MONTANA NSF EPSCoR
NEWSLETTER
SPRING 2020

SENSORS DEPLOYED STATE-WIDE

Sensing technology is a core aspect of the CREWS research project. Understanding water quality across large and diverse landscapes and over periods of time requires both remote and *in situ* for data collection. The CREWS project deploys autonomous sensor in the water to collect data over time on key water quality indicators - this work is led by the DeGrandpre group at UM. A concurrent effort on the project led by the Shaw group at MSU employs remote sensing to image streams from the air to better understand the spatial and temporal changes in algae and other organic matter.

Mike DeGrandpre and Cory Beatty deploy a stream sensor array (measuring continuous dissolved oxygen, carbon dioxide, nitrate, and more) in Louse Creek, a headwater tributary of the Judith River. Photo by Stephanie Ewing.

Launching the CREWS *in situ* sensor network over the first field season went from zero to 100 MPH in seconds. In June of 2019, faculty and students from across the state came together for a sensor 'Boot Camp' to learn about SAMI sensors created by Sunburst Sensors, a partner in the CREWS project (UM researcher Mike DeGrandpre founded Sunburst Sensors). SAMI sensors test water pH and carbon dioxide content. The team also uses SUNA V2 sensors to measure nitrate concentration as well as Onset data loggers for depth and conductivity and MiniDOTS to record dissolved oxygen and temperature.

Drone with hyperspectral imaging systems ready to collect data. Photo by Joseph Shaw.

Soon after the training workshop, UM and MSU groups (DeGrandpre, Beatty, Payn, Ewing and others) converged on Louse Creek in the Judith River Watershed (JRW), placing nitrate, CO_2, O_2 and conductivity sensors at two locations along a stretch of the creek. We found that the creek has extremely high nitrate concentrations, and one goal of CREWS is to find out where those high concentrations come from and how they change in the stream. The Payn and Ewing groups subsequently completed two additional sensor deployments in the JRW.

On the west side of the continental divide, field work ramped up in August of 2019 with deployment of sensors at four locations on the Upper Clark Fork River (UCFR). The Valett, DeGrandpre and Colman groups traveled up and down I-90 along the Clark Fork River for a couple of months, collecting water samples to support the sensor data. This work will help us understand differences in river productivity and to what extent metal pollution from historic mining varies with stream chemistry and biology.

The CREWS project also launched its remote sensing work over the course of the first field season, following extensive calibration and preparation in the laboratory. The Shaw group deployed a hyperspectral imaging system (from industry partner, Resonon, Inc.) mounted to a remotely operated drone in the Judith River Watershed as well as along the Clark Fork River. The Shaw group conducted six field tests in collaboration with CREWS researchers from both study sites. Hyperspectral imaging in combination with inference software (under development) will allow the CREWS team to track vegetation and algal growth in both water systems. Algal and plant growth relates to water chemistry, linking remote sensing measurements to the *in-situ* monitoring of water quality parameters.

SEED FUNDING AWARDED

The CREWS Research Seed Award Program is designed to fund innovative research related to water quality and build research capacity across Montana's higher education institutions. Three competitive seed categories provide opportunities for Montana researchers and educators, through new awards in 2020, to research, workforce development, and Tribal College initiatives. The research seed program was substantially augmented through supporting contributions from the research offices at Montana State University (MSU), Montana Technological University (MTU), and the University of Montana (UM). This collaboration with campus research offices showcases the unique statewide partnership with NSF ESPCoR and allowed the CREWS project to fund seven research seed projects that will enhance the water quality research program.

The workforce development seed program was open to two- and four-year campuses across the state targeted towards extending institutional participation on the CREWS project beyond the state's primary research campuses. New awards will be issued to faculty at Montana State University Billings (MSU-B), University of Montana Western (UM-W), and Rocky Mountain College (RMC). Seven research, four workforce development, and three tribal college proposals were selected for funding from the 30 proposals received.

Research Awards

Seasonal anoxia under winter ice cover enhances mobilization, methylation and downstream transport of mercury from Georgetown Lake, Montana. MSU PI John Dore and co-PI Eric Boyd.

Effect of nitrate and sulfate on the biotransformation of selenium, microbial diversity and multi-domain biofilm formation: implications for the remediation of selenium-laden waters. MSU PI Erika Espinosa-Ortiz, and co-PIs Rebecca Muller, Ellen Lauchnor, Robin Gerlach, and Brent Peyton.

Preventing Environmental Impact of Metals Extraction Using Biocompatible, Magnetic Nanomaterials. MTU PI Katie M. Hailer.

ArduiNMR: a low cost infiltration sensor. MSU PI Trevor Irons and co-PI Xiaobing Zhou.

Technology Platform for High-Spatial-Resolution Monitoring of Water Quality with Redundant in situ Micro-Sensors. MSU PI Stephan Warnat.

Interactive effects of heavy metals and temperature on the survival, growth, and thermal tolerance of salmonfly nymphs from the Upper Clark Fork River. UM PI Art Woods.

Synergic field identification of heavy metal contaminants in mining tailings and exposed sediments using laser-induced breakdown spectroscopy and hyperspectral spectroscopy. MTU PI Xiaobing Zhou and co-PIs Marvin Speece and Gary Wyss.

Tribal College Awards

A STEM Summer Camp for Secondary Students on the Flathead Reservation. SKC PI Heather Bleecker.

Building Chemistry Curriculum Laboratories for Natural Resources and Environmental Science. LBHC PI Neva Tall Bear.

Little Bighorn River Watershed Management Plan: Utilizing GIS technologies and analysis. LBHC PI Emery Three Irons.

Workforce Development Awards

Promoting Community Resilience Through Understanding: Social Perceptions of Water Quality and Contamination in the Upper Clark Fork River Watershed. UM-W PI Arica Crootof.

CREWS Montana State University Billings Water Quality and Environmental Impact Undergraduate Research Internship Program. MSU-B PI Matt Queen.

Baseline Assessment of Phase Four Proposed Remediation on the Upper Clark Fork Near Galen, Montana. UM-W PI Robert C. Thomas.

Stakeholder visions of the past, present, and future of water quality in Montana coal country. RMC PI Luke Ward.

We are pleased to welcome our new collaborators Rocky Mountain College, MSU-Billings and UM-Western.

DOYLE SERVES ON EPA COUNCIL

John Doyle and Emery Three Irons sample water. Photo by A. Dvorakova.

John Doyle, Little Big Horn College, was appointed to the Environmental Protection Agency's National Environmental Justice Advisory Council (NEJAC) as a Tribal representative in November 2019. NEJAC provides advice and recommendations about broad, crosscutting issues related to environmental justice to the EPA administrator. The EPA selected eight new members from a pool of approximately 100 highly qualified candidates. We are excited that a member of the CREWS team has been appointed to this council. John, part of the PRB team, will do a fantastic job in this role.

METCALF FEATURED IN MONTANAN

Libby Metcalf UM photos

Libby Metcalf, of UM's W.A. Franke College of Forestry & Conservation,has been featured in an article in UM's Montanan Magazine. The article focuses on Libby's involvement in UM's S.E.A. Change initiative and highlights her work and contributions to the campus and state. Libby is a part of the Natural Resource Social Science team for CREWS. Read the full article here: www. montanan.umt.edu/issues/winter-2020

FACULTY HONORED AT MSU CONVOCATION

Top: Julia Haggerty Bottom: Joe Shaw MSU staff photos

Two MSU CREWS faculty were recognized with prestigious awards during Spring Convocation 2020. Julia Haggerty, associate professor in the Dept. of Earth Sciences and member of the CREWS Natural Resource Social Science team, was presented with the Betty Coffey Award for outstanding achievement in women's equity. Joe Shaw, professor in the Dept.of Electrical and Computer Engineering and member of the JRW team, received the Provost's Award for Graduate Research and Creativity Mentoring.

MEREDITH ON STEM CAREERS

Liddi Meredith. Photo by Simon Bierbach.

Research professor Liddi Meredith, Montana Bureau of Mines and Geology at Montana Technological University, was featured in a STEM Careers story on the CREWS blog. Meredith is a member of the PRB team studying how energy development affects water quality in the Powder River Basin. Check out her interview at: https://www.mtnsfepscor.org/index.php/projects/crews/blog

GRUMSTRUP WINS PECASE

Erik Grumstrup. Photo by Kelly Gorham

Congratulations to Erik Grumstrup, Dept. of Chemistry and Biochemistry at MSU, who earned a Presidential Early Career Award for Scientists and Engineers (PECASE). This honor is the U.S. government's highest award to recognize leading early career researchers who show exceptional potential for leadership in the advancement of scientific knowledge. Erik is a member of the CREWS JRW team.

DIRECTORS UPDATE

The CREWS project is in year 2 of the 5 year award. We have made great progress toward our goals and objectives, ranging from research to a vast array of linked broader engagement activities. We are particularly excited by new research and workforce development activities through our competitive seed grant program. The quality of research in Montana is outstanding, and we had a hard time picking among many outstanding proposals. The team visited with NSF in early March for a Reverse Site Visit where NSF assembled a plan to review our work to date and plans forward. Soon we will put together our Year 2 annual report for NSF. This report will include a review of our efforts by both an external advisory board and external evaluators. Finally, we want to make sure that everyone saves the date for our next All-hands Meeting. We will hold this meeting in Bozeman on October 7-8, 2020. Stay tuned for details this summer.

JUDITH RIVER WATERSHED UPDATE

In Year 1 of the CREWS initiative, the Judith River Watershed (JRW) team had a busy and productive summer field season. From June to August 2019, graduate students Duncan Ocel and Caitlin Mitchell, working with Stephanie Ewing, Rob Payn, Mike DeGrandpre and Cory Beatty, deployed water chemistry sensors and took measurements at sites along Louse Creek in Judith Basin County, while graduate student Riley Logan (working with Joe Shaw) conducted initial drone flights in the watershed to identify vegetation via hyperspectral imaging. Additionally, Mitchell and graduate student Joe Capella (working with Ewing) collaborated with Simon Fordyce from the Central Agricultural Research Center (CARC) in Moccasin to install snow-monitoring equipment at CARC during the fall.

JRW team members also were productive in the lab. Katelyn Duncan, a graduate student in Rob Walker's group, is finishing up preliminary studies of synthetic organic solutes in model biological membranes. Preliminary studies have shown that a solutes partitioning coefficient is insufficient in describing the solutes affinity for bioaccumulation and that a more quantitative, mechanistic description is required. With the results obtained, studies are moving away from model solutes and toward analyzing herbicides. Shelton Varapragasam, a postdoc in Erik Grumstrup's group, constructed a home built transient absorption spectroscopy to study charge carrier dynamics of semiconductor photocatalytic materials, and established an inert atmosphere synthesis apparatus to perform colloidal synthesis of various semiconductor photocatalytic materials. Different types of iron oxide nanoparticles have been synthesized, characterized, and evaluated for photocatalytic aqueous nitrate reduction. Finally, undergraduates Allison Kelly, Emily Vincent, Sam Butcher, and Alexis Icenogle, M.S. student Sarah Kaufman, and Brian St. Clair worked with Katherine Zodrow to identify the effects of pesticides on bacterial and biofilm growth and build a bench-scale reverse osmosis system.

The team held regular meetings for all members to stay up to date on activities. Over the course of the semester, Shelton Varapragasam, Duncan Ocel, Katherine Zodrow, Katelyn Duncan, and Riley Logan presented results of their research to the group. Members of the JRW team also presented in October at the CREWS all-hands meeting and at the Annual Montana Chapter of the American Water Resources Conference in Red Lodge, and Adam Sigler presented results of his dissertation work at the Annual American Geophysical Union Meeting in San Francisco.

Graduate student Riley Logan and undergraduate student Elizabeth Rehbein, both in Joe Shaw's lab, conduct a test flight of a drone equipped with a hyperspectral camera near the upstream end of Louse Creek, a headwater of the Judith River. Photo by Rob Payn.

In October, the JRW team hired Ann Marie Reinhold, a fluvial geomorphologist and biogeochemical modeler. Reinhold has worked with Rob Payn and Stephanie Ewing to develop conceptual models of contaminant transport across process domains in the JRW and across the focal sites, and with Adam Sigler and Venice Bayrd to develop a data product from prior research in the Judith River Watershed.The larger CREWS team also brought on Madison Boone as a Project Liaison. In this role, Boone has helped the JRW team coordinate their regular meetings as well as convene the team's advisory committee.

UPPER CLARK FORK RIVER UPDATE

CREWS researchers are working to quantify and monitor river sediment metals and nutrients, and to study river productivity, algal blooms, and ecological integrity along the Upper Clark Fork River (UCFR). The summer field season in the first year of the project (summer 2019) established 13 sites for in situ sensors, water sampling, and flow measurements along 200 km of the river.

During the Summer 2019 field campaign, the CREWS UCFR field team placed *in situ* sensors that measure carbon dioxide, dissolved oxygen, nitrate, and conductivity, into the river at four monitoring sites: Galen, Racetrack, Gold Creek, Jens Bridge. Data from these sensors was paired with systematic measurements of water volume, depth, and pH, by the field team.

Metals in the banks of the Clark Fork River. Photo by Maury Valett.

Water samples from these monitoring sites over the course of the field season were taken back to the lab and analyzed for nutrients (nitrogen, phosphorous, carbon) and for metals and arsenic within different size fractions. CREWS researchers are also tracking the growth and proliferation of river algae that often forms nuisance blooms in the upper river to tie bloom development to river chemistry. As part of the effort to track riverine algal blooms, researchers conducted hyperspectral imaging drone flights at Galen Road with the intent of developing methods required to employ remote sensing techniques for measuring algal abundance along the UCFR.

Food web researchers also initiated sampling of river macroinvertebrates and their food sources with the intent of assessing stable isotope and metal content to address why energy, nutrients, and contaminants move from water and sediments into riverine biota. Coordinated efforts are underway to work with MT FWP and include investigation of riverine fishes as a key part of the UCFR food web.

In the lab, remediation techniques addressing the use of engineered nanoparticles to remove metal contamination from freshwater were the focus of work by the Downey research group at MTU. Work in this realm continues to develop technology associated with the Continuous Flow Metal Recovery, with the intent of scaling it for use in environmental waters.

Social science research in the UCFR focuses on community resilience and how communities respond to acute or chronic water quality issues. Researchers have started work in the Anaconda and Deer Lodge communities and are preparing to conduct interviews.

CREWS faculty, students, and postdocs are collaborating with Montana agencies (DEQ, NRDP, MT FWP), NGOs (Clark Fork Coalition), and private companies (Sunburst Sensors, Resonon, Inc., and Geum, Inc.) to carry out this work, share monitoring data, and align CREWS research with State priorities. To accomplish this, the CREWS team has generated the Upper Clark Fork Working Group (UCFWG). With support from the NRDP, Geum Inc., and the Montana Institute on Ecosystems, the UCFWG is a coalition of scientists, managers, and area experts with a mission to *facilitate, produce, analyze and share science-based knowledge among key participants involved in the remediation, restoration, research, and monitoring of the Upper Clark Fork River and its tributaries*. For more information and a list of UCFWG participants, please see: ucfwg.org. The CREWS UCFR team includes the Valett, DeGrandpre, Colman, Metcalf, and Hall research groups at the UM, the Shaw, Cross and Payn research groups at MSU, the Downey research group at MTU, and the Berthelote and Lichtenberg groups at Salish Kootenai College. Graduate students and postdocs contributing to the work include: Bailey, Feijó, Gold, Quiros, Hutchins, Kyro, Logan, Leitzke, Moore, Prater, Perkins, Johnson, Sanchez-Ruiz, Shangguan, Wisotzkely, Young.

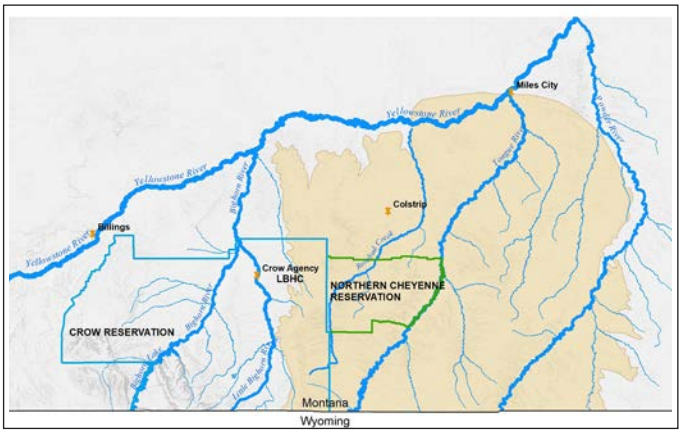
POWDER RIVER BASIN UPDATE

The Powder River Basin team is starting to ramp up on-site research efforts. The team has selected a study watershed and site for new water quality sampling. New graduate students are joining the team, and plans for summer 2020 are underway. We have secured access to private land, and drilling is planned to begin in June on four to six water sampling wells. We have made preliminary measurements of neutral surfactant adsorption to gypsum surfaces from vapor phase and carbon nanoparticle adsorption to water surfaces and aggregation tendencies.

The term Powder River Basin (PRB) refers to the area that sits atop the vast geological formation that encases rocks like the Fort Union coal seams and is one of the world's largest deposits of low-sulfur coal. The PRB is the largest coal producing region in the US. It supplies 40% of US coal and also contains petroleum, gas, and uranium resources; 3% of world coal reserves are in the PRB. The surface geology in this area is largely dominated by gypsum. Accessing coal deposits requires displacement of surface materials, creating spoils piles that are used to reclaim and restore land after mining activities end. Reclaimed land consisting of spoils materials has significantly more surface area than the original geologic material and different flow patterns. Water flowing over and through reclaimed mine sites into streams and rivers will continue to reflect effects of 'landscape disruption' for decades to come.

This has a significant impact on the range lands in the area and the high-quality water needed for the range to be productive. Some waters generated by aquifer disruption and spoil heap processing in the PRB have transient sulfate concentrations dangerously high for human consumption and at levels that cause neurological damage in livestock. High sulfate concentrations also inhibit uptake by plants, making sulfate impaired water unfit for agricultural use. The PRB team is working on understanding the impacts of mining to ground and surface water exchange relating to surface water quality. The Powder River watershed is limited to the area that drains the Powder River to the Yellowstone, and does not include Rosebud Creek (Colstrip) or the Tongue River.

The CREWS PRB team includes the Walker, Eggers, Ewing, and Payn research groups along with Lauchnor at MSU; researchers Doyle, Three Irons and EPA coordinator Martin at LBHC; Meredith and Zodrow at MTU, and Tsosie at UM; graduate students Shaikh and Galip and undergraduate Hernandez at MSU.



Map of the Powder River Basin. Image by Andrew Hauer.

Top: historical photo of open mining in the Powder River Basin.
Bottom: reclaimed range land in the Powder River Basin.

STEM GIRLS IN GOVERNMENT CAMP

Students in STEM Girls in Government Camp. Photo by Suzi Taylor.

Girls from two rural areas of Montana descended on the state capital for a 48-hour extravaganza of STEM activities designed to introduce them to women in science, technology, engineering, and mathematics and showcase diverse and good-paying jobs in Montana.

STEM Girls in Government took place Sept. 15-17 in Helena. Two teams were chosen by competitive application: a group of seventh grade girls from Gardiner Public Schools, and a team of high school girls from the Salish Kootenai College (SKC) Upward Bound program, which serves several communities on the Flathead Indian Reservation.

The camp was filled with interactive opportunities, including measuring trees and creating maps with staff from the Montana State Library, doing coding exercises and learning about cybersecurity, studying bats with Montana Fish, Wildlife and Parks, and much more. The girls toured the State Capitol and had lunch with Governor Steve Bullock and First Lady Lisa Bullock, who serves on the advisory board for the Girls STEM Collaborative.

Joanne Morrow of the SKC Upward Bound program said, “Learning about the amazing variety of STEM careers in state government and the personal connections the students were able to make were the most beneficial aspects for my Upward Bound students.” Morrow’s students expressed great appreciation for the camp and indicated they are now exploring new and different career paths. One of her students said this of the positive impact of the camp a few month’s after its conclusion, “Now I'm rethinking what I want to do in terms of a career and I still take up coding on my own time."

The camp was hosted by the IT Managers Council with support from the Montana Girls STEM Collaborative, an NSF EPSCoR program started in 2012.

SENSING FOR SCIENCE EXHIBIT

spectrUM staff piloted Sensing for Science activities with K-12 teachers at the 2019 Montana Educator Conference.

What is a sensor? How does it work? How are scientists using sensors to understand our water systems?

These are some of the questions that the public will have the opportunity to explore through “Sensing for Science,” a mobile exhibition that the University of Montana spectrUM Discovery Area is collaboratively developing with CREWS researchers. Designed to spark K-12 students’ excitement about STEM and engage them and their families with CREWS research, the exhibition will travel to communities and K-12 schools across Montana, as well as to spectrUM’s permanent Missoula locations.

Part of the CREWS broader engagement strategy, Sensing for Science features activities that encourage visitors to explore how researchers use sensors to measure phenomena such as magnetism, conductivity, and temperature. Exhibit signage will make connections between user-friendly, off-the-shelf sensors such as FLIR infrared and Vernier sensors, as well as sensors that CREWS researchers are using to explore questions about Montana’s water systems.

A pilot version of the exhibition traveled to schools in Anaconda and Superior and to the Montana Educator Conference in Belgrade in fall 2019. With additional funding from Enbridge, Sensing for Science will visit the central Montana communities of Lewistown, Stanford, and Harlowton in 2020.

WHAT IS EPSCOR?

ABOUT NSF EPSCOR

The Montana NSF EPSCoR Consortium for Research on Environmental Water Systems, or CREWS, is a five year project that explores how changing compositions and levels of nutrients and contaminants affect water quality--from soils and rivers to local communities that rely on clean water. The project focuses on three main landscapes where water and economy are inextricably linked: the Upper Clark Fork River, the Judith Basin, and the Powder River Basin. This project creates opportunities in workforce development, innovation, and entrepreneurship through partnerships with private business and is a collaborative effort across Montana's universities and colleges. For additional information please visit our website at **https://mtnsfepscor.org**.

The National Science Foundation's Established Program to Stimulate Competitive Research (EPSCoR) enhances the research competitiveness of targeted jurisdictions by strengthening STEM capacity and capability.

Montana's EPSCoR governing committee is the Montana Science & Technology Committee within the Office of the Commissioner of Higher Education. The CREWS project's leadership and topic were selected by this committee through a statewide competitive process. NSF EPSCoR has been a quiet but powerful partner in growing Montana's Research and Development enterprise since 1979.

Montana NSF EPSCoR

Ragan Callaway
Project Director

32 Campus Drive - 4884
University of Montana
Missoula, MT 59812-4884

Todd Kipfer
Associate Project Director

PO Box 170585
Montana State University
Bozeman, MT 59717

Email: info@mtnsfepscor.org

Web: www.mtnsfepscor.org

facebook.com/MontanaEPSCoR

Twitter.com/MontanaEPSCoR

This material is based on work supported by the National Science Foundation under Grant OIA-1757351. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

RESEARCH TEAM

Maury Valett, co-PI, UM, Division of Biological Sciences & Institute on Ecosystems
Robert Walker, co-PI, MSU, Dept of Chemistry and Biochemistry & Graduate Program in Materials Science
Jerry Downey, co-PI, MTech, Dept of Metallurgical & Materials Engineering
Stephanie Ewing, co-PI, MSU, Dept of Land Resources and Environmental Sciences
Venice Bayrd, MSU, CREWS Data Manager
Antony Berthelote, SKC, Dept of Hydrology
Ben Colman, UM, College of Forestry and Conservation
Wyatt Cross, MSU, Department of Ecology & Montana Water Center
Michael DeGrandpre, UM, Dept of Chemistry and Biochemistry
John Doyle, LBHC, Crow Water Quality Project
Margaret Eggers, MSU, Center for Biofilm Engineering
Erik Grumstrup, MSU, Dept of Chemistry and Biochemistry
Julia Haggerty, MSU, Dept of Earth Sciences & Institute on Ecosystems
Bob Hall, UM, Division of Biological Sciences & Flathead Lake Biological Station
Janene Lichtenberg, SKC, Dept of Wildlife and Fisheries
Liddi Meredith, MTech, Montana Bureau of Mines and Geology
Elizabeth Metcalf, UM, College of Forestry and Conservation
Robert Payn, MSU, Dept of Land Resources and Environmental Sciences & Institute on Ecosystems
Joe Shaw, MSU, Dept of Electrical and Computer Engineering & Optical Technology Center
Jack Skinner, MTech, Dept of Mechanical Engineering
Brian St. Clair, MTech, Dept. of Chemistry and Geochemistry
Katherine Zodrow, MTech, Dept of Environmental Engineering

EXTERNAL ENGAGEMENT & PARTNERSHIPS

Madison Boone, MSU, Site Liaison and Communications Manager
Jessie Herbert-Meny, UM, spectrUM Discovery Area
Jakki Mohr, UM, College of Business
Suzi Taylor, MSU, Academic Technology and Outreach
Aaron Thomas, UM, Dept of Chemistry and Biochemistry & Indigenous Research and STEM Education
Nathalie Wolfram, UM, CREWS Broader Impacts Group

MONTANA NSF EPSCOR OFFICE

Ragan Callaway, Project Director/Principal Investigator, UM
Todd Kipfer, Associate Project Director, MSU
Chelle Terwilliger, Project Administrator, UM
Rhonda Stoddard, Fiscal Administrator, UM
Susie Couch, Fiscal Administrator, MSU
Andrew Hauer, Technical Coordinator, UM