of the two extracted cores expanded by approximately 30% inside the liner (Figure 3).

Prior to installing the piezometers, the outer rod string was pulled up by 1 m, leaving an open interval below the lower end of the string. To remove the potential impact of soil expansion upon the withdrawal of rod string, the sidewall of the 1 m open interval was scraped several times with an 8.6 cm diameter brush. Instead of using a PVC screen, the open interval was filled with clean industrial quartz sands to allow collection of groundwater for sampling and water level monitoring. In piezometers G2J2–G2J4, the entire 1 m interval was filled with the clean sands, and the outer steel rods above the sands were left on site until the sands became completely saturated. After the sands were completely saturated, a PVC pipe (3.175 cm OD) was lowered inside the outer rods and pushed 2.5 cm into the sands. The rods were pulled up slowly while the open space between the PVC and the aquitard was grouted to the land surface (Enviroplug® grout; K approximately 1×10^{-11} m s^{-1}). In piezometer G2J1, only the lower 30 cm of the 1-m open interval was initially filled with the sands; and without waiting for the sands to saturate, a 3.175 cm (OD) PVC pipe was pushed 2.5 cm into the sands on the same day of drilling. With the top of the PVC sealed with a cap to avoid contamination inside the piezometer, the area between the aquitard and the PVC was filled with clean industrial quartz sands for 70 cm, followed by 10 cm of granular bentonite (Enviroplug® #16). Finally, the outer steel rod was pulled up slowly as the open space between the PVC and the aquitard was grouted. Details on each aquitard piezometer can be found in Table 1.

Boreholes for VWP1 and VWP2 were drilled following the same procedure as for piezometer G2J1. After adding 30 cm of clean sand at the bottom of the borehole, we lowered the VWP into each borehole and added 70 cm of sand, making the entire collection zone of the VWP 1 m long. The steel rods were left on site until the whole collection zone was saturated. Then, we added 10 cm of granular bentonite (Enviroplug® #16) followed by bentonite grout (Enviroplug® grout NSF/ANSI/60) to the land surface as the steel rods were pulled up. Two cores were collected in the 1 m collection zone of VWP1, and the whole vertical profile of VWP2 was cored every 0.5 m.

VWPs (Geokon 4500AL-170 kPa unvented) were connected to a solar-powered CR6 Campbell Scientific© datalogger, recording VWP readings every 5 min (Figure 4). VWP readings are converted to porewater pressure and corrected for temperature and barometric changes using a formula dictated by the instrument used.

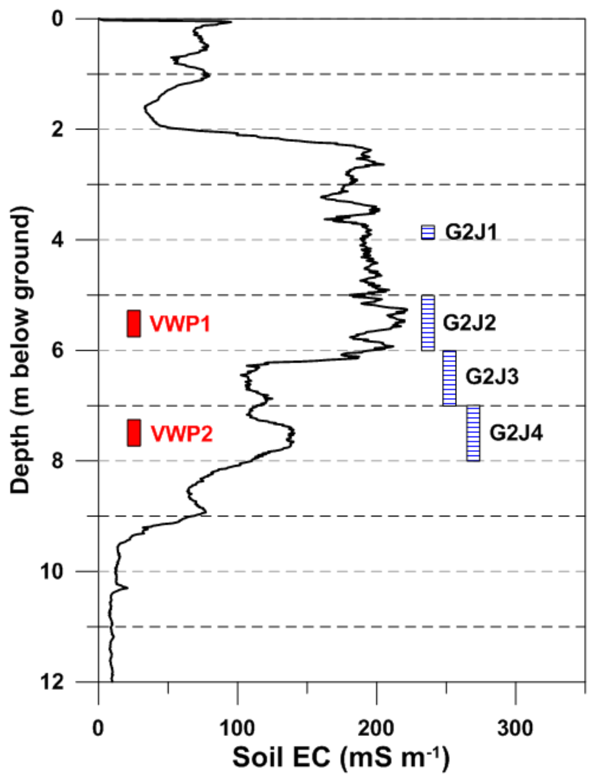

Figure 2. GEMS2 vertical profile showing the location of vibrating wire piezometers (VWP1 and VWP2) and screens of aquitard piezometers (G2J1–G2J4). Location of VWPs and aquitard piezometers screen were decided on the basis of the Direct Push (DP) Electrical Conductivity (EC) profile performed on the site. Low EC values represent sand and gravels, while high EC values represent clays. The top of the confined aquifer is located between 9 and 10 m below ground.

Figure 3. Two 0.5 m soil cores sampled from the screen interval of a piezometer.

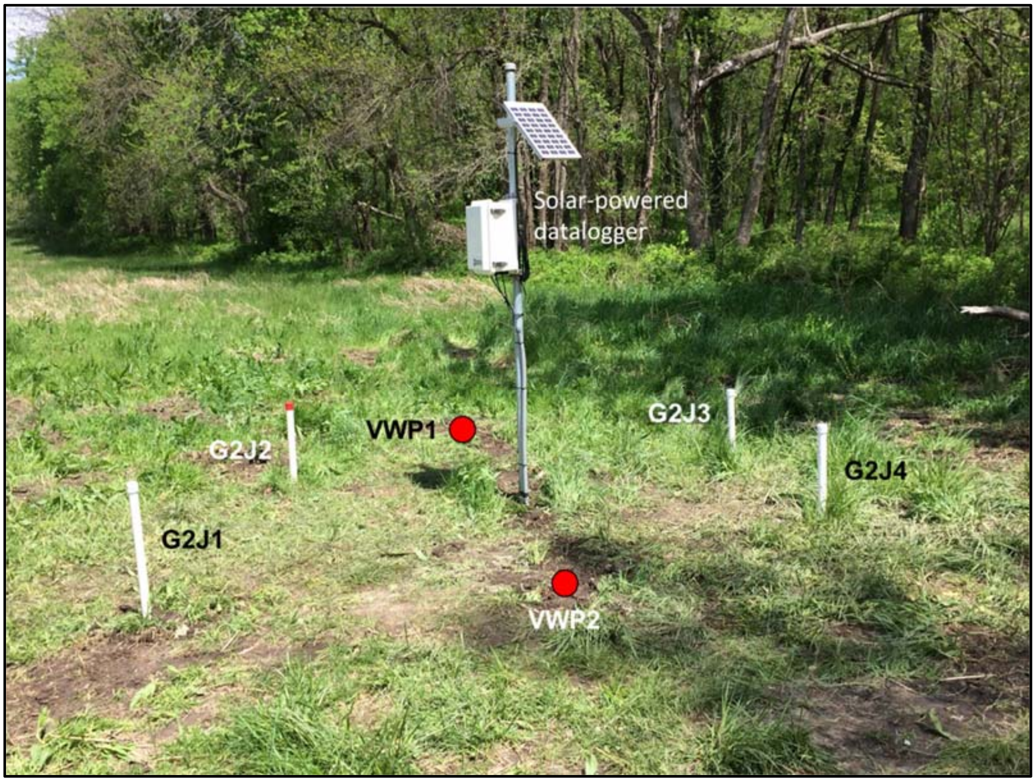

Figure 4. Geohydrologic Experimental and Monitoring Site 2 (GEMS2) setup and instrumentation. VWP1 and VWP2 are vibrating wire piezometers deployed at depths of 5.5 m and 7.5 m below ground, respectively. G2J1–G2J4 are piezometers screened in the aquifer at depths of 3.7–4.0 m, 5.0–6.0 m, 6.0–7.0 m, and 7.0–8.0 m, respectively. VWPs are wired to a solar-powered CR6 Campbell Scientific© datalogger with 5 min interval measurement and recording.

An existing well (C2; approximately 20 m from the aquitard piezometers) screened in the confined aquifer was equipped with a pressure transducer INW (Instrumentation Northwest Inc.) PT2X 0–30 psi at the center of the screen length. Effects of barometric fluctuations on piezometric heads are corrected using barometric pressures obtained from a barometer (INW PT2X 0–20 psi) installed inside at the top of C2. Pressure head and barometric fluctuations were monitored at 5 min intervals. The same monitored barometric fluctuations were used to correct porewater changes.

Table 1. Details of drilling and instrumentation at GEMS2 (mbg: meters below ground; r.n.a.y.: results not available yet)

Aquitard piezometers						
ID	**Total depth (m)**	**Screen depth (mbg)**	**Drilling date**	**Completion date**	**Time for sand to saturate (days)**	**Sampling date**
G2J1	4	3.7 – 4.0	4/19/2017	4/19/2017	r.n.a.y.	r.n.a.y.
G2J2	6	5.0 – 6.0	11/16/2016	4/19/2017	127	25/5/2017
G2J3	7	6.0 – 7.0	9/1/2016	9/27/2016	7	12/5/2016

G2J4	8	7.0 – 8.0	9/29/2016	10/19/2016	16	12/5/2016
Vibrating Wire Piezometers						
ID	**Total depth (m)**	**Diaphragm depth (mbg)**	**Drilling date**	**Grouting date**	**Time for sand to saturate (days)**	**Monitoring interval (mins)**
VWP1	6	5.7	8/30/2016	11/11/2016	57	5
VWP2	8	7.7	11/10/2016	4/19/2017	18	5
Confined aquifer						
ID	**Total depth (m)**	**Screen depth (mbg)**	**Pressure transducer**	**Barometer**	**Monitoring interval (mins)**	**Sampling date**
C2	21	10.3 – 21.0	yes	yes	5	12/5/2016

3.2 Soil laboratory analyses

To obtain a vertical profile of gravimetric water content (θ_g, mass of water per mass of dry soil) from the clay aquitard, a small portion of each core was weighed, dried in an oven at 105°C for at least 24h (or until no additional loss in weight was observed) to remove the water, and weighed again dry. Subsequently Eq. (1) was used:

$$\theta_g = \frac{M_w - M_d}{M_d} \quad (1)$$

where M_w and M_d are mass of wet and dry soil.

Aquitard porosity n was calculated using Eq. 2:

$$n = 1 - \frac{\rho_{bulk}}{\rho_{particle}} \quad (2)$$

where $\rho_{particle}$ is the density of solid particles (M L^{-3}) and assumed by default as 2.65 g cm^{-3}, and ρ_{bulk} is the soil bulk density (M L^{-3}), calculated as follows:

$$\rho_{bulk} = \frac{M_d}{V_{sample}} \quad (3)$$

where V_{sample} is the volume of the aquitard sample [L^3].

3.3 Porewater sampling, extraction, and analyses

One of the main reasons that make aquitards challenging formations to study is their low to extremely low fluid velocity and low capacity to yield a significant amount of water (Batlle-Aguilar et al., 2016). After a waiting period from weeks to months, porewater was sampled from each aquitard piezometer using a low flow rate peristaltic pump. Samples were collected for analysis of major cations (Ca, Na, K, Mg) and anions

(Cl, HCO_3, SO_4, NO_3) as well as water stable isotopes (^2H, ^{18}O). A multiparameter probe (Thermo Scientific Orion Star A321) was used to measure pH, specific electrical conductivity (SEC), and temperature in the field. Porewater samples for analyses of major ions were collected in 50 mL polyethylene bottles, filtered (0.45 µm) and, for cations, acidified with concentrated HNO_3 (the same day in the laboratory). Porewater samples for water stable isotope ratios ($^2H/^1H$, $^{18}O/^{16}O$) were collected in 20 mL polyethylene vials and filtered (0.45 µm) in the field.

Groundwater at well C2 was also sampled for major cations and anions and stable isotope ratios using a peristaltic pump, but these samples were collected once pH, SEC, and temperature stabilized or did not change by more than 5% within a half-hour period to ensure representativeness of samples. Surface water from Mud Creek was also sampled for major cations, anions, and stable isotope ratios using a submersible pump and following the same procedure for sample representativeness.

Extraction of porewater from cores was performed using a centrifuge at the Kansas Geological Survey. A portion of each core was centrifuged for at least 8h at 2,300 rpm.

Anions were analyzed by ion chromatography (Dionex-120) at the department of Geography & Atmospheric Sciences at the University of Kansas, and cations will be analyzed by inductively coupled plasma optical emission spectrometry (Horiba Ultima 2) at the Kansas Geological Survey. Samples for water stable isotope ratios were analyzed at the University of Kansas Keck Paleoenvironmental Stable Isotope Laboratory on a Picarro L2120-i Cavity Ring Down Spectrometer (CRDS) water isotope analyzer with an A0211 High Precision Vaporizor. The spectrometer was calibrated with two external standards that have been calibrated through inter-laboratory comparisons. Results are reported as a deviation from the Vienna Standard Mean Ocean Water (SMOW) in per mil (‰) difference using delta (δ) notation.

3.4 Porewater stable isotopes analyses by liquid-vapor equilibration

Vertical profiles of $\delta^{18}O$ and δ^2H have been extensively used in aquitards to determine the origin and movement of water, vertical hydraulic conductivity, and paleoclimate, among others (Desaulniers et al., 1981; Hendry et al., 2013; Hendry and Wassenaar, 1999; Remenda et al., 1996; Sanford et al., 2013). Although installing aquitard piezometers can be a successful method to obtain porewater for analysis, it can take a long time for porewater to flow into the piezometer (Neuzil and Provost, 2014). Recently, Wassenaar et al. (2008) proposed a new technique based on $H_2O_{(liquid)} – H_2O_{(vapor)}$ equilibration. The basis of the method is to store aquitard samples in Ziploc® freezing bags with double zipper seal, inflate the bag with dry air and allow isotopic equilibration between porewater and air at room temperature for 24h. To avoid failure of proper sealing, a double bagging system is used.

Equilibrated vapor samples were analyzed for water stable isotope ratios at the University of Kansas Keck Paleoenvironmental Stable Isotope Laboratory on a Picarro L2120-i Cavity Ring Down Spectrometer (CRDS) water isotope analyzer with an A0211 High Precision Vaporizor. The same protocol for standards applies as for water analysis as previously described.

4 Preliminary results

4.1 *Confined aquifer*

At GEMS2, the boundary between the clay aquitard and the confined aquifer is between 9 and 10 m deep (Figure 2). The potentiometric head of the confined aquifer varies between 4.5 m and 5.5 m below ground (Figure 5). The potentiometric head of the confined aquifer strongly fluctuates on a daily basis as a result of groundwater pumping in a nearby pumping station (approximately 600 m from the study site) for the rural community living in the area. Simultaneously, the confined aquifer is very responsive to rainfall, as can be seen for precipitation events during September 2016 and the beginning of April 2017 (Figure 5).

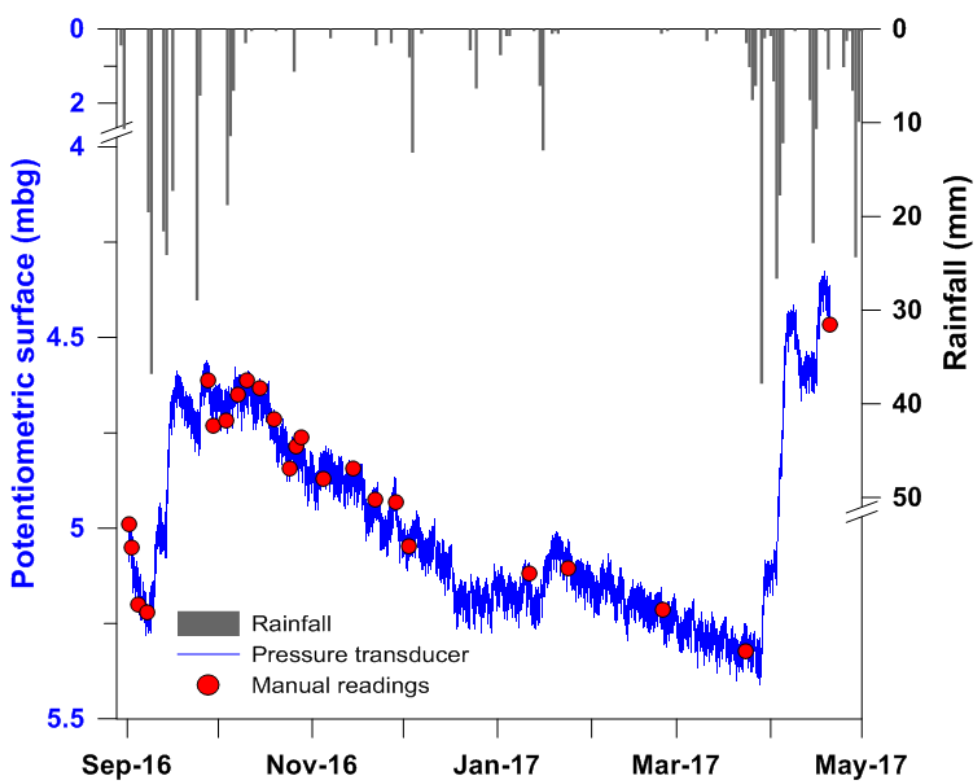

Figure 5. Potentiometric surface at well C2 (pressure transducer and manual readings) and rainfall as measured at the Lawrence airport weather station, ~1 km from GEMS2 (source: NOAA).

4.2 Vibrating wire piezometers

During the period before the VWPs were not grouted, we were able to follow the evolution of saturation of the collection zone for each VWP through pore pressure measurements. The uncorrected pore pressure fluctuated with barometric pressure changes, providing confidence that the VWPs were functioning properly (red line in Figure 6). Once the pore pressure was corrected for barometric fluctuations, the barometric effect was removed and we were able to follow the saturation of the sand in the collection zone of the VWP (blue line in Figure 6). We could conclude that the sand was saturated when we saw a sharp change in slope in the corrected pore pressure. Once the sand in the collection zone was saturated, we grouted each VWP as described in Section 3.1.

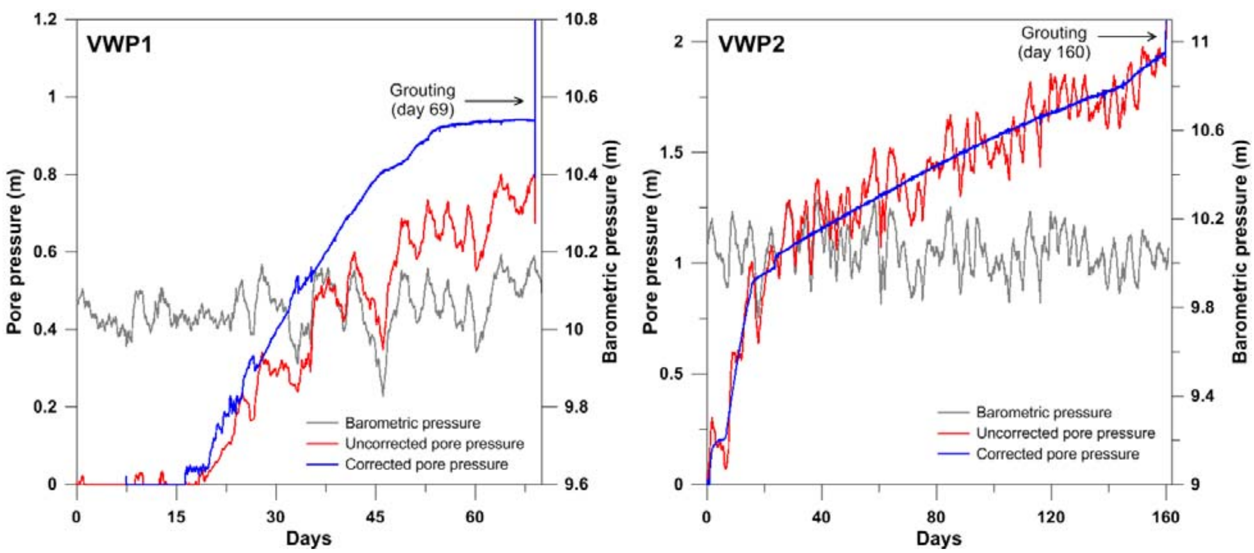

Figure 6. Pore pressure in VWP1 (left) and VWP2 (right) before grouting. These graphs provide confidence that the VWPs are functioning properly because uncorrected pore pressure fluctuates with barometric pressure changes. The change of slope in the corrected pore pressure line marks the moment when the sand in the collection zone is fully saturated. Day 0 corresponds to the day when the VWP was placed into the borehole in the sand collection zone but not grouted. Grout was pumped down on days 69 and 160, respectively.

After a sharp increase in pressure during grouting, the pressure decreased when we stopped grouting and remained unstable for a relatively long period (3 months and counting; 7). During this time, uncorrected pore pressure have shown limited influence of barometric pressure fluctuations, although some periods of more stable pore pressure show small but damped influence of barometric fluctuations (see inset in Figure 7). In principle, one would expect a more direct influence of barometric fluctuations in the uncorrected pore pressure than what we observe, but we anticipate that other processes may be involved in GEMS2. For instance, a close look at Figure 8 shows that the pore pressure is directly correlated to increases in potentiometric head in the confined aquifer. The pressure of the confined aquifer into the aquitard is upward, whereas the atmospheric pressure is downward. With the limited data available at this stage, it is difficult to postulate a definite explanation, but it could potentially indicate that VWPs are measuring the result of two different pressures acting in opposite directions.

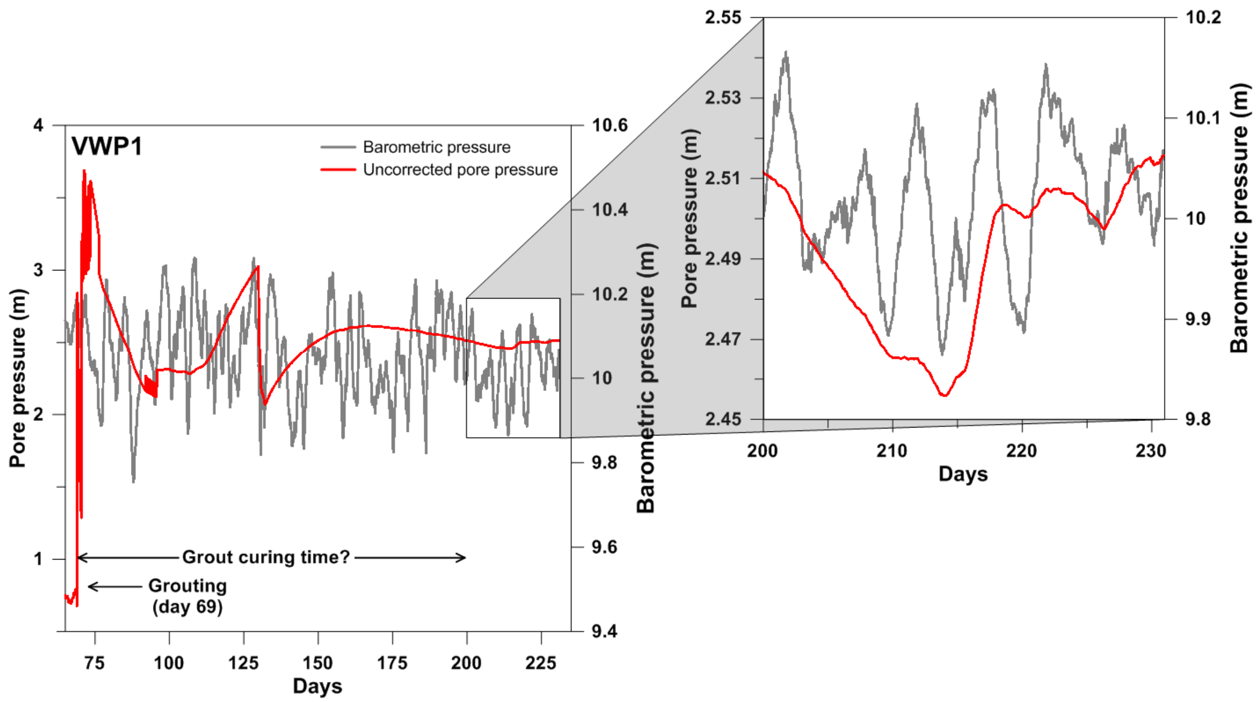

Figure 7. Uncorrected pore pressure in VWP1 after grouting. Barometric fluctuations seem to disappear during a period after grouting (grout curing time?) and reappear at approximately day 200 (~130 days after grouting).

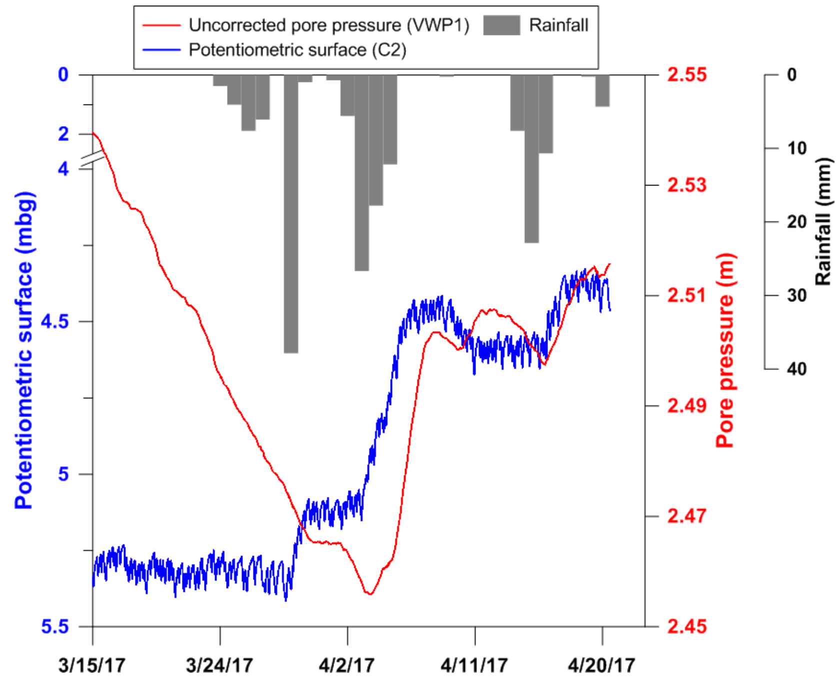

Figure 8. Relationship between rainfall (as measured at the Lawrence airport NOAA weather station), potentiometric surface in well C2, and uncorrected pore pressure in VWP1.

4.3 Aquitard profile

The gravimetric water content of the clay aquitard at GEMS2, as collected from the VWP2 borehole, ranges between 0.25 and 0.46 (profile VWP2_o in Figure 9a). The water content increases from 0.27 at the soil surface to up to 0.46 at a depth of 4.5 m. From there, the water content of the clay aquitard decreases in a relatively steady fashion to about 0.28 at a depth of about 8.5 m. The gravimetric water content was also analyzed on cores from intake zones of other aquitard piezometers and collection zone of vibrating wire piezometers (different colors in Figure 9a). Generally speaking, the water content from other cores closely reproduced the vertical trend of water content as estimated from the VWP2_o profile. Also the vertical water content profile reproduces in general terms the aquitard EC profile.

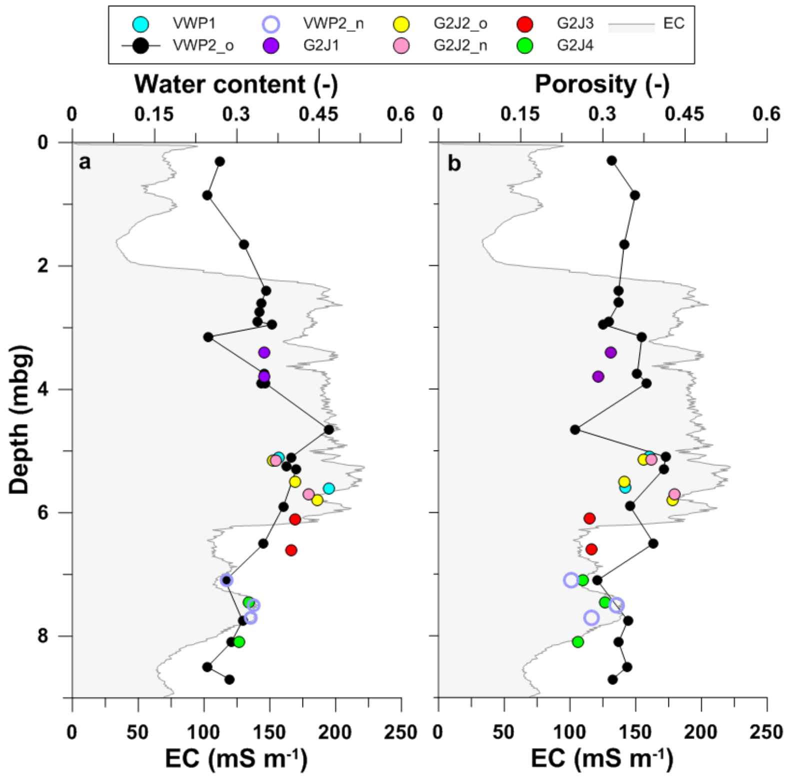

Figure 9. Vertical profiles of (a) gravimetric water content, and (b) porosity. Black solid dots are from a single borehole that was cored from top to bottom. For comparison, cores from different screen depths in other boreholes were analyzed (multiple colors). Aquitard EC is shown in the background for reference.

The porosity of the clay aquitard ranges between 0.25 and 0.41 (profile VWP2_o in Figure 9b). There seems to be a decrease of porosity with depth, although data are not conclusive. Two main characteristics are worth highlighting: 1) peaks of lower and higher porosity are inversely correlated to peaks of gravimetric water content. This is expected and thus provides a certain degree of confidence on both gravimetric water content and porosity estimates. It also shows that the clay aquitard is not homogeneous in the vertical direction, with the possible presence of interbedded layers or lenses richer in silt. 2) Porosity from intake zones of various aquitard piezometers and collection zone of vibrating wire piezometers (different colors in 9b) do not reproduce the main porosity profile as well as the water content did. This may be caused by using the same value of $\rho_{particle}$ (density of solid particles; 2.65 g cm^{-3}) throughout the field site; but it also indicates that clay heterogeneity does not only occur vertically but also horizontally at different locations.

4.4 Porewater chemistry and water stable isotope ratios

Only chemistry results for anions were available at the time of writing this report (Table 2). Nonetheless, some lines of evidence can be noted. Porewater chemistry appears to strongly differ from groundwater in the confined aquifer, with higher conductivity (EC) and bicarbonate (HCO_3) and sulfate (SO_4)

concentrations. Porewater chloride (Cl) as measured in G2J3 (intake zone 6–7 m deep) is very close to that measured in the aquifer (12.89 and 12.26 mg L^{-1}, respectively), whereas porewater Cl as measured in G2J4 (intake zone 7–8 m deep) is much lower (4.42 mg L^{-1}). Once results for cations are available and aquitard piezometers G2J2 and G2J1 have enough standing water to be sampled, chemical results will be fully interpreted. It is interesting to note that nitrate (NO_3) concentration, with 17.13 mg L^{-1}, is quite high for a confined aquifer. This is particularly relevant because NO_3 is very low in Mud Creek and below the detection limit in the porewater.

Gravimetric water contents between 0.25 and 0.46 confirmed that the liquid-vapor equilibration method to analyze water stable isotope ratios is appropriate (the method is considered not accurate if gravimetric water content is less than 5%; Orlowski et al., 2016; Wassenaar et al., 2008). Preliminary results of porewater stable isotopes are shown in Figure 10. Oxygen-18 and deuterium (^2H) ratios still need to be corrected upon laboratory internal standards used, but some interesting patterns can already be seen. The vertical profile of stable isotope ratios quite closely reproduces the aquitard EC: depleted or lighter porewater (ratio values shifted toward more negative values) is directly correlated with clay areas; enriched or heavier porewater (ratio values shifted toward more positive values) is found in those depths where more silt and possibly fine sand exist. Nevertheless this is not the case for the two upper meters of the profile, where low clay contents coexist with depleted (lighter) porewater. Also some cores collected in intake and collected zones other than the general profile VWP2_o present heavier (shifted toward more positive values) porewater ratios than those from the main VWP2_o profile. This could possibly indicate fractionation effects due to evaporation processes during handling of the cores. Isotopic ratios for the G2J1 core, for example, appear inconsistent (see opposite vertical trends between ^{18}O and ^2H in 10).

Table 2. Chemistry and stable isotope ratios for surface water, groundwater, and porewater directly obtained from the aquitard piezometers and extracted using a centrifuge (n.d.: not detected; r.n.a.y.: results not available yet; D: deuterium -^2H).

	Extraction method	Field measured			mg L^{-1}								‰	
		T (°C)	EC (µS cm^{-1})	pH	HCO_3	NO_3	Cl	SO_4	Ca	Mg	Na	K	$\delta^{18}O$	δD
Surface water														
Mud Creek	-	6.7	566	8.25	215.25	0.71	7.17	26.81	r.n.a.y.					
Groundwater														
Well C2	-	13.9	467	6.71	133.10	17.13	12.26	18.38	r.n.a.y.					
Porewater														
G2J3	Direct	14.4	1,211	6.82	299.35	n.d.	12.89	278.74	r.n.a.y.					
G2J4	Direct	14.8	888	6.86	273.75	n.d.	4.42	127.55	r.n.a.y.					

G2J3_6.5-7m	Centrifuge	Insufficient volume of water	r.n.a.y.
VWP2_o_8.5m	Centrifuge	Insufficient volume of water	r.n.a.y.

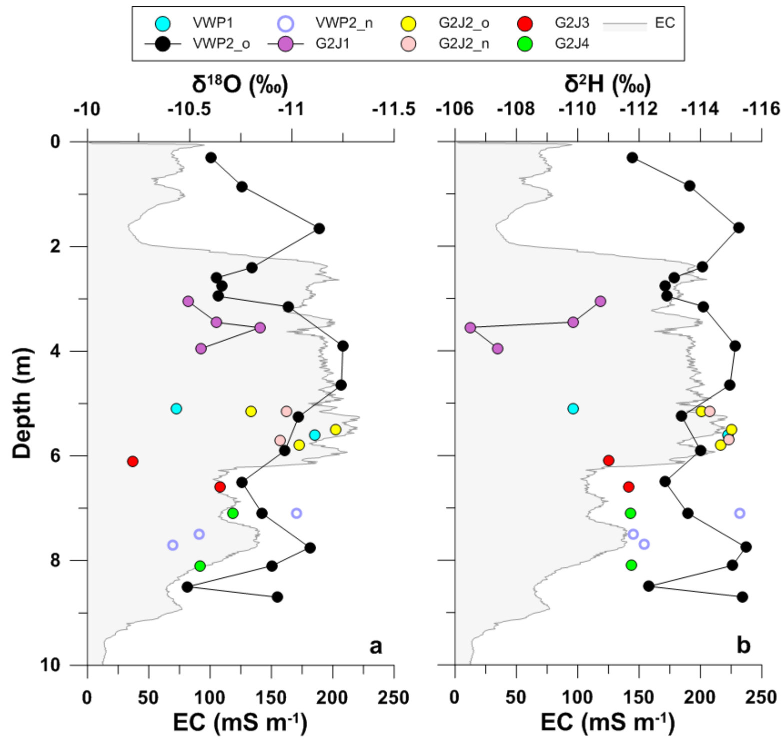

Figure 10. Vertical profile of (a) ^{18}O and (b) ^{2}H ratios at GEMS2. Aquitard EC is shown in the background for reference.

5 Continuing and forthcoming work

At the time of this report, drilling and equipment installation have been finished at the GEMS2 field site. Monitoring has produced aboundant water level data in both the aquitard and confined aquifer. Most chemistry and stable isotope results have also been obtained. Due to the change in the PI, some activities were delayed in the last period. Those activities, along with other planned project activities, will be completed over the remaining funding period:

- VWP1 and VWP2 in GEMS2 are continuously monitored at a 5-minute interval. Detailed analyses will be performed on these long-term data to provide more insights into both the vertical flux and hydraulic properties of the aquitard at the site.
- Once enough porewater has been collected in the aquitard piezometer G2J1, they will be sampled and analyzed for major anions and stable isotopes. Additionally, aquitard piezometers G2J2, G2J3

and G2J4, well C2, and Mud Creek will be resampled to confirm sampling results from previous sampling efforts.

- Pending cations analyses will be finalized, and preliminary isotopic results shown in this report will be corrected as required.
- We will construct a flow and transport model for the aquitard to incorporate all the hydraulic and chemical data we have collected at GEMS2. This model will allow us to analyze different sources of data in a unified framework. The model will also allow us to assess the quality of the vertical K estimates using different methods.
- A final project report summarizing the major findings of this work will be compiled. We will also submit a journal paper for publication based on the results of this project.

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Examining Sedimentation and water quality of small impoundments: Sediment capturing opportunity upstream of federal reservoirs

Basic Information

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Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	KS-001
Research Category:	Water Quality
Focus Categories:	Sediments, Water Quantity, None
Descriptors:	None
Principal Investigators:	Vahid Rahmani

Publications

1. V. Rahmani (2016), Climate Change and Finite Water Resources in Kansas, Natural Resources and Environmental Science (NRES) Course, Manhattan, KS. Oct. 13, 2016
2. V. Rahmani (2016), Impacts of Climate Change on Kansas Water Resources, Water Resources Engineering Course, Manhattan, KS. Oct. 26, 2016
3. Rahmani, V., D. Huggins, J. Kastens, and A. Tavakol* (2016), Sediment Capturing Opportunity by Small Impoundments Upstream of Federal Reservoirs, Annual Governor s Conference on the Future of Water in Kansas, Manhattan, KS. Nov. 15, 2016
4. V. Rahmani (2016), Extreme Weather Events and Finite Water Resources in Kansas, Annual Governor s Conference on the Future of Water in Kansas, Manhattan, KS. Nov. 15, 2016
5. V. Rahmani (2017), Extreme Events and Streamflow Quantity and Quality, Kansas Department of Health and Environment, Topeka, KS. Apr. 18, 2017
6. Tavakol, A., and V. Rahmani (2017), Analyzing the Impacts of Watershed Characteristics on Sedimentation Quality and Quantity in Small Ponds, American Society of Agricultural and Biological Engineers (ASABE) Annual International Meeting, Spokane, WA. July 17, 2017
7. Tavakol, A, V. Rahmani, D. Huggins, and J. Kastens (2018), Farm Ponds as a Sediment Trapping and/or Water Conservation Resource, Poster Presentation, Annual Kansas Natural Resources Conference, Manhattan, KS. February 8, 2018

Examining sedimentation and water quality of small impoundments: Sediment capturing opportunity upstream of federal reservoirs

Report Date: 15 May, 2018

Report Period: March 1, 2016 – February 28, 2018

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Submitted by: Vahid Rahmani, Kansas State University

Project goals and objectives

The objectives of this project were to study two main properties of the farm ponds in Delaware River Basin of eastern Kansas: 1) sediment quantity, quality, and infill; and 2) water quality. We planned to study 6 (± 3) ponds (two small-, two mid-, and two large-size), with the final number depending upon existing and possibly limiting sediment sampling, as well as field and weather conditions. We were successful in sampling 9 ponds (Fig. 1). With this study we began to quantify the nature of sedimentation and water holding capacity in upland ponds and better define their water quality, both of which are important factors for understanding the nature and function of the complex impoundment networks that drain into our major reservoirs in Kansas. This effort is necessary to better understand and potentially model (or quantify) the transportation and storage mechanisms that, in part, control and contribute to downstream sedimentation. In this project, we seek to improve the state's understanding of watershed-wide sedimentation processes in order to facilitate the development and optimization of sediment control strategies that will help prolong the life and services of our small impoundments and large reservoirs.

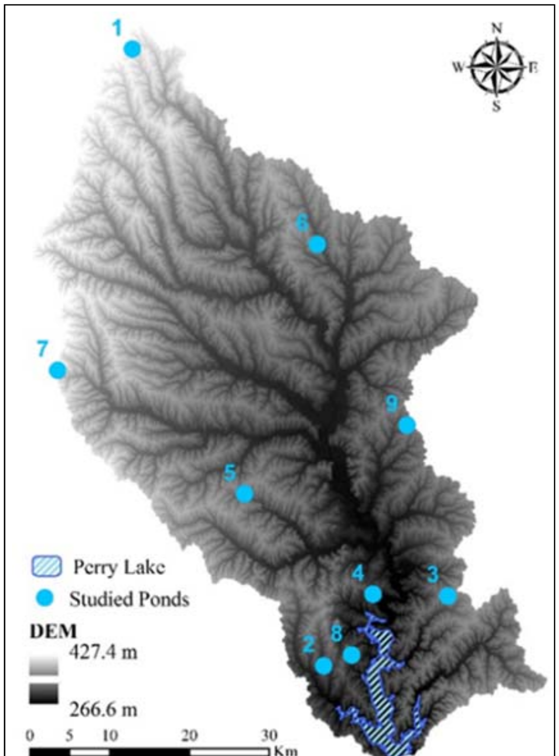

Figure 1. Location of the nine studied ponds in the Delaware River Basin, KS

Completed tasks

Hydrology, Remote Sensing, and GIS. Nine study sites were selected from a candidate population developed from an earlier project using GIS and LiDAR analysis. Catchments for the study site impoundments were determined and characterized using LiDAR and available land use/land cover data. Pond boundaries used for field sample location determination were refined using LiDAR, existing GIS layers from the USGS National Hydrography Dataset, and available aerial imagery. These boundaries were analyzed to determine approximate locations for field sampling of water, sediment, pond depth, and sediment thickness.

Water Quality. Water quality samples were drawn from a single composite sample of water collected from the upper 0.25 meters of the water column at five locations within each pond. Three equally-spaced 500 ml samples were collected along a longitudinal transect following the mid-line of the study reach from the uppermost boat accessible site to the dam. In addition, at the center longitudinal sampling point two samples were collected midway between the center sample and right and left shorelines to create a perpendicular sample transect line (Fig. 2). These five 500 ml samples were composited into a one-gallon sample container, placed on ice, and returned to the Kansas State University (KSU) labs. The samples were tested for total suspended solids (TSS) and volatile suspended solids (VSS) in the PI Rahmani and KSU Civil engineering labs, and for nutrients in the KSU soils lab. Samples were sent to the University of Iowa state hygienic lab for chlorophyll analysis. A Horiba® Model U-52 sonde was used to measure *in situ* water parameters including: air temperature, water temperature, pH, dissolved oxygen, turbidity, conductivity, total dissolved solids, salinity, and oxygen reduction potential.

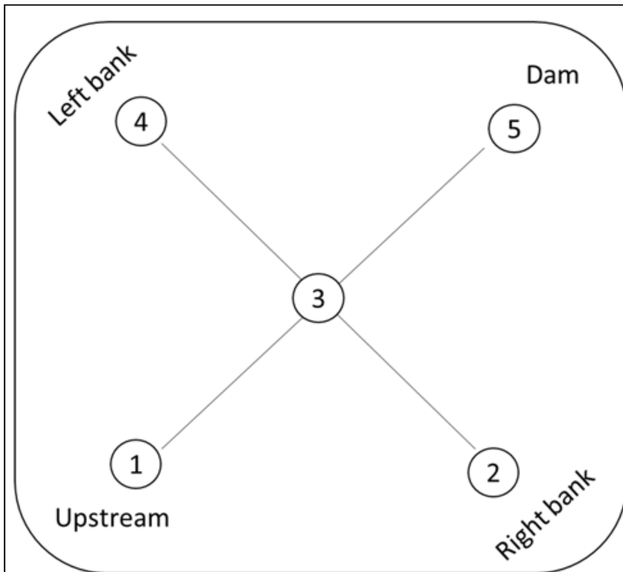

Figure 2. Sample point 1 is upstream at > 0.25 m depth and sample point 5 is downstream at least 1 m from dam. Sample points 2 and 4 are near the ends of the perpendicular sample transect line in at least 0.25 m of water and at least 1 m from each shoreline when possible.

Sediment. Sediment cores were collected and analyzed to determine sediment physicochemical conditions in the study ponds. The same sampling regime was used to generate a composite sample from five samples obtained from the upper 5 – 10 cm of sediment using a small hand corer (Wildco® liner-type Hand Corer). The composite samples were returned to the University of Kansas (KU) Pedology Laboratory for analyses of three soil particle size classes, bulk density, total phosphorus and nitrogen, and percent organic matter (OM).

One of the primary challenges in sediment thickness and quality characterization in small impoundments is the sampling technique. These small ponds usually do not have boat access ramps and typically are shallow, making sampling with a large boat prohibitive. A large number of devices and methods have been designed and developed to collect bottom sediment cores in waterbodies. These include gravity corers, multiple gravity corers, hydraulically damped corers, box corers, piston corers, freeze corers, vibracoring corers, and drilling. All of these have specific advantages and disadvantages. Our perceived need was to somehow obtain a small but minimally disturbed bottom core that would contain a complete sample of the new sediment that had been deposited in small, artificial ponds of various ages. The small size of the waterbodies precluded the use of large, bulky and difficult to operate corers, yet the coring instrument must drive the corer into the full depth of the softer sediments until the corer contacted the original and more consolidated (i.e. harder and denser compacted substrates) pond bottom. With some trial and error we determined that a clear PVC corer of about 1-1/4 inch could be manually driven into the pond sediments from a small flat-bottom boat that could accommodate two researchers. Sections of the PVC coring pipe were linked as each segment was lowered into the water and then driven into the sediment. This linking of shore corer sections allowed the researchers to both eliminate the handling of long cumbersome sections and to reduce the end protruding from the water to a level that could be driven with a commercial posthole driver purchased from a farm and home store. In addition, we used a stainless steel penetrometer which penetrated into the bottom layer and provided an estimate of the thickness.

Using the sediment depth at five sampled points in each pond, sediment accumulation ration was estimated:

$$SAR = \frac{V}{S_l} / age\ of\ pond\ in\ year$$

Where SAR is the annual sediment accumulation ratio (m^3/m/yr), V is sediment volume (m^3), and S_l is the is length of stream between inlet and outlet (m).

All the tests were evaluated for with a 0.05 confidence level (p-value < 0.05).

Results and discussion

Ponds. Nine ponds were selected from 100 candidates sampled in earlier projects. Specifically ponds with the following conditions were of interest: known age, size between 1 to 5 acres (4045 to 20234 m^2), located across the watershed, maximum information available regarding past changes on the sediment including any dredging, have boat access, and have access permission from the owner. Table 1 shows a summary of the characteristics of the ponds.

Sediment thickness measurement. We planned to measure sediment thickness at at five points in each pond. However, because of the higher depth of the pond with/without sediment layer than the penetrometer length, we could not reach the bottom of the sediment layer at a few points in the ponds (Fig. 2). Sediment thickness at point one in each pond was measured with the two methods; penetrometer and PVC tube. Results showed a strong agreement ($r = 0.86$) between the measurements from these two methods (Fig. 3). Therefore, sediment depth at missing points were estimated using this relationship. Using the PVC tube method is time consuming and more expensive in materials. We propose to use the penetrometer for future analyses to save time and cost.

Table 1- Physical characteristics of nine studied ponds in the Delaware River Basin

Pond Number	W (km^2)	A (km^2)	P (km)	S_l (m)	D_{max} (km)	Year of built	Age of pond (yr)	V (m^3)	SAR (m^3/m/yr)
1	1.64	0.074	7.20	884	1.67	2011	6	7636	1.439
2	0.08	0.007	1.23	102	0.27	1995	22	808	0.358
3	0.29	0.022	2.70	222	0.59	1966	51	4759	0.419
4	0.27	0.015	2.81	219	0.68	1960	57	3629	0.290
5	0.34	0.012	2.82	176	0.72	1991	26	4753	1.036
6	0.55	0.033	4.08	269	0.76	1991	26	9906	1.411
7	0.19	0.012	2.00	162	0.61	1960	57	1335	0.144
8	0.06	0.008	1.46	76	0.35	2000	17	1392	1.071
9	0.11	0.028	1.79	244	0.38	2007	10	2019	0.824

W is watershed area, A is pond area, P is pond perimeter, S_l is length of stream between inlet and outlet, D_{max} is maximum distance between pond inlet and watershed boundary, V is sediment volume, and SAR is sediment accumulation ratio.

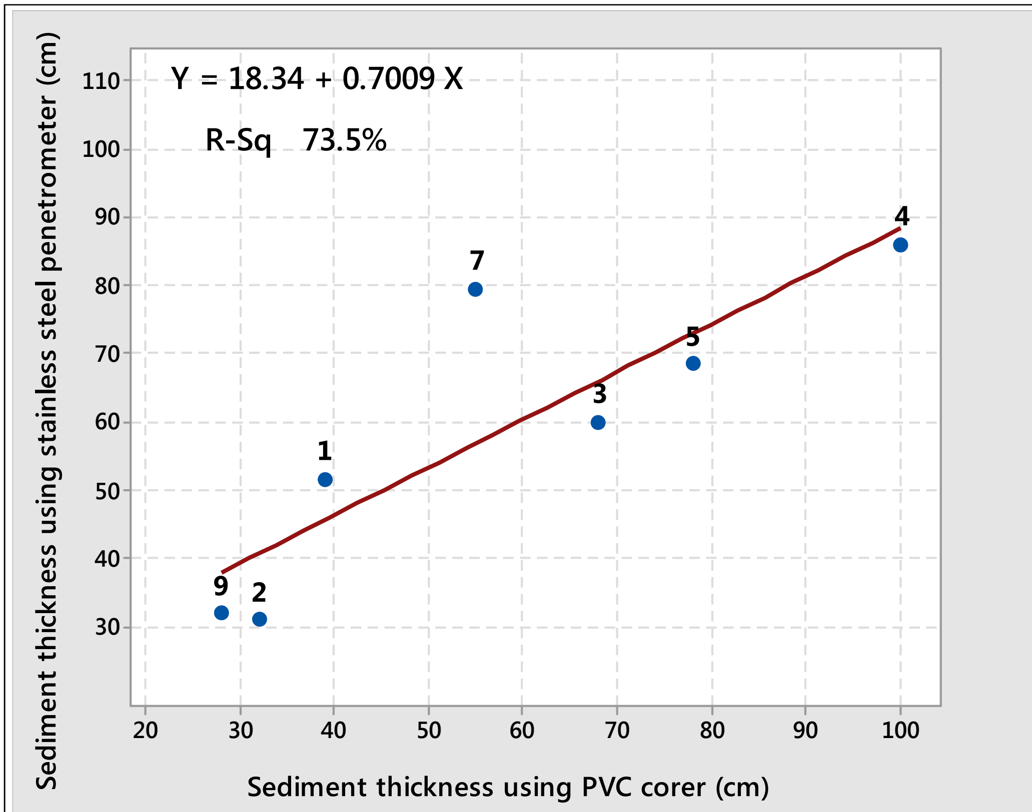

Figure 3- Comparison of the sediment layer thickness measurement techniques; penetrometer (rod) and clear PVC tube methods.

Sediment accumulation. Watershed and pond characteristics were analyzed to determine factors impacting sediment accumulation rates in ponds. Results indicated significant agreement between sediment accumulation rates and catchment perimeter, compactness coefficient, stream length, maximum distance between pond inlet and watershed boundary, high water content, and length of slope. Length of slope was calculated by multiplying the average slope in each slope class and length of the slope class. Steeper areas cause higher erosion rates and increase the accumulated sediment in ponds (Fig. 4).

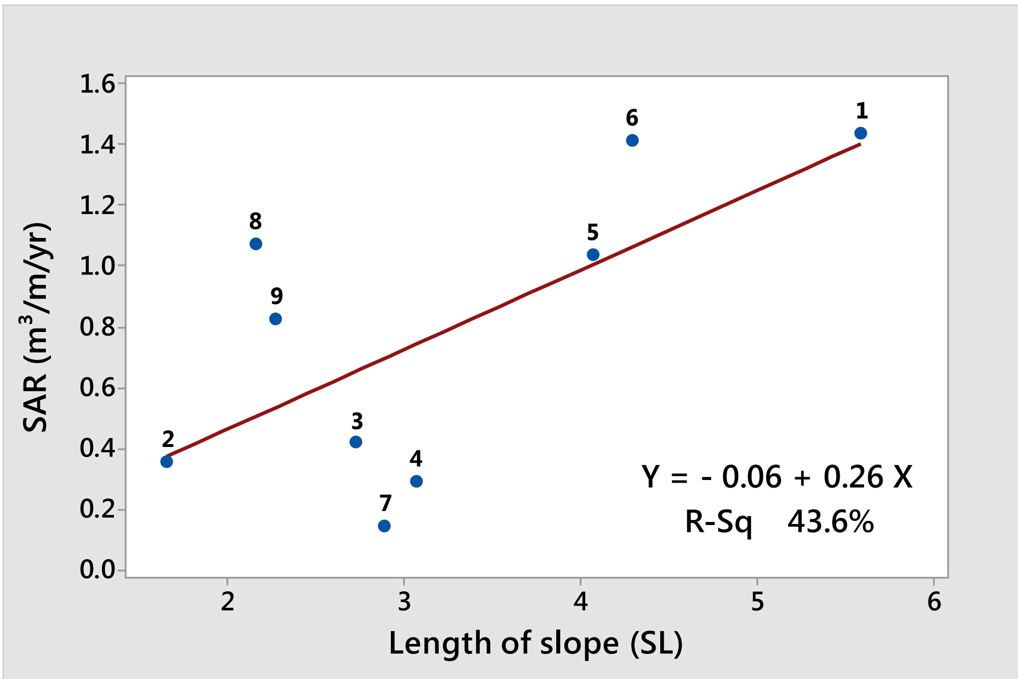

Figure 4- Length of slope showed significant impact on the sediment accumulation ratio

Soil information reported a high correlation between the available water storage in soil profile and the texture of soil. Most catchment areas were covered with two classes of soils including soils with moderate (43%) and high (55%) amount of water. Clay loam and silty clay loam soils are mostly associated with moderate ($r = 0.84$) and high ($r = 0.99$) amount of water in soil, respectively. Lower water storage in soils reduce the chance of erosion (Fig. 5).

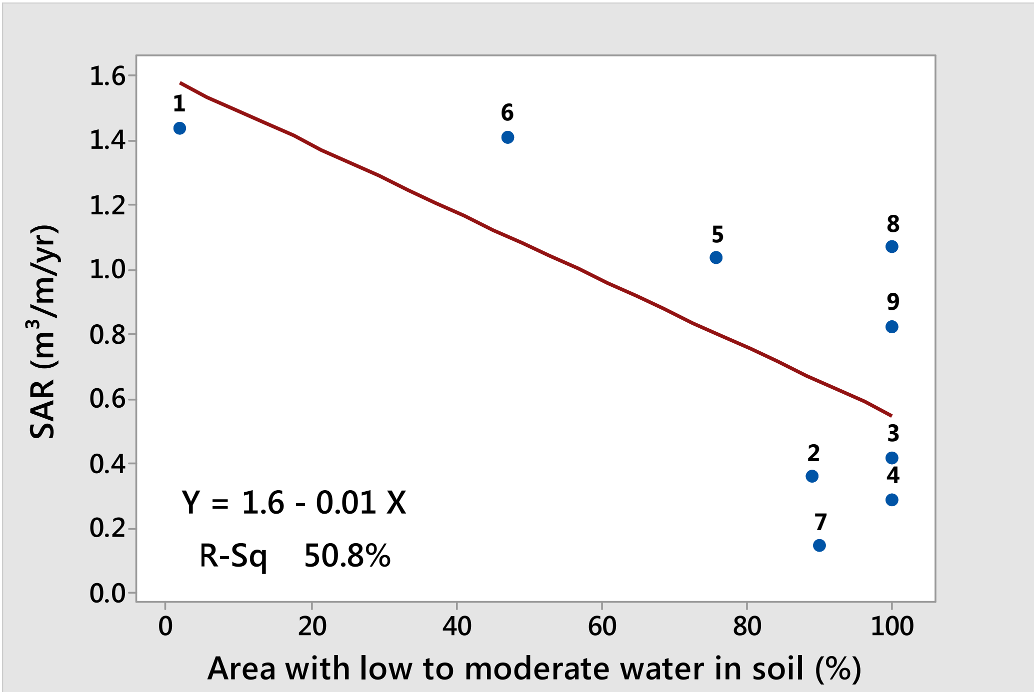

Figure 5- Larger area with soil with low water storage will reduce sediment accumulation rate.

Sediment quality. Previous studies discussed the importance of sediment quality for aquatic environment ecosystems (Munawar et al. 1999, Crane. 2003). Sediment physicochemical conditions were analyzed against watershed variables to capture any associations among factors. Based on US Department of Agriculture soil taxonomy, clay, silt and sand particles have diameter limits of 0.002, 0.05 and 0.10 mm respectively. Although the sediment deposition process is unique for each pond, in general, heavier, coarser sediments (sands) tend to settle down earlier, while lighter, finer (clay) particles deposit slower. Sediment samples showed the dominant percentage of silts in eight ponds. Just one pond showed more percentage of sands. Among sediment particles, the most significant correlation (r = 0.61) was found between the percentage of clay particles and the length of stream (m) in ponds. Dry bulk density of sediment samples, defined as mass per volume (g/cm^2), was inversely but significantly associated with total carbon (r = 0.93) and total nitrogen (r = 0.93). Previous studies found the same relationship between OM% and bulk density (Brainard and Fairchild. 2012, Dean and Gorham. 1998, Menounos. 1997).

Table 2- Summary of the lab results for sediment and water quality

Pond Number	Sediment		Water				
	Total N (ppm)	Total P (ppm)	Total N (mg/L)	Total P (mg/L)	TSS (g/L)	VSS (g/L)	Chlorophyll a (micrograms/L)
1	1,165	361	5.87	0.80	0.1211	0.1000	170
2	786	348	0.55	0.04	0.0870	0.0830	12
3	2,548	645	0.98	0.08	0.0230	0.0170	32
4	2,152	430	1.47	0.04	0.0050	0.0020	22
5	2,883	644	1.11	0.09	0.0090	0.0030	55
6	1,796	457	1.08	0.16	0.0490	0.0460	27
7	906	246	3.65	0.34	0.2029	0.0778	45
8	973	251	0.54	0.03	0.0250	0.0210	6
9	1,478	370	2.34	0.15	0.0070	0.0030	59

Water quality. TN and TP are significantly correlated with croplands (r = 0.62 and r = 0.76) and herbaceous and pastures (r = 0.71 and r = 0.75). Cultivated croplands significantly impact chlorophyll A (r = 0.82) and conductivity (r = 0.67) and pasture and herbaceous significantly impact chlorophyll A (r = 0.72) and pheophytin (r = 0.59). Normal pH for agriculture ranges from 6.5-8.4 and abnormal pH (out of this range) may cause a nutritional imbalance (Ayers. 1985). Results reported a pH between 8.04 and 8.97, which means a few of the ponds might not meet agricultural needs. It should be noted that only one sample was collected from each pond. Sampling in different times of the year would provide more reliable findings. A strong relationship was observed between the percentage of woodland and the water temperature (r =0 .80) which based on sampling time (summer) could be explained with the blocking impact of forest and decrease the wind speed and air circulation above the farm ponds.

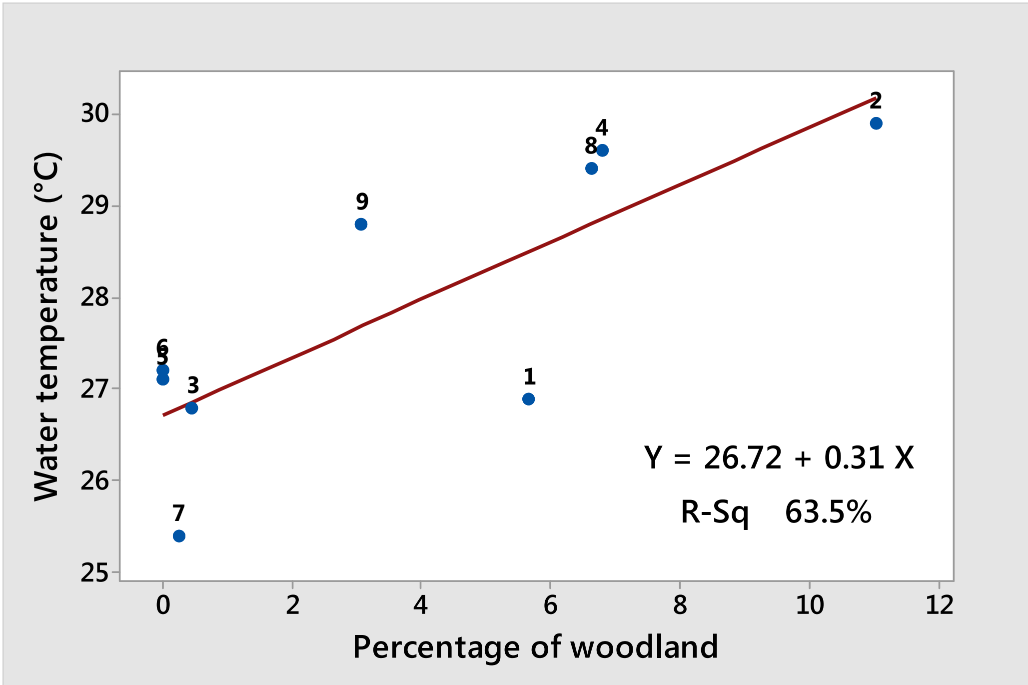

Figure 6- Pond water temperature increases with the percent of woodland in the watershed

Student Training

In this project, a PhD student, a research assistant and an undergraduate student were trained for field work, lab tests, results analysis and interpretation. All trainees are in the Department of Biological and Agricultural Engineering at the Kansas State University. Figure 7 shows the graduate and undergraduate student colleting water and sediment samples.

Figure 7a- Team members (graduate and undergraduate students) are sampling for sediment layer thickness using PVC tube.

Figure 7b- Sampling for sediment surface layer using a Wildco® liner-type Hand Corer.

Summary and Conclusions

Impacts of various watershed and pond characteristics on sediment quantity and sediment and water quality were analyzed for nine selected ponds in the Delaware River Basin, KS. A list of the most important factors affecting sediment and water in small impoundments were determined. Results of this study will help water managers to understand the opportunity provided by small impoundments for long-term management of watersheds and improve water sustainability. These small impoundments, by capturing and releasing sediment and water during drought and flooding events, impact the availability and accessibility of water downstream of the watersheds particularly in much larger reservoirs.

Future work

Findings of this phase (I) of the study was based on nine sample points to start understanding the value of small impoundments for long-term water management. However, a more comprehensive study on theseponds and additional ponds from other watersheds will provide more insight on how the network of small impoundments can improve sustainable water management. Additionally, by developing a new sediment thickness measurement technique (using the penetrometer), we will be able to measure the sediment thickness at more points in less time in each pond to improve the sediment volume estimates. Continuous monitoring of these ponds will help to understand how they function during high and low water regimes.

Acknowledgments

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2017 NIWR-USGS National Competitive Grant Review

Basic Information

Title:	2017 NIWR-USGS National Competitive Grant Review
Project Number:	2017KS193S
USGS Grant Number:	G17AP00085
Sponsoring Agency:	U.S. Geological Survey
Start Date:	7/1/2017
End Date:	9/0/2017
Funding Source:	104S
Congressional District:	None
Research Category:	None
Focus Categories:	
Descriptors:	None
Principal Investigators:	

Publications

There are no publications.

Each year, the NIWR receives research proposals for funding from the National Competitive Grants Program 104(g) of the Water Resources Research Act. Principal Investigators (PIs) from universities across the U.S., Virgin Islands, Puerto Rico, Guam and Washington DC submitted a preproposal of their proposed research project for review by NIWR. NIWR contracted with Kansas Water Resources Institute (KWRI) to receive and organize the preproposals and to obtain reviews for each of the preproposals that had been submitted. One hundred fifty-eight approved preproposals were submitted. All 54 water institute directors were contacted and asked to review 11 or 12 preproposals. Thirty-nine directors responded and completed their reviews.

After all reviews were received and recorded, the preproposals were rated according to reviewer's scores. The top 30 preproposals were determined and a full proposal was requested via email to each PI. The full proposals were submitted through the grants.gov website. The unsuccessful candidates were notified by KWRI via email as to the status of their preproposal. Dan Devlin chaired the review panel and recruited panelists to review the full proposals. Zip files containing the proposals were emailed to the panelists. The panel met and selected which proposals would be funded and determined the monetary amount of each funded grant. Earl Greene, USGS, notified the successful candidates and the unsuccessful candidates were notified via email by KWRI.

Information Transfer Program Introduction

The KWRI is committed to transferring knowledge generated by its researchers to clientele. The KWRI uses a variety of methods. These include:

The fifth statewide Kansas "Governor's Conference on the Future of Water in Kansas Conference" was held on November 8-9, 2017 in Manhattan, Kansas. The conference was highly successful with 691 people registered and attending. Attending the conference was the Governor of Kansas, Sam Brownback, and several state and national senators and representatives. The Governor fully supports this conference and has expressed his concern about the issue of preserving and protecting the future viability of water in Kansas. Thirty-five volunteer scientific and four invited presentations were presented in plenary and concurrent sessions. Four panel discussions were conducted. Eight Faculty/Staff/Professional scientific posters and thirty-three student posters were presented during the poster session. An undergraduate/graduate student poster award program was conducted to encourage student participation. The program agenda is included with this report. The conference will be held again on November 13-14, 2018. The conference website is located at: https://kwo.ks.gov/news-events/governor's-water-conference#39;s-water-conference

The KWRI website, http://www.kcare.k-state.edu/kansas-water-resources-institute/, is used to transfer project results and inform the public on issues and scientists on grant opportunities.

Governor

Basic Information

Title:	Governor
Project Number:	2016KS184B
Start Date:	3/1/2017
End Date:	2/28/2018
Funding Source:	104B
Congressional District:	KS-001
Research Category:	Not Applicable
Focus Categories:	Conservation, Water Quantity, Education
Descriptors:	None
Principal Investigators:	Dan Devlin

Publications

1. Rivard, Cary and Cathie Lavis. 2016. Drip Irrigation Basics . Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF3125, 8 pg.
2. Soil Testing Laboratory. 2016. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF734, 2 pg.
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Governor's Conference on the Future of Water in Kansas

2017

November 8-9, 2017

Held at the Hilton Garden Inn & Conference Center, Manhattan, Kansas

Hosted By

Ad Astra Per Aspera

Kansas Water Office

K-State Research & Extension/Kansas Water Resource Institute

Kansas Geological Survey/KU

Kansas Department of Agriculture

Kansas Department of Health & Environment

Kansas Department of Wildlife, Parks & Tourism

Tuesday, Nov. 7th Evening Kickoff!

Early Registration 6:30-7:30 pm

AGENDA - *Wednesday, November 8, 2017*

Breakfast Available at 7:30 am

7:30 - **Registration/Tour Exhibits** *(Foyer)*

8:30 - **Opening Session/Welcome -** *Tracy Streeter, Kansas Water Office*

8:40 - **Presentation of Colors -** *Gary Harshberger, Kansas Water Authority*

8:45 - **Vision for the Future of Water in Kansas -** *Governor's Vision Team*

9:15 - **Governor Sam Brownback**

9:35 - **Lt. Governor Jeff Colyer**

9:45 - **Water Legacy Award Presentation -** *Governor Sam Brownback*

10:00 - ***Break/Tour Exhibits***

10:15 - **Jim Gulliford,** *EPA Region 7 Administrator*

11:00 - **Michael Teague,** *Oklahoma Secretary of Energy & Environment*

11:45 - ***Break for Lunch*** *(Clear the room for lunch set-up)*

12:30 - **Lunch -** *Be the Vision Presentation*

1:45 - **Water & Emergency Response** *(Big Basin)*

- *Major General Lee Tafanelli, Adjutant General of Kansas*
- *Colonel Christopher Hussin, Commander, Tulsa District, U.S. Army Corps of Engineers*
- *Jake White, Burns & McDonnell*

Public Water Supply & Agriculture: Solving Non-Point Source Pollution Problems Together *(Kaw Nation)*

- *Mike Naig, Deputy Secretary, Iowa Department of Agriculture*
- *Dave White, American Water Works Association*
- *Sandi Formica, Executive Director, Arkansas Watershed Conservation Resource Center*

3:00 - ***Break/Tour Exhibits***

3:15 - **Water Management Solutions - Drought to Surplus** *(Big Basin)*

- *Dr. Eilon Adar of Ben Gurion University of the Negev*
- *Andrew Shaw, Black & Veatch*

The Farm Bill's Role in Water and Natural Resource Management & Sustainability Initiatives in Ag *(Kaw Nation)*

- *Ryan Flickner, Kansas Farm Bureau*
- *Rob Manes, The Nature Conservancy*
- *Aaron Popelka, Kansas Livestock Association*
- *Elmer Ronnebaum, Kansas Rural Water Association*
- *Ashley McDonald, National Cattlemen's Beef Association*

5:00 - **Evening Social at Flint Hills Discovery Center -** *(5:00 pm - 6:30 pm)*

AGENDA - *Thursday, November 9, 2017*

Breakfast Available at 7:15 am

7:15 - Registration/Poster Set-up

8:00 - Concurrent Session 1

A. Local Governance & Funding: How does it work in our neighboring states? *(Flint Hills, Kings & Konza Prairie)*
B. Flood Waters Mitigation and Measurement *(Kaw Nation)*
C. Water Quality & Wetlands *(Big Basin)*
D. Data Collection, Monitoring Weather, & Management *(McDowell)*
E. Water Management *(Big Blue/Ft. Riley)*

9:20 - *Break/View Posters*

9:40 - Concurrent Session 2

A. Innovative Municipal Solutions *(Flint Hills, Kings & Konza)*
B. Harmful Algae Blooms *(Kaw Nation)*
C. Ogallala Progress *(Big Basin)*
D. Water & Health *(McDowell)*
E. Produced Water *(Big Blue/Ft. Riley)*

11:00 - *Break/View Posters*

11:20 - Concurrent Session 3

A. Soil Health: A New Hope For Water Resources *(Flint Hills, Kings & Konza)*
B. Water, Wind and Sun: Choices for the Future of Western Kansas *(McDowell)*
C. Assessment and Adaptation to Extreme Events in the Great Plains *(Big Blue/Ft. Riley)*
D. The Importance of Brewing Water: Local Brewmasters Discuss Water's Role in the Craft Beer Industry *(Discovery Center, 2nd Floor)*

12:20 - *Break/View Posters*

12:30 - Lunch - *Tracy Streeter, Kansas Water Office*

1:15 - Student Poster Awards - *Dan Devlin, Kansas State University*

1:40 - Secretary Robin Jennison-*Kansas Department of Wildlife, Parks & Tourism*

2:20 - Closing Words - *Tracy Streeter, Kansas Water Office*

2:30 - *Adjourn*

#KSWATERVISION17

Concurrent Sessions - Day 2

Thursday, November 9, 2017

8:00 - Concurrent Session 1

A. Local Governance & Funding: How does it work in our neighboring states? *(Flint Hills, Kings & Konza)*

Moderator: Tracy Streeter, Kansas Water Office

PANEL:

- Dean Edson, *Executive Director, Nebraska Association of Resources Districts*
- Peter Ampe, *Partner, Hill and Robbins & Counsel, Republican and Rio Grande Water Conservation Districts, Denver Colorado*
- Colleen Meredith, *Director, Soil & Water Conservation Program, Missouri Department of Natural Resources*

B. Flood Waters Mitigation & Measurement *(Kaw Nation)*

Moderator: Tom Morey, KDA-DWR, Floodplain Program Manager

- Topeka Levee Project - *Kelly Ryan, City of Topeka*
- Updated Methods of Flood Frequency Calculation - *Craig Painter, United States Geological Survey*
- LiDAR and the Kansas Surface Water Landscape - *Jude Kastens, Kansas Biological Survey*
- An Overview of USGS Programs: Flooding - *Andy Ziegler, United States Geological Survey*

C. Water Quality & Wetlands *(Big Basin)*

Moderator: Angela Anderson, Neosho RAC Chair, Twin Lakes WRAPS Coordinator

- Midwest Water Quality Challenges in the Face of Weather Extremes - *Terry Loecke, University of Kansas*
- Improving Water Quality with Cover Crops and Fertilizer Management - *Nathan Nelson, Kansas State University*
- Extension Ed Program and Research on Poultry Litter Utilization and Storage in Southeast Kansas - *Peter Tomlinson, Kansas State University*
- Investigating Wetland Function in the Federal Reservoirs of Kansas - *Erica Schmitz, Kansas State University*

D. Data Collection & Management *(McDowell)*

Moderator: Shannon Kenyon, Assistant District Manager, Northwest Kansas GMD #4

- Challenges and Opportunities of Creating a Hi-Res Soil Moisture Map for Kansas - *Andres Patrignani, Kansas State University*
- Kansas' Participation in the National Groundwater Monitoring Network - *Brownie Wilson, Kansas Geological Survey*
- Monitoring Weather with the Kansas Mesonet - *Christopher Redmond, Kansas State University*
- Evaluating Playas as Sources of Recharge to the High Plains Aquifer in Western Kansas - *Randy Stotler, University of Kansas*

Concurrent Sessions - Day 2

Thursday, November 9, 2017

8:00 - Concurrent Session 1 - *(Continued)*

E. Water Management *(Big Blue/Ft. Riley)*

Moderator: Cara Hendricks, Kansas Water Office

- Sustainability Assessment for Equus Beds, GMD #2 - *Don Whittemore, Kansas Geological Survey*
- Simulating How to Decrease Water Shortages in the Lower Republican River Basin Using New Management Options - *Andrea Brookfield, Kansas Geological Survey*
- Water Supply Infrastructure, Conservation, and Moderation: How Owning a Well Affects Kansans' Environmentalism - *Brock Ternes, SUNY Cortland*
- Endangered Fish Species in Kansas: Historic vs. Contemporary Distributions - *Muluken Muche, Kansas State University*

9:20 - ***Break/View Posters***

9:40 - Concurrent Session 2

A. Innovative Municipal Solutions *(Flint Hills, Kings & Konza)*

Moderator: Brian Meier, Equus-Walnut RAC, Burns and McDonnell

- Wichita's MS4 Program: Implementation of an Off-Site BMP for Unified Watershed Management - *Trisha Moore, Kansas State University*
- Joint Municipal and Ag Cooperation Project for Groundwater Contamination Remediation - *Don Koci, City of Hutchinson*
- Streamflow Alteration in Kansas: Assessment, Causes, and Habitat Implications - *Kyle Juracek, United States Geological Survey*
- Sustainable Resource Recovery from Municipal Wastewater in Pilot-Scale Anaerobic Membrane Bioreactor - *Prathap Parameswar, Kansas State University*

B. Harmful Algae Blooms *(Kaw Nation)*

Moderator: Tom Stiles, Kansas Department of Health and Environment, Bureau of Water

- Kansas Surface Water Supplies Continue to be Challenged: Understanding Causes to Guide Effective Management - *Jerry deNoyelles, Kansas Biological Survey*
- Dealing with Algae Blooms - *Mike Carney, Clay County Park*
- Harmful Cyanobacterial Blooms in Kansas - *Ted Harris, Kansas Biological Survey*
- Cyanobacterial Harmful Algae Blooms and United States Geological Survey Science Capabilities - *Jennifer Graham, United States Geological Survey*

Concurrent Sessions - Day 2

Thursday, November 9, 2017

9:40 **Concurrent Session 2** *(Continued)*

C. Ogallala Progress *(Big Basin)*

Moderator: Armando Zarco, KDA-DWR, Garden City Field Office

- Water Technology Farms Update - *Jonathan Aguilar, Kansas State University*
- Monitoring the Impacts of the Sheridan County 6 Local Enhanced Management Area - *Bill Golden, Kansas State University*
- Water Technology Farms: A Producer's Perspective - *Dwane Roth, Big D Farms, Holcomb*
- Wichita County WCA - *Matt Long, Red Barn Enterprises, Inc.*

D. Water & Health *(McDowell)*

Moderator: Fred Jones, Upper Arkansas RAC Chair, Water Resource System Manager, City of Garden City

- Protecting Domestic Well Water Quality in Kansas - *Elizabeth Ablah, University of Kansas*
- Water and Wastewater Reduction Using a Pollution Prevention Intern - *Kevin Moluf, Kansas State University Engineering Extension*
- Potential Health Effects of Municipal Water Reuse in Kansas: A Health Impact Assessment - *Carlie Houchen, Kansas Health Institute*
- Reclaimed Water in Florida: Issues and Funding - *Diane Kemp, CDM Smith*

E. Produced Water *(Big Blue/Ft. Riley)*

Moderator: Hi Lewis, Red Hills RAC, Directional Drilling Systems, LLC

- Oklahoma's Produced Water Study - *Julie Cunningham, Oklahoma Water Resources Board*
- Water Quality and Flow in Salt Containing Formations in Kansas - *Dave Newell, Kansas Geological Survey*
- Produced Water Management in Kansas: Treatment and Reuse Options - *Ted Peltier, University of Kansas*

11:00 - ***Break/View Posters***

Be sure to check out the 2017 Governor's Water Conference filters on Snapchat!

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Concurrent Sessions - Day 2

Thursday, November 9, 2017

11:20 - Concurrent Session 3

A. Soil Health: A New Hope for Water Resources *(Flint Hills, Kings, Konza)*

Moderator: Steve Swaffer, No Till on the Plains

PANEL:

- Shane New, *Jackson County Producer & Entrepreneur*
- Gretchen Sassenrath, *Associate Professor of Agronomy, Kansas State University Southeast Research and Extension Center*
- Andrew Lyon, *WRAPS Technical Unit Program Manager, Kansas Department of Health and Environment*

B. Water, Wind, and Sun: Choices for the Future of Western Kansas *(McDowell)*

Moderator: Susan Stover, Kansas Geological Survey

PANEL:

- Mary Hill, *Professor of Geology, University of Kansas*
- Anil Pahwa, *Professor, College of Engineering, Kansas State University*
- Danny Rogers, *Extension Agricultural Engineer, Kansas State University*

C. Assessment and Adaptation to Extreme Events in the Great Plains *(Big Blue/Ft. Riley)*

Moderator: Vahid Rahmani, Kansas State University

PANEL:

- Doug Kluck, *Regional Climate Services Director, NOAA*
- Dave Brown, *Director of Southern Plains Climate Hub, USDA*
- Tom Jacobs, *Environmental Program Director, Mid-America Regional Council*
- Amy Kremen, *Project Manager, Ogallala Water CAP (NIFA-USDA), Colorado State University*
- Natalie Umphlett, *Interim Director, High Plains Regional Climate Center*

D. The Importance of Brewing Water: Local Brewmasters Discuss Water's Role in the Craft Beer Industry *(Discovery Center, 2nd Floor)*

Moderator: Katie Goff, Kansas Water Office

PANEL:

- Larry Cook, *Dodge City Brewing Company*
- Chuck Magerl, *Free State Brewing Company*
- Jeremy "JJ" Johns, *Radius Brewing Company*

12:30 - Lunch *(Kaw Nation & Big Basin)*

1:15 - Dan Devlin, KSU

Presentation of Graduate/Undergraduate Student Poster Awards

1:40 - Secretary Robin Jennison, *Kansas Department of Wildlife, Parks, &Tourism*

2:15 - Closing Words - *Tracy Streeter, Director, Kansas Water Office*

2:30 - Adjournment

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Governor’s Conference on the Future of Water in Kansas
Poster Presenters

Faculty/Staff/Professional

1. **Property Grids for the Kansas High Plains Aquifer from Water Well Drillers’ Logs**
   Geoff Bohling, Kansas Geological Survey, University of Kansas
   Dana Adkins-Heljeson, Kansas Geological Survey, University of Kansas
   Brownie Wilson, Kansas Geological Survey, University of Kansas

2. **Organic Geochemistry Research Laboratory Methods of Analysis**
   Julie Dietze, Organic Geochemistry Research Laboratory, U.S. Geological Survey
   Mike Meyer, Organic Geochemistry Research Laboratory, U.S. Geological Survey

3. **Water Quality and Geochemical Variability in the Equus Beds Aquifer, South-Central Kansas, 2001–16**
   Mandy Stone, Kansas Water Science Center, U.S. Geological Survey
   Brian Klager, Kansas Water Science Center, U.S. Geological Survey
   Andrew Ziegler, Kansas Water Science Center, U.S. Geological Survey
   Brian Kelly, Kansas Water Science Center, U.S. Geological Survey

4. **Scientific drilling in Cenozoic strata of the central High Plains Aquifer: Recent advances toward developing a U-Pb zircon chronostratigraphy in western Kansas**
   Jon Smith, Stratigraphic Research, Kansas Geological Survey
   Greg Ludvigson, Stratigraphic Research, Kansas Geological Survey
   Anthony Layzell, Stratigraphic Research, Kansas Geological Survey
   Andreas Möller, Geology, University of Kansas
   Eli Turner, Geology, University of Kansas

5. **Preliminary assessment of 2016 Water Use in Kansas**
   Jennifer Lanning-Rush, Kansas Water Science Center, U.S. Geological Survey
   Andy Terhune, Division of Water Resources, Kansas Department of Agriculture
   Ginger Pugh, Division of Water Resources, Kansas Department of Agriculture

6. **Occurrence of cyanobacteria, microcystin, and taste-and-odor compounds in Cheney Reservoir, Kansas, 2001-16**
   Ariele Kramer, Kansas Water Science Center, U.S. Geological Survey
   Jennifer Graham, Kansas Water Science Center, U.S. Geological Survey
   Guy Foster, Kansas Water Science Center, U.S. Geological Survey
   Thomas Williams, Kansas Water Science Center, U.S. Geological Survey

7. **Cyanobacteria and Associated Toxins and Taste-and-Odor Compounds in the Kansas River, Kansas**
   Thomas Williams, Kansas Water Science Center, U.S. Geological Survey
   Jennifer Graham, Kansas Water Science Center, U.S. Geological Survey
   Guy Foster, Kansas Water Science Center, U.S. Geological Survey
   Matthew Mahoney, Kansas Water Science Center, U.S. Geological Survey
   Keith Loftin, Kansas Water Science Center, U.S. Geological Survey

8. **Republican River and Milford Lake 2017 Nutrient Surveys – Preliminary Results**
   Lindsey King, Kansas Water Science Center, U.S. Geological Survey
   Guy Foster, Kansas Water Science Center, U.S. Geological Survey
   Jennifer Graham, Kansas Water Science Center, U.S. Geological Survey

Student Posters

1. **Evaluating Teff Grass as a Summer Forage**
   Jeremy Davidson, Agronomy, Kansas State University
   Doohong Min, Kansas State University
   Robert Aiken, Kansas State University, NWREC
   Gerard Kluitenberg, Kansas State University

2. **Opportunities and Constraints Related to Generating Biogas from Food Manufacturing and Storage Facilities in Kansas**
   Robert Weil, Civil Engineering, Kansas State University
   Prathap Parameswaran, Kansas State University

3. **An Economic Impact Analysis of a Proposed Local Enhanced Management Area (LEMA) for Groundwater Management District (GMD) #4**
   Kellen Liebsch, Agricultural Economics, Kansas State University

4. **High-resolution water footprints of production in the United States**
   Yufei Ao, Civil Engineering, Kansas State University
   Landon Marston, Kansas State University
   Megan Konar, University of Illinois at Urbana-Champaign
   Mesfin M. Mekonnen, University of Nebraska
   Arjen Y. Hoekstra, University of Twente, Netherlands

5. **Validation of the SPoRT-LIS surface soil moisture product in the Missouri and Arkansas-Red-White River Basins**
   Kelsey McDonough, Biological and Agricultural Engineering, Kansas State University
   Stacy Hutchinson, Kansas State University
   Shawn Hutchinson, Kansas State University
   Vahid Rahmani, Kansas State University

6. **Geophysical Methods with Landsat Satellite Imagery to Characterize the Hydrogeologic Template of the Konza Prairie**
   Weston Koehn, Civil Engineering, Kansas State University
   Sarah D. Auvenshine, Kansas State University
   Seaver L. Williams, Kansas State University
   Stacey E. Tucker-Kulesza, Kansas State University
   David R. Steward, Kansas State University

7. **Identifying the Temporal Resolution of Data necessary to Evaluate Annual and Seasonal Trends in Soil Moisture using BFAST Statistical Software.**
   Elijah Vandepol, Biological and Agricultural Engineering, Kansas State University
   Shawn Hutchinson, Kansas State University
   Stacy Hutchinson, Kansas State University
   Kelsey McDonough, Kansas State University

8. **The Spatial and Temporal Impacts of Impervious Land Use Cover on Flash Flooding Patterns within a Developing Watershed**
   Victoria Thomas, Biological and Agricultural Engineering, Kansas State University
   Kelsey McDonough, Kansas State University
   Stacy Hutchinson, Kansas State University

9. **Variation in groundwater geochemistry in the High Plains aquifer system, south-central Kansas**
   Alexandria Richard, Geology, Kansas State University
   Adam Lane, Kansas State University
   Janet Paper, Kansas State University
   Ben Haller, Kansas State University
   John Hildebrand, Big Bend Groundwater Management District #5
   Orrin Feril, Big Bend Groundwater Management District #5
   Randy Stotler, University of Kansas
   Matthew Kirk, Kansas State University

10. **Managing Groundwater Together in Western Kansas**
    Steven Lauer, Sociology, Anthropology, and Social Work, Kansas State University
    Matthew Sanderson, Kansas State University

11. **CO2 Foam Fracturing Fluids Stabilized in High Salinity Environment Using Polyelectrolyte Complex Nanoparticles**
Hooman Hosseini, Chemical and Petroleum Engineering, University of Kansas
Reza Barati, University of Kansas
Jyun-Syung Tsau, University of Kansas
Edward Peltier, University of Kansas

12. **Measuring the Knowledge, Self-Efficacy and Satisfaction of Students Attending the Kansas Youth Water Advocates Conference**
Katelyn Bohnenblust, Communications and Agricultural Education, Kansas State University
Gaea Hock, Kansas State University
Zachary Callaghan, Kansas State University

13. **Using the Anuga Hydrodynamic Model to Understand Mechanisms of Surface Inundation in Areas of Impermeable Soil: A Study from Fredonia, KS**
Tyler Vaughn, Geology, Kansas State University
Saugata Datta, Kansas State University and Texas A&M University
Abby Langston, Kansas State University
Claudia Adam, Kansas State University

14. **Investigation of playa hydrology and recharge flux to the High Plains aquifer at Ehmke Playa in western Kansas**
Kaitlin Salley, Geology, University of Kansas
Randy Stotler, University of Kansas
Bill Johnson, University of Kansas

15. **Modeling Runoff from Terraced Fields with Tile Drain Systems**
Daniyal Siddiqui, Environmental Engineering, University of Kansas
Edward F. Peltier, University of Kansas
Pamela L. Sullivan, University of Kansas
Bryan Young, University of Kansas

16. **Headwater Stream Discharge Characterization in the Konza Prairie's Merokarst Environment Using a Pitot Tube**
Chantelle Davis, Geology, University of Kansas
G. L. Macpherson, University of Kansas

17. **Performance of a Pilot Scale Anaerobic Membrane Bioreactor in Ft. Riley, Kansas**
Kahao Lim, Civil Engineering, Kansas State University
Prathap Parameswaran, Kansas State University
Patrick Evans, CDM Smith
Tyler Penfield, Kansas State University
Chad Olney, Kansas State University
Bernadette Drouhard, Kansas State University
Kristen Jones, Kansas State University

18. **Landscape-scale Soil Moisture Monitoring Using Cosmic-ray Neutrons**
Pedro Rossini, Soil Physics Laboratory, Kansas State University

19. **Evaluating Ephemeral Gullies with Photogrammetry and Computer Modeling**
Chinthaka Weerasekara, Biological and Agricultural Engineering, Kansas State University
Aleksey Sheshukov, Kansas State University

20. **Testing a Synthetic Biodegradable Polymer to Reduce Soil Water Evaporation Rate**
Vibhavi Jayasinghe, Agronomy, Kansas State University
Andres Patrignani, Kansas State University

21. **Dynamic simulation of lower salinity brine exchange with high salinity Lansing-Kansas City produced water**
Stanley Thompson, Chemical and Petroleum Engineering, University of Kansas
Reza Barati, University of Kansas
Steve Rrandtke, University of Kansas
Edward Peltier, University of Kansas

22. **Remote sensing soil moisture: Validation analysis of SMAP and SPoRT-LIS surface soil moisture data in Kansas using in situ measurements**
Ameneh Tavokol, Biological and Agricultural Engineering, Kansas State University
Vahid Rahmani, Kansas State University

23. **Carbon Sources in Lake Zooplankton**
Tamara Tyner, Ecology and Evolutionary Biology, University of Kansas
Rachel Bowes, Karstad University, Sweden
James Thorp, University of Kansas

24. **Optimizing the design of the Kansas mesonet environmental monitoring network**
Narmadha Mohankumar, Statistics, Kansas State University
Andres Patrignani, Kansas State University
Mary Knapp, Kansas State University
Christopher Redmond, Kansas State University

25. **Agronomic and Scientific Challenges to the Treatment and Unconventional Reuse of Produced Water**
Orion Dollar, Civil and Environmental Engineering, University of Kansas
Edward Peltier, University of Kansas
Min Chen, University of Kansas
Karen Peltier, University of Kansas
Stephen Randtke, University of Kansas

26. **Physical properties and nutrient concentrations of confined disposal facility (CDF) sediments from John Redmond Reservoir, Burlington, Kansas.**
Jesse Higginbotham, Physical Sciences/Earth Science, Emporia State University
Marcia Schulmeister, Emporia State University

27. **Erodibility of Claypan Soils in Southeastern Kansas**
Mark Mathis, Civil Engineering, Kansas State University
Stacey Kulesza, Kansas State University
Gretchen Sassenrath, Kansas State University

28. **Playa Ecosystem Vulnerability in Future Climates: Taking Science to Stakeholders in the Great Plains**
Rachel Owen, Natural Resources, University of Missouri
Lisa Webb, U.S. Geological Survey
Keith Goyne, University of Missouri

29. **Monitoring the Effectiveness of Streambank Stabilization Projects in Northeast Kansas**
Denisse Benitez-Nassar, Horticulture and Natural Resources, Kansas State University
Charles Barden, Kansas State University

30. **Temporal Variability in Soil Microbial Properties in Claypan Soils**
Che-Jen Hsiao, Agronomy, Kansas State University
Gretchen Sassenrath, Kansas State University
Charles Rice, Kansas State University
Lydia Zeglin, Kansas State University
Ganga Hettiarachchi, Kansas State University

31. **The Impact of Storm Events on Hydrology and Biogeochemistry in Tile Outlet Terrace Agriculture Fields**
Marvin Stops, Physical Geography, University of Kansas
P. L. Sullivan, University of Kansas
E. Peltier, University of Kansas

32. **The Application of Sandstone to Reduce Limestone Armoring in Acid Mine Drainage Remediation**
Amy Bailey, Geology, Wichita State University
Andrew Swindle, Wichita State University

33. **Decadal Trends of Nitrogen Concentrations in Prairie Streams**
James Guinnip, Biology, Kansas State University
Walter Dodds, Kansas State University

Special thanks to the Governor's Award judges:

Charles Barden, Horticulture and Natural Resources, Kansas State University
Chuck Bever, Kansas Wildlife, Parks and Tourism
Amber Campbell, Kansas Center for Agricultural Resources and the Environment, Kansas State University
Ted Harris, Kansas Biological Survey, University of Kansas
Melissa Harvey, KCARE, Kansas State University
Ken Kopp, Kansas Rural Water Association
Gaisheng Lui, Kansas Geological Survey, University of Kansas
Chelsea Paxson, Kansas Department of Health and Environment
Ginger Pugh, Division of Water Resources, Kansas Department of Agriculture
Russell Plashka, Ag Marketing/Workforce Development, Kansas Department of Agriculture
Anna Smith, Burns and McDonnell
Elizabeth Smith, Kansas Department of Health and Environment
Andrew Swindle, Wichita State University
Nate Westrup, Kansas Water Office

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	3	0	0	0	3
Masters	1	0	0	0	1
Ph.D.	3	0	0	0	3
Post-Doc.	0	0	0	0	0
Total	7	0	0	0	7

Notable Awards and Achievements

2017 Graduate Poster Competition, Runner-up Award to Mr. Chinthaka Bandara (MS Student) at The Governor's Conference on the Future of Water in Kansas, Manhattan, KS. Evaluating ephemeral gully erosion with photogrammetry and modeling by Bandara and Sheshukov

2017 ASABE Outstanding Natural Resources and Environmental Systems (NRES) Student Presentation Award to Mr. Vladimir Karimov at the ASABE Annual International Meeting in Spokane, WA. Presentation by Karimov and Sheshukov entitled Integrated process-based modeling of channelized flow and soil erosion in small watersheds.

2016 Graduate Poster Competition, Winner Award to Mr. Vladimir Karimov (PhD Candidate) at The Governor's Conference on the Future of Water in Kansas, Manhattan, KS. The impact of climate change on the efficiency of best management practices: Case study of ephemeral gully erosion by Karimov and Sheshukov