South Dakota State University
SDSU

Office of Research
and Sponsored Programs

Box 2201, SAD 200
SDSU
Brookings, SD 57007-0001
Phone: 605-688-6696
FAX: 605-688-5530

James.Doolittle@sdstate.edu

September 25, 2015

Barry A. McLaury
South Dakota Department of Environment & Natural Resources
Joe Foss Building
523 East Capitol
Pierre, SD 57501
Barry.McLaury@state.sd.us

Re: Project Titled: "Persistence of E.coli in Stream Sediments and the Impact on Water Quality"

PI/PD: Dr. Rachel McDaniel
Sponsor: South Dakota Department of Environment & Natural Resources
Federal Funds requested: $188,965
Non Federal Match Funds: $75,599
Proposed Total Budget: $264,564

South Dakota State University is pleased to submit the above-referenced grant application. It has been reviewed and approved by the appropriate programmatic and administrative personnel at SDSU. If the proposal is selected for funding, South Dakota State University assures that it will fulfill all commitments made in the grant application.

Sincerely,

James J. Doolittle, PhD
Associate Vice President for Research

1.0 PROJECT PROPOSAL SUMMARY SHEET

Project Title: Persistence of *E. coli* in stream sediments and the impact on water quality

Project Period: July 1, 2016 – June 30, 2019

Project Sponsor:
South Dakota State University
Project Director: Rachel McDaniel, Assistant Professor
Mailing Address: Box 2120, Brookings, SD 57007
Email: rachel.mcdaniel@sdstate.edu
Phone: 605-688-5669

Project Funding:

Budget Category	**Amount ($)**
NPS Funding Requested	$188,965
Match (cash/in-kind)	$75,599
Other	
Total Project Costs	**$264,564**

Project Type: Planning/Assessment

Project Location: The proposed project is applicable to waters throughout the state; however, sampling will primarily occur on Skunk Creek.

Project Location	
Watershed(s)	Skunk Creek
303(d) Listed Stream	Yes
HUC (8 digit)	10170203
Counties	Moody, Lake, and Minnehaha
Coordinates of project location	N 43°46’44’’ W 96°51’41’’

NPS Pollution Sources:

NPS Pollution Source categories to be addressed (percent)			
Agriculture	100	Silviculture	0
AFOs	0	Hydrologic Modification	0
Urban Runoff	0	Construction	0
Resource Extraction	0	Other	0

NPS Functional Category:

NPS Functional Category (percent)			
BMP Implementation	0	Technical Assistance	5
Information and Education	20	Planning	10
Watershed Assessment	0	Groundwater	0
Water Quality Monitoring	65	Other	0

NPS Pollutants to be Addressed:

NPS Pollutants to be Addressed (Check all that apply)			
Excess Nitrogen		Pesticides	
Excess Phosphorus		Oil and Grease	
Sedimentation	X	Temperature	
Pathogens/Bacteria	X	pH	
Metals		Other	
Low dissolved oxygen		Other	

Project Goals:

The goal of this project is twofold:

1. Develop a standard sampling procedure for *E. coli* in stream sediments; and
2. Using the standard procedure, evaluate the persistence of in-stream sediment stores of *E. coli* and their implications for water quality.

Project Description:

This project will use a combination of literature review and spatial sampling to determine a standard method for sampling *E. coli* in stream sediments. Using the standard method, the project will also assess the stability of *E. coli* concentrations over time including the impact of stormflow, shear stress, and sediment particle sizes. Stormflows have the potential to deplete sediment stores of *E. coli*; therefore, this project will also evaluate the potential for *E. coli* recovery after such events. Outcomes from the project will provide broad insight into the risks to South Dakota waterbodies from existing in-stream *E. coli* stores and the potential persistence of the risks from *E. coli* stores over time.

2.0 STATEMENT OF NEED

2.1 DEMONSTRATED WATER QUALITY NEED

Nearly 70% of the streams assessed from 2008 through 2013 in South Dakota did not support at least one of their designated beneficial uses (DENR, 2014). The primary causes for nonsupport

were total suspended solids (TSS) and bacteria including *Escherichia coli* (*E. coli*). *E. coli* alone was responsible for poor water quality in over 2,000 miles of streams in South Dakota (EPA, 2015). Livestock, wildlife, and crop production are listed as the top three probable sources of impairment in the state.

What is not considered is the reservoir of fecal bacteria within stream sediments which can often have much higher concentrations of fecal bacteria than the water column. For example, van Donsel and Geldreich (1971) found 100 to 1000 times more fecal coliform in bottom sediments than the water column. In addition, fecal bacteria have been shown to survive and persist in stream sediments for extended periods of time (Flint, 1986, Davies et al., 1995). Sediment composition, including texture and organic matter, can affect survival of fecal bacteria, but the results have not been consistent. Several studies show smaller particles and more organic matter are associated with higher fecal bacteria concentrations (Garzio, 2009; Niewolak, 1998; Ferguson et al., 1996; Irvine and Pettibone, 1993); however, Cinotto (2005) found higher concentrations of *E. coli* in sand.

Disturbances of stream bottom sediments (e.g. cattle crossing the stream or storm events) can transport bacteria from these sediment reservoirs into the water column, thus contributing to water quality impairments. In one study, an artificial flood event was created by releasing water from a reservoir, preventing external input of *E. coli* into the system (i.e. in runoff). The results showed an increase in *E. coli* concentrations from 100 to 13,000 MPN $100mL^{-1}$ (Nagels et al., 2002), far above the South Dakota limited contact recreation single sample standard of 2,000. Current data show that *E. coli* stores from stream sediments in Skunk Creek can range from an average of 83 to over 12,000 cfu g^{-1}, indicating that the sediment may be a significant source of *E. coli* to the water column in some areas of South Dakota.

The information obtained from this study can be used statewide to provide a standard sampling method for *E. coli* concentrations in stream sediments. It will also provide information on the stability of *E. coli* reservoirs in South Dakota's streams, the potential impacts of storms on instream *E. coli* reservoirs, the potential recovery of *E. coli* reservoirs, and the impact of SRAM on sediment *E. coli* reservoirs.

Though the information can be used throughout the state, the study will focus on Skunk Creek. Skunk Creek is listed as impaired for *E. coli* and fecal coliform. A TMDL published in 2004 indicates a required storm flow reduction of 95% for fecal coliform in Skunk Creek; however, a more recent TMDL for the Big Sioux River determined that Skunk Creek will need to meet stricter standards because of its' high contribution to the Big Sioux River.

2.2 WATERBODY INFORMATION

Skunk Creek flows from Brandt Lake to the Big Sioux River and covers portions of Lake, Moody, and Minnehaha counties. The length of Skunk Creek is approximately 74 miles and the watershed is about 373,000 acres. Precipitation averages about 25 inches per year. The primary land use is

agricultural including both cropland and rangeland. Cattle have the potential to be a major contributor to bacterial impairments.

The 2014 Water Quality Assessment Report lists Skunk Creek as impaired for *E. coli*, fecal coliform, and TSS. Limited Contact Recreational and Warmwater Marginal Fish Life uses are not supported in Skunk Creek. To address these issues, best management practices (BMPs) have been implemented along the creek including Riparian Area Management (RAM) and Seasonal RAM (SRAM). These systems are aimed at minimizing fecal bacteria loading from cattle by reducing or eliminating their time in the stream as well as providing a buffer between grazing lands and the stream to reduce overland transport.

Reservoirs of *E. coli* can be found in stream sediments, providing a potential source for water quality impairments. Monitoring for *E. coli* concentrations in the sediment of Skunk Creek began in 2014. Current data show a range of *E. coli* concentrations from 10 to 24,200 MPN/g sediment.

2.3 PROJECT MAP

See Figure 1.

2.4 GENERAL WATERSHED INFORMATION

Skunk Creek watershed is approximately 373,000 acres and is located within Moody, Lake, and Minnehaha counties. The elevation change of Skunk Creek is greater than 200 feet over 63 miles. As stated above, it flows from Brandt Lake to the Big Sioux River. The primary land uses are cropland and rangeland. The average precipitation is approximately 25 inches per year.

Skunk Creek is impaired for fecal coliforms, *E. coli*, and TSS. The creek joins the Big Sioux River in Sioux Falls and has been identified as a major contributor of fecal pollution to the Big Sioux. BMPs, including SRAM buffers along the creek, have been implemented along the creek to reduce fecal loading to the stream.

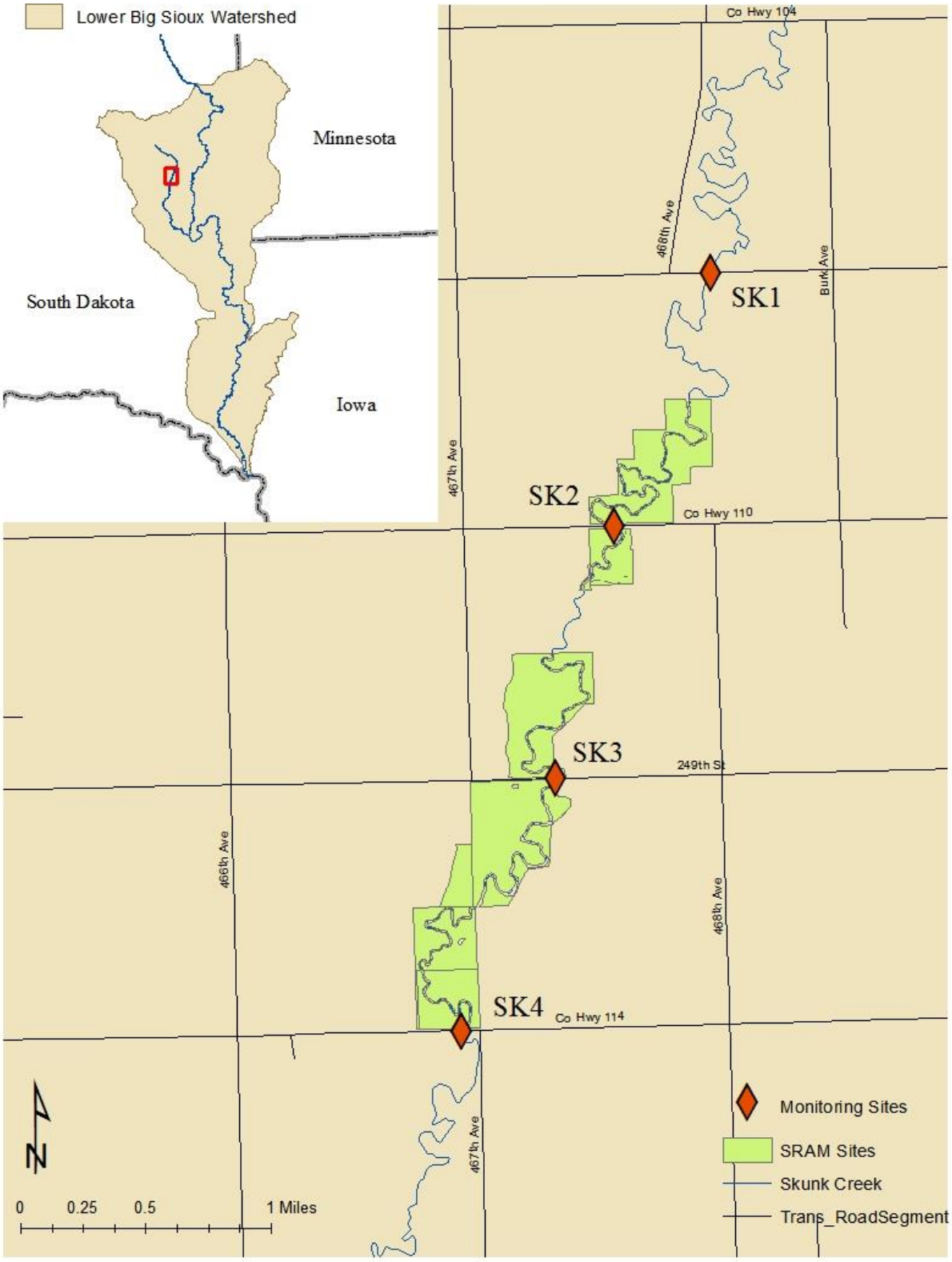

Figure 1: Location of Skunk Creek monitoring sites within the Lower Big Sioux Watershed. Green areas are SRAM sites while orange diamonds are the monitoring locations.

3.0 PROJECT DESCRIPTION

3.1 PROJECT OUTCOMES

The goal of this project is twofold:

3. Develop a standard sampling procedure for *E. coli* in stream sediments; and
4. Using the standard procedure, evaluate the persistence of in-stream sediment stores of *E. coli* and their implications for water quality.

The project will assess the stability of *E. coli* concentrations over time including the impact of stormflow, shear stress, and sediment particle sizes. Stormflows have the potential to deplete sediment stores of *E. coli*; therefore, this project will also evaluate the potential for *E. coli* recovery after such events. Outcomes from the project will provide broad insight into the risks to South Dakota waterbodies from existing in-stream *E. coli* stores and the potential persistence of the risks from *E. coli* stores over time. This project will also provide water resource managers information regarding the impact of SRAM implementation on *E. coli* concentrations in stream sediments and the potential lag time for the reduction of existing in-stream *E. coli* sources.

These goals will be achieved through the following outcomes:

1. Provide a document detailing the sampling and testing procedure for evaluating *E. coli* concentrations in stream sediments,
2. Monitor *E. coli* concentrations in stream sediments and the water column during a range of flow conditions,
3. Determine stream sediment particle size and the attachment rates of *E. coli* to particles in the sediment,
4. Evaluate the relationship between sediment particle size and *E. coli* concentrations in stream sediments,
5. Assess the effect of stream-channel dimensions on *E. coli* reservoir depletion through shear stress estimates, and
6. Evaluate the effects of Seasonal Riparian Area Management (SRAM) on stream sediment *E. coli* concentrations and potential persistence after cattle exclusion.

3.2 OUTCOMES, TARGETS, AND TASKS

Outcome 1: Provide a document detailing the sampling and testing procedure for evaluating *E. coli* concentrations in stream sediments.

The potential for high concentrations and persistence of *E. coli* in stream sediments poses a threat to water quality when disturbed. Therefore, stream sediments should be assessed as potential sources for water impairments. However, to compare results between studies, a standardized sampling and testing procedure needs to be developed. Methods for disassociating bacteria from

particles were examined by Soupir et al. (2008). They suggested using a combination of physical (e.g. a shaker) and chemical (e.g. Tween 85) methods to achieve the best results. While this study addresses some of the testing methodologies, further examination of literature and evaluation of sediment samples will be performed to address additional sampling and testing questions such as the volume of sediment required and sediment sample depth.

Existing standard methods for *E. coli* in stream environments were created for evaluating *E. coli* in the water column. However, *E. coli* have demonstrated the ability to be more persistent and stable within stream sediments. Therefore, a series of samples will be processed using the current EPA approved method for water sampling (i.e. 8 hours after collection) and the former standard (i.e. 24 hours after collection) to determine if there is a significant difference between *E. coli* concentrations. In addition, the high variability of *E. coli* concentrations in stream sediments underscores the importance of evaluating the sample variability and the spatial variability of *E. coli* concentrations within bottom sediments. This will provide information on how many samples should be collected at each location and if sample replicates should be completed.

The number of required dilutions is uncertain. Plates should contain between 20 and 200 colonies for accurate counts. However, sediment *E. coli* concentrations in Skunk Creek have been measured from 10 to 24,200. This means dilutions could range from 10^{-1} to 10^{3} to achieve the appropriate range. Therefore, cost estimates are based on plating two different dilutions for more accurate colony counts.

Task #1: Examine existing literature for sediment sampling methods	
Task Description	Collect existing literature for sediment sampling methods. Evaluate the methods including their suitability for South Dakota.
Task Outputs	Document that includes standardized sampling procedure (i.e. core diameter, sampling depth, etc.) and required equipment.
Cost	Labor costs included in overall budget

Task #2: Examine Temporal Variability		
Task Description	Collect and process a minimum of 150 sediment samples for *E. coli* throughout the recreation season. Process them at 8 hours after collection and 24 hours after collection. (300 total at two dilutions)	
Task Outputs	Document that includes a statistical evaluation of *E. coli* concentrations processed at 8 hours and 24 hours after collection.	
Cost	Federal (319) Funds	$3,000
	Non-Federal Match	
	Other Federal Funds	
	Total Task Cost	$3,000 Labor costs included in overall budget

Task #3: Examine variability within a sample		
Task Description	Collect and process a minimum of 150 sediment samples for *E. coli* throughout the recreation season. Process them in triplicate to estimate the variability of processing a sample (450 total at two dilutions).	
Task Outputs	Document that includes an evaluation of *E. coli* concentration variability within a single stream sediment sample.	
Cost	Federal (319) Funds	$4,500
	Non-Federal Match	
	Other Federal Funds	
	Total Task Cost	$4,500 Labor included in overall budget

Task #4: Examine variability between nearby sampling locations		
Task Description	Collect a minimum of 6 sets of 25 gridded samples (i.e. 5 x 5 sample grid) for a total of 150 sediment *E. coli* samples at two dilutions. Evaluate the typical variation of *E. coli* concentrations.	
Task Outputs	Document that includes a statistical evaluation of the spatial variability of *E. coli* concentration within stream sediments.	
Cost	Federal (319) Funds	$1,500
	Non-Federal Match	
	Other Federal Funds	
	Total Task Cost	$1,500 Labor included in overall budget

Outcome 2: Monitor *E. coli* concentrations in stream sediments and the water column during a range of flow conditions.

E. coli concentrations in bottom sediments and the overlying water will be evaluated at a minimum of once a month from April through October and intensely during the time surrounding three storm events each monitoring year. Testing will occur along Skunk Creek at the SK1, SK2, SK3, and SK4 monitoring locations and will be coordinated with the EDWDD and the South Dakota DENR. Monthly testing will be performed at four sites and will include total *E. coli* concentrations, the fraction attached to particles, and the unattached fraction. Samples will be run in triplicate to account for sample variation, resulting in a minimum of 504 plates per monitoring year (assuming three samples are adequate to account for spatial variability). Additional plating may be necessary if dilution is required or a larger number of samples is found to be required during the standard method development phase of the project.

Two of the monitoring sites will be selected for intense storm sampling. Each site will have a three by three sample grid for a total of 9 sediment samples and one water column sample (10

samples at each site). Total *E. coli* concentrations and sediment particle size will be evaluated. These grids will be sampled three times following the proposed schedule if possible:

1. 1 day prior to the storm event
2. 1 day following the storm event
3. 7 days following the storm event

The proposed schedule will be altered if conditions, such as stream flow, are not favorable for sampling. Sampling around a storm event will allow for the analysis of *E. coli* reservoir depletion due to storm events as well as the potential for recovery after such events. In addition, the grid provides the necessary information to analyze the changes in *E. coli* concentrations spatially. Estimates can be made about loading from *E. coli* reservoirs in the stream sediments to the water column based on the concentration reductions.

Again, cost estimates are based on plating two different dilutions for more accurate colony counts.

Task #1: Sediment *E. coli* concentrations will be monitored at a minimum of once a month		
Task Description	Collect and process samples from four locations at a minimum of once a month using the proposed standard method. Samples will be tested for *E. coli* concentrations. A minimum of 252 plates are required per monitoring year for a single dilution (504 during the two year monitoring period). More may be required if additional dilutions are needed or more samples are required to account for spatial variability. Cost estimates are based on plating two dilutions.	
Task Outputs	*E. coli* sediment concentrations and attachment rates at four locations along Skunk Creek once a month from April through October. Evaluations on persistence and sediment composition will be examined (see Outcomes 4, 5, 6).	
Cost	Federal (319) Funds	$4,600
	Non-Federal Match	$1,000
	Other Federal Funds	
	Total Task Cost	$5,600 Labor costs included in overall budget

Task #2: Sediment *E. coli* concentrations will be monitored surrounding a storm event	
Task Description	Collect and process sediment *E. coli* samples from two locations surrounding a minimum of three storm events per year. Samples will be taken approximately one day prior to a storm event, one day after a storm event, and seven days after a storm event. Each sampling timeframe and location will include samples from a three by three sampling grid (9

	sediment samples) and one sample from the water column. Samples will be examined for total *E. coli* concentrations and particle size. A minimum of 540 plates will be required per year for a single dilution (1080 for the two year monitoring period). More may be required if additional dilutions are needed. Cost estimates are based on two dilutions.	
Task Outputs	*E. coli* sediment concentrations for two locations along Skunk Creek surrounding a total of six storm events. Evaluations on depletion due to storm events and potential recovery will be examined (see Outcomes 4, 5, and 6)	
Cost	Federal (319) Funds	$10,000
	Non-Federal Match	$2,000
	Other Federal Funds	
	Total Task Cost	$12,000 Labor costs included in overall budget

Outcome 3: Determine stream sediment particle size and the attachment rates of *E. coli* to particles in the sediment.

Sediment particle size will be determined for each sample (228 samples per monitoring year). This will allow for the evaluation of *E. coli* concentrations with respect to sediment compositions. Monthly samples will be evaluated for attachment rates of *E. coli* to sediment particles (84 samples per monitoring year processed in triplicate). This is important because unattached *E. coli* have the ability to remain in the water column for a longer period of time, thus allowing them to travel farther. On the other hand, attached *E. coli* settle out of the water column more readily and can be treated similarly to sediment.

Task #1: Evaluation of sediment particle size		
Task Description	The sediment particle size will be tested from the remaining sediment collected for the evaluation of *E. coli* concentrations. A minimum of 228 samples will be evaluated per monitoring year (years 2 and 3).	
Task Outputs	Sediment sample particle size distributions will be obtained for further evaluation of *E. coli* concentrations in sediment (see Outcomes 4 and 5).	
Cost	Federal (319) Funds	$5,904
	Non-Federal Match	
	Other Federal Funds	
	Total Task Cost	$5,904

Task #2: Evaluation of *E. coli* attachment rates		
Task Description	The monthly monitoring of sediment samples will be assessed for *E. coli* attachment rates. Samples will be filtered to enumerate unattached *E. coli* concentrations from which the attached fraction will be calculated. A minimum of 168 sediment samples will be run in triplicate for unattached *E. coli* concentrations over the two year period (1008 plates total assuming two dilutions). More may be required if additional dilutions are needed.	
Task Outputs	*E. coli* attachment rates to particles will be assessed for further evaluation of *E.coli* transport from sediments.	
Cost	Federal (319) Funds	$7,900
	Non-Federal Match	$907
	Other Federal Funds	
	Total Task Cost	$8,807 Labor costs included in overall budget

Outcome 4: Evaluate the relationship between sediment particle size and *E. coli* concentrations in stream sediments.

Statistical comparisons between samples at a given site will determine how much variability within a site is likely due to differences in particle sizes. This will provide some insight into the variations of *E. coli* concentrations between sites. For example, if it is found that sediments with a higher clay content have higher *E. coli* concentrations, part of the *E. coli* persistence at a site with high clay content may be attributed to the sediment type.

Task #1: Evaluation of sediment composition and *E. coli* concentrations over time		
Task Description	Statistical evaluations will be performed on *E. coli* concentrations, attachment rates, and sediment composition over time. For example, sediment particle size will be assessed to determine what, if any, sediments have a higher tendency to be reservoirs for *E. coli.*	
Task Outputs	Information regarding the persistence and temporal stability of *E. coli* concentrations in stream sediments including how sediment composition may affect *E. coli* concentrations.	
Cost	Federal (319) Funds	
	Non-Federal Match	$1,500
	Other Federal Funds	
	Total Task Cost	$1,500 Labor costs included in overall budget

Outcome 5: Assess the effect of stream-channel dimensions on *E. coli* reservoir depletion through shear stress estimates.

Shear stress will be calculated via Equation 1 which was proposed by Jamieson et al. (2005).

$$\tau_b = yS^{1/4}\left(\frac{n}{A}\right)^{3/2} Q^{3/2} \quad (1)$$

Where τ_b is the bed shear stress (N m^{-2}), y is the specific weight of water (N m^{-3}), S is the slope (m m^{-1}), n is Manning's roughness coefficient, A is the cross-sectional area (m^2), and Q is flow (m^3 s^{-1}).

This will leverage existing data, including the cross-sectional area of the stream at the site, to evaluate if and how the *E. coli* concentrations are affected by stress due to flow and the stream's geometry.

Task #1: Estimate shear stress during storm event		
Task Description	Estimate shear stress using the cross-sectional area of the stream, stream slope, and flow. Compare *E. coli* concentration reduction from storm events to shear stress and flow during the storm to determine storm reduction potential of *E. coli* reservoirs.	
Task Outputs	Information regarding the persistence and temporal stability of *E. coli* concentrations in stream sediments including the effect of storm on the stability of *E. coli* sediment reservoirs.	
Cost	Federal (319) Funds	
	Non-Federal Match	
	Other Federal Funds	
	Total Task Cost	Labor costs included in overall budget

Outcome 6: Evaluate the effects of Seasonal Riparian Area Management (SRAM) on stream sediment *E. coli* concentrations and potential persistence after cattle exclusion.

Statistical comparisons will be performed between the start of the recreation season, when the cattle are initially excluded, mid-season, and the end of the recreation season. Analyses between sites will consider information obtained from the sediment particle size portion of the study as particle size will likely vary between sites and has been shown to affect *E. coli* concentrations.

Task #1: Compare *E. coli* sediment concentrations upstream of, at, and downstream of SRAM sites.		
Task Description	Statistically compare the four locations (SK1, SK2, SK3, and SK4) against each other and through time to determine if SRAM affects *E. coli* concentrations in stream sediments.	
Task Outputs	Information regarding the performance of the SRAM BMP on *E. coli* concentrations in stream sediments and the potential delay in concentration reductions.	
Cost	Federal (319) Funds	
	Non-Federal Match	
	Other Federal Funds	
	Total Task Cost	Labor costs included in overall budget

3.3 MILESTONE TABLE

Project Name: Persistence of *E. coli* in stream sediments and the impact on water quality

Date: July 2016 - June 2019	Year 1												Year 2												Year 3											
Task	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Outcome 1: Standard Method																																				
Task 1: Examine existing literature[1]																																				
Task 2: Assess temporal variability[2]																																				
Task 3: Assess variability within a sample[2]																																				
Task 4: Assess variability between locations[2]																																				
[2] Product 1: Sampling																																				
[2] Product 2: Statistical analysis																																				
[1 2] Product 3: Standard methods document																																				
Outcome 2: Monitoring *E. coli* in stream sediments																																				
Task 1: Monthly monitoring																																				
Task 2: Storm event monitoring																																				
Outcome 3: Assess particle size and attachment rates																																				
Task 1: Assess particle size																																				
Task 2: Assess *E. coli* attachment																																				
Outcome 4: Particle size and *E. coli* concentrations																																				
Task 1: Statistical evaluation																																				
Outcome 5: Shear stress and *E. coli* depletion																																				
Task 1: Statistical evaluation																																				
Outcome 6: Location comparison between sampling sites																																				
Task 1: Statistically compare the four sampling locations																																				
Reporting																																				
Semi-annual reports																																				
Annual reports																																				
Final report																																				

All tasks will be completed by SDSU personnel.

3.4 PROJECT MANAGEMENT AND TRACKING

The project personnel have expertise with water quality issues including bacterial fate and transport in stream environments. Progress will be tracked by semi-annual and annual reports that will be submitted to the DENR in December and July of each project year. In addition, the project personnel will meet annually with the DENR to discuss project progress.

3.5 PERMITS

This project will include sampling, lab work, and statistical analyses. No permits will be required.

4.0 COORDINATION PLAN

4.1 COOPERATING ORGANIZATIONS

The SDSU personnel on this project have expertise with water quality, including bacterial fate and transport, as well as soil microbial environments. The research team has access to the SDSU soils testing lab for processing sediment particle size. SDSU will also provide facilities and equipment to process *E. coli* samples from stream sediments and the water column.

4.2 LOCAL SUPPORT FOR THE PROJECT

Concern over *E. coli* concentrations in the Big Sioux River and its tributaries is apparent through events such as the Big Sioux River Water Summit which provided a forum for discussing water quality concerns in the Big Sioux River, including *E. coli*. Other entities, such as the Moody County Conservation District, are working with stakeholders to implement BMPs and improve water quality.

The project investigators will work with local organizations currently sampling and working to reduce *E. coli* concentrations in Skunk Creek and Big Sioux River. Contact has been established withthe East Dakota Water Development District, the Moody County Conservation District, and the South Dakota DENR.

4.3 DUPLICATE EFFORT

Currently, sediment samples are being processed to examine *E. coli* reservoirs in South Dakota; however, there is no standard sampling procedure. This project will coordinate efforts to monitor *E. coli* reservoirs in stream sediments across the state by standardizing the sample collection method, thus allowing direct comparisons between sampling locations and monitoring organizations.

The project personnel will work with the EDWDD and DENR to coordinate sampling efforts, who have been sampling the water column and sediment in Skunk Creek for *E. coli*. The aim of this project is to expand current monitoring efforts by evaluating particle size, attachment rates, and the spatial distribution of *E. coli* concentrations to begin determining how factors, such as particle size, contribute *E. coli* stability in stream sediments.

4.4 ASSUMPTION OF RESPONSIBILITIES OF OTHER ENTITIES

To the knowledge of the project director, all project responsibilities fall to the project director and her team.

5.0 EVALUATION AND MONITORING PLAN

5.1 MONTORING STRATEGY

Years two and three of the project will include monthly monitoring of stream sediments from April through October. The current monthly monitoring strategy includes four locations monitored at each side and the middle of the stream for a total of three samples per location. Samples will be analyzed for *E. coli* concentrations, attachment rates, and sediment particle size.

In addition, monitoring will be completed surrounding 6 storm events over the two year monitoring period. Samples will be collected at two locations in a 3x3 sampling grid. If possible, samples will be collected one day prior to, one day following, and seven days following a storm. This schedule may be altered conditions are not favorable for sampling, such as high flows that do not permit access to the stream. Samples will be analyzed for *E. coli* concentrations and sediment particle size.

5.2 SAMPLING AND ANALYSIS PLAN

A standard method of sediment sampling will be developed in year 1 of the project. This procedure will be followed during years 2 and 3 of the project.

5.3 QUALITY ASSURANCE PROJECT PLAN

A Quality Assurance Project Plan will be developed prior to project implementation if the project is selected for funding.

5.4 DATA COLLECTION, MANAGEMENT, AND ANALYSIS

Data will be collected, managed, and analyzed by SDSU personnel. The data will be located on the SDSU server and will backed up on external drives at a minimum of twice monthly by project personnel. All data will be reported to the DENR and will be made available upon request.

5.5 MODELS

No models will be required to meet the desired outcomes of this project.

5.6 OPERATION AND MAINTENANCE

No BMPs will be implemented in relation to this project; therefore, no operation and maintenance plan will be required. Instead, the results of the proposed project will be used to inform future BMPs.

6.0 INFORMATION AND EDUCATION

6.1 INFORMATION AND EDUCATION ACTIVITIES

The project personnel will disseminate information through a project website, state and national conferences, and publications. A project website will be maintained throughout the life of the project, providing interested parties with information on the standard sampling method and other results. Posters and/or presentations will be given at state and national conferences. Lastly publications will be created from this project including a document describing the standard method for sampling sediment to evaluate *E. coli* concentrations.

7.0 BUDGET AND BUDGET JUSTIFICATION

Project: Persistence of *E. coli* in stream sediments and the impact on water quality

Date: July 2016 - June 2019

Item	Year 1	Year 2	Year 3	Total	319	SDSU
Senior project personnel, incl benefits	$ 19,545.00	$ 20,154.00	$ 20,782.00	$ 60,481.00	$ 19,233.00	$ 41,248.00
Graduate assistant, incl benefits	$ 24,326.00	$ 25,056.00	$ 25,808.00	$ 75,190.00	$ 75,190.00	$ -
Undergraduate assitant, incl benefits	$ 3,889.00	$ 4,577.00	$ 4,126.00	$ 12,592.00	$ -	$ 12,592.00
Travel	$ 1,000.00	$ 2,700.00	$ 2,900.00	$ 6,600.00	$ 6,600.00	$ -
Publication	$ 200.00	$ 400.00	$ 600.00	$ 1,200.00	$ 1,200.00	$ -
Tuition Remission	$ 3,400.00	$ 3,600.00	$ 3,800.00	$ 10,800.00	$ 10,800.00	$ -
Task Costs						
Outcome 1: Standard Method Document						
Task 1: Examine existing literature	$ -	$ -	$ -	$ -	$ -	$ -
Task 2: Assess temporal variability	$ 3,000.00	$ -	$ -	$ 3,000.00	$ 3,000.00	$ -
Task 3: Assess variability within a sample	$ 4,500.00	$ -	$ -	$ 4,500.00	$ 4,500.00	$ -
Task 4: Assess variability between locations	$ 1,500.00	$ -	$ -	$ 1,500.00	$ 1,500.00	$ -
Outcome 2: Monitoring *E. coli* in stream sediments						
Task 1: Monthly monitoring	$ 1,700.00	$ 2,300.00	$ 1,600.00	$ 5,600.00	$ 4,600.00	$ 1,000.00
Task 2: Storm event monitoring	$ 3,400.00	$ 5,000.00	$ 3,600.00	$ 12,000.00	$ 10,000.00	$ 2,000.00
Outcome 3: Assess particle size and attachment rates						
Task 1: Assess particle size	$ 1,265.00	$ 2,952.00	$ 1,687.00	$ 5,904.00	$ 5,904.00	$ -
Task 2: Assess *E. coli* attachment	$ 2,607.00	$ 3,950.00	$ 2,250.00	$ 8,807.00	$ 7,900.00	$ 907.00
Outcome 4: Particle size and *E. coli* concentrations						
Task 1: Statistical evaluation	$ 1,500.00	$ -	$ -	$ 1,500.00	$ -	$ 1,500.00
Outcome 5: Shear stress and *E. coli* depletion						
Task 1: Statistical evaluation	$ -	$ -	$ -	$ -	$ -	$ -
Outcome 6: Location comparison between sampling sites						
Task 1: Statistically compare the four sampling locations	$ -	$ -	$ -	$ -	$ -	$ -
Reporting						
Semi-annual reports	$ -	$ -	$ -	$ -	$ -	$ -
Annual reports	$ -	$ -	$ -	$ -	$ -	$ -
Final report	$ -	$ -	$ -	$ -	$ -	$ -
Indirect (27.6%)	$ 19,146.00	$ 18,034.00	$ 17,710.00	$ 54,890.00	$ 38,538.00	$ 16,352.00
Total	$ 90,978.00	$ 88,723.00	$ 84,863.00	$ 264,564.00	$ 188,965.00	$ 75,599.00

Budget Justification

Senior Personnel

$14,113 is requested for Rachel McDaniel, who will serve as the Principal Investigator and will be responsible for the overall project goals and objectives. 0.5 months of the PI's summer is being dedicated to this project each year. $2,611 is requested for Bruce Bleakley, who will serve as the Co-Investigator and will be responsible for assistance with the overall project. 0.1 months of the PI's summer is being dedicated to this project each year.

Fringe benefits for the personnel above is at a rate of 15% plus $9,053 health and life. Based on the time given to this project, the cost of benefits for senior personnel is $2,509.

Other Personnel

$74,446 is requested for one Ph.D. student who will support this project as a research assistant. This amount represents 49% effort of the calendar year. Fringe benefits for graduate students is calculated at a rate of 1% for a total of $744.

$10,800 is requested for tuition remission at a rate of $3,400 for year 1 and increasing by $200 each year thereafter.

Travel

Travel funds for a total of 40 site visits is requested, totaling $970. Project personnel also plan an annual visit to Pierre to discuss progress with the DENR which totals $360.

Lastly, $5,270 is requested to attend three state and two national conferences to disseminate the results of this project to both local and national audiences.

Other Direct Costs

The estimated costs of materials and supplies is $31,500 over the entirety of the project. This includes general lab supplies, such as petri dishes, agar, filters, etc., and minor lab equipment required for processing samples for attachment rates.

A total of $1,200 is requested for publication costs that may include posters and peer-reviewed publications.

$5,904 is requested for contractual services. The SDSU Soil Testing Lab will assist the PI and Co-Investigator with analyzing sediment particle size, which is critical to the proposed project.

Facilities and Administration

F&A costs totaling $38,537 is associated with the proposed project at the rate of 27.6% of the Modified Total Direct Costs.

Matching Funds

In-Kind Match

Rachel McDaniel will provide an in-kind match equal to 11% of her academic salary, totaling $27,944 over the duration of the project. Co-Investigator Bruce Bleakley will provide an in-kind match equal to 2% of his academic salary, totaling $4,701 over the duration of the project. Senior personnel benefits over the duration of the project total to $8,604.

In addition, an undergraduate research assistant will be provided for the project for an estimated 1,100 hours over the duration of the project for an estimated total of $12,467. Benefits are an additional 1% and total to $125.

Materials/Equipment costs required for this project totaling $5,407 will be purchased by the sponsor.

Indirect costs totaling $16,352 are also provided.

8.0 REFERENCES

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