MONTANA AWRA

Proceedings

for

Collaborative Science

American Water Resources Association Montana Section 2018 Conference

October 17 - October 19, 2018
Holiday Inn West Yellowstone-- West Yellowstone, Montana

Contents

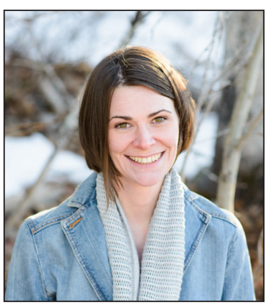
***These abstracts were not edited and appear as submitted by the author, except for some changes in font and format.**

THANKS TO ALL WHO MAKE THIS EVENT POSSIBLE!

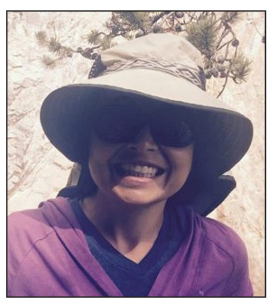
- **The AWRA Officers**
  Emilie Erich Hoffman, President -- Montana DEQ
  Melissa Schaar, Vice President -- Montana DNRC
  Kim Snodgrass, Treasurer -- Water and Environmental Technologies
  Nancy Hystad, Executive Secretary -- Montana State University

- **Montana Water Center, Meeting Coordination**
  Wyatt Cross, Director, and Whitney Lonsdale, Assistant Director

And especially the conference presenters, field trip leaders, moderators, student judges and volunteers.



Emilie Erich Hoffman



Melissa Schaar

Kim Snodgrass

Nancy Hystad

Montana Section of the American Water Resources Association would like to thank our sponsors:

WEDNESDAY, OCTOBER 17, 2018

REGISTRATION

9:30 am – 7:00 pm REGISTRATION
Preconference registration available at water.montana.edu/awra/registration/

WORKSHOP, FIELD TRIP and HYDROPHILE RUN

10:00 am - 12:00 pm **Communication Workshop: Effective Presentation Training** *(please register)*
Led by MT State Professional Development Center

1:00 pm – 5:00 pm **Field Trip to Yellowstone National Park** *(bus leaves Holiday Inn promptly at 1pm)*
Peter Brown*, Stewardship Director Gallatin Valley Land Trust;*
Alan English, *Hydrogeologist MBMG;*
Dr. Alysia Cox*, Assistant Professor of Chemistry and Geochemistry at Montana Tech*
Dr. Brian St Claire, *Center for Advanced Mineral, Metallurgical and Materials Processing at Montana Tech*
Organized by: Kim Snodgrass*, AWRA Treasurer*

5:30 pm – 6:30 pm **Hydrophile 5k Run/Walk -** *Run starts and finishes at Holiday Inn West Yellowstone*

THURSDAY, OCTOBER 18, 2018

REGISTRATION

7:30 am REGISTRATION, COFFEE AND CONVERSATION

OPENING DAY PLENARY SESSION

8:00 am WELCOME WITH INTRODUCTIONS, LOGISTICS AND ANNOUNCEMENTS
Emilie Erich Hoffman -- *AWRA Montana Section President*

8:10 A MESSAGE FROM THE MONTANA WATER CENTER
Wyatt Cross -- *Montana Water Center, Director*

8:20 KEYNOTE SERIES 1: Andy Ray, *National Park Service*; Tom Henderson, *Montana Dept of Environmental Quality*; Brian Ertel, *National Park Service*
Title: Collaborative Science at Soda Butte Creek

9:30 *BREAK*

9:50 Special Speaker: Jason Mohr, *Research Analyst* - Legislative Update

10:10 KEYNOTE SERIES 2: Tom Osborne, *Vice President HydroSolutions*; James Patterson, *West Yellowstone Public Works Director*; Alan English, *Hydrogeologist Montana Bureau of Mines and Geology*; Kerri Strasheim, *DNRC Bozeman Regional Manager*
Title: West Yellowstone Groundwater Panel Discussion

11:10 Water Legend Presentation: Congratulations to Larry Dolan!

11:45 *BREAK*

12:00 Lunch - provided to all registered conference attendees

THURSDAY, OCTOBER 18, 2018 (continued)

TECHNICAL SESSIONS: ORAL PRESENTATIONS (Red text indicates student presenters)

SESSION 1 (Concurrent) ECOLOGY

Moderator: Maurice Valett

1:00 pm Nolan Platt. *Assessing Connectivity Benefits of Denil Fishways, an Integrated Approach.*

1:20 Kimberly Bray. *Epilithic Biomass Abundance and Composition: Influences on Allochthonous and Autochthonous Nitrogen Sources.*

1:40 Patrick Hurley. *Biogeochemical dynamics in a wetland-stream continuum.*

2:00 Tyler Blue. *Assessing the efficacy of flow restrictor plates in denil fishways for upstream passage of arctic grayling.*

2:20 Benjamin Colman. *Emerging contaminant increases wetland methane fluxes by stimulating production and potential trophic cascade.*

2:40 *BREAK & POSTER SET UP*

.

SESSION 2 (Concurrent) HYDROLOGY

Moderator: Melissa Brickl

1:00 pm Robert Payn. *Using longitudinal synoptics of water quality along Hyalite Creek and the Gallatin Valley to understand the distribution of groundwater sources to stream flow generation in the Gallatin River Watershed.*

1:20 Katherine Chase. *From Droughts to Floods and Back Again: Looking back at Montana 2017 – 2018 Streamflows.*

1:40 Camela Carstarphen. *Montana's Precipitation Isotope Network (MTPIN) Montana Bureau of Mines and Geology's (MBMG) Ground Water Assessment Program (GWAP).*

2:00 Luke Buckley. *The Surface Water Assessment and Monitoring Program (SWAMP) and the MBMG Data Center.*

2:20 Robin Welling. *Influence of large wood on sediment routing in a mixed bedrock-alluvial stream*

2:40 *BREAK & POSTER SET UP*

SESSION 3 (Concurrent) ENVIRONMENTAL CHEMISTRY

Moderator: Andrew Bobst

3:00 pm Robert Rader. *Geochemistry of metals and nutrients in fine-sediment pore water in Blacktail and Silver Bow creeks, Butte, Montana.*

3:20 Christina Eggensberger. *Living Filtration Membranes*.

3:40 Brian St Clair. *Host rock influences metal abundance and speciation in hot springs.*

SESSION 4 (Concurrent) WATER QUALITY

Moderator: John LaFave

3:00 pm Ngaio Richards. *Using Detection Dogs to Monitor Environmental Contaminants in Freshwater Ecosystems Via Sentinel Species.*

3:20 Chris Ellison. *Application of Dimensionless Sediment Rating Curves to Predict Suspended-Sediment Concentrations, Bedload, and Annual Sediment Loads for Rivers and Streams.*

TECHNICAL SESSIONS: ORAL PRESENTATIONS (continued)

4:00 Valerie Stacey. *Groundwater fluoride in Helena, Montana: a function of bedrock geology and geothermal activity*

4:20 *BREAK*

3:40 David Naftz. *Non-resident selenium imports to Lake Koocanusa and Bighorn Lake, MT: Sources, biogeochemical cycling, and tailwater implications.*

4:00 Kim Snodgrass. *Pollutant Transport in the Sanitary Sewer Collection System*

4:20 Katherine Zodrow. *Passive Evaporation Enhancement of Acidic Mine Water.*

4:40 *BREAK*

POSTER SESSION

5:00 – 7:00 pm AWRA 2018 POSTER PRESENTATIONS

1. John Allard. *Using sediment maps to understand fluvial sediment dynamics associated with in-channel, deformable structures.*
2. Jonathon Feldman. *Aqueous metal and semimetal speciation in Silver Bow and Blacktail Creeks.*
3. Lydia Landau. *Pre-restoration characteristics of high elevation mesic sites in greater sage-grouse habitats.*
4. John Lunzer. *Using groundwater modeling to assess groundwater and stream connectivity in a river restoration application.*
5. Adrian Massey. *A Checklist of the Elmidae (Coleoptera) of Montana, USA with a Description of a New Species in the Genus Narpus.*
6. Ross Monasmith. *Evaporative effects of solar absorbers: passive solar evaporation islands (PSEI) reduce water treatment volumes.*
7. Megan Moore *Ranchers and Natural Water Storage: Are Some More Willing to Adopt Adaptation Strategies?*
8. Evan Norman. *Monitoring the Impacts of Beaver-Mimicry on Groundwater and Surface Water Interactions in the Blacktail Creek.*
9. Robert Ray. *Developing a River Restoration Definition and Policy for Montana.*
10. Hannah Riedl. *An Interactive 319 Projects Map*
11. Lauren Sullivan. *Exploring the size of contaminants in wastewater.*
12. Alisa Wade. *UM BRIDGES National Research Traineeship: Bridging Divides across the Food, Energy, and Water Nexus.*
13. Andrew Wilcox. *Multiyear geomorphic response of the Clark Fork River, Montana, to dam removal and floods.*

SOCIAL HOUR

5:00 - 7:00 pm SOCIAL HOUR (concurrent with poster session):

Snacks, Photo contest, Announcements; dinner on your own

FRIDAY, OCTOBER 19, 2018

7:30 am Gather for Coffee and Conversation with Colleagues

TECHNICAL SESSIONS: ORAL PRESENTATIONS

SESSION 5 (Concurrent)
MANAGEMENT & RESTORATION

Moderator: Madeline Gotkowitz

8:00 am Joanna Thamke. *Understanding the relation between energy and water resources in the Williston Basin.*

8:20 Brian Sugden. *Effectiveness of Montana's Streamside Management Zone Law at Protecting Stream Temperatures during Forest Harvesting.*

8:40 Heidi Anderson Folnagy. *Funding Projects that Benefit Natural Resources.*

9:00 Robert Sain. *Reconnection and restoration of Elbow Coulee in the Sun River watershed.*

9:20 Jeff LeProwse. *Mapping, Managing, and Maintaining data with Survey123 and ArcGis Online.*

9:40 Robert Ray. *TMDL Implemetation Evaluations from around Montana.*

10:00 *BREAK*

SESSION 5 (Concurrent)
COLLABORATION

Moderator: Christine Miller

8:00 am Aaron Fiaschetti. *The Confluence of Law and Science: A collaborative effort to manage water resources on the Teton River, Montana.*

8:20 Maurice Valett. *Consortium for Research on Environmental Water Systems (CREWS): a Montana collaborative effort for integrated research and application.*

8:40 James Efta/Clint Sestrich. *Application of the Wetted Perimeter Methodology to Identify and Mitigate Potential Impacts from Proposed Exploratory Drilling- Iron Creek, Beartooth R.D., Custer Gallatin National Forest.*

9:00 John Babcock *Little Bitterroot Lake – 20 Years of Collaborative Science with a Pro-Active Lake Association.*

9:20 Amy Jensen. *Forest Service NHD Stewardship Strategy.*

9:40 Sharon Brodie. *H20 Tools: An Online Platform for Collaboration and Data Integration*

10:00 *BREAK*

SESSION 7 (Concurrent) MODELING

Moderator: Attila Folnagy

10:20 am Kirk Waren. *A Groundwater Model for the Meadow Village Alluvial Aquifer, Big Sky, Gallatin County, Montana.*

10:40 Chuck Dalby. *Comparison of Satellite-Based, Remote-Sensing Methods for Estimating Evapotranspiration from Irrigated Land in the Flathead and Smith River Basins of Montana.*

SESSION 8 (Concurrent) CLIMATE

Moderator: Joanna Thamke

10:20 am Paul Stoy. *The role of land management in creating cooler and wetter conditions during May and June across the northern North American Great Plains.*

10:40 Paul Stoy. *Convective suppression before and during the flash drought of 2017.*

FRIDAY, OCTOBER 19, 2018 (continued)

TECHNICAL SESSIONS: ORAL PRESENTATIONS (continued)

11:00	Adam Sigler. *The Big Levers - Management, Soils, and Weather. Interactions controlling soil water and nitrate loss in a non-irrigated cropping system.*
11:20	Andy Bobst. *Using groundwater models to explore how beaver-mimicry stream restoration affects dynamic seasonal water storage*
11:40	BREAK

11:00	Justin Martin. *Increased drought intensity driven by warming in the Upper Missouri River basin.*
11:20	John LaFave. *State-Wide Groundwater Monitoring Network – Assessing Drought Impacts and Ground Truthing Big Data*
11:40	BREAK

CLOSING PLENARY

12:00 pm CLOSING PLENARY

Announcements - New Officer, Student Awards, Next Year's Location

ADJOURN

KEYNOTE SERIES 1 SPEAKER BIOS

COLLABORATIVE SCIENCE AT SODA BUTTE CREEK

Andrew Ray

Ecologist, National Park Service, Greater Yellowstone Network

Andrew Ray is an Ecologist with the National Park Service's Greater Yellowstone Network in Bozeman, MT. Andrew works on water quality and amphibian projects in Bighorn Canyon National Recreation Area and Grand Teton and Yellowstone national parks.

Tom Henderson

Project Manager/Hydrogeologist, Montana Department of Environmental Quality

Tom Henderson is a Project Manager and Hydrogeologist with the Montana Department of Environmental Quality. Tom received a Bachelor's in Geology from Oberlin College and a PhD in groundwater modeling from the University of British Columbia. His work experience includes coal mine reclamation in Kentucky, environmental consulting in Colorado, and abandoned mine reclamation in Montana. Tom worked on the McLaren Tailings Reclamation Project at the northeast corner of Yellowstone National Park for the past ten years and is currently working on projects to address acid mine drainage from abandoned coal mines near Great Falls. He is planning to return to the Alps for a sixth time with his wife and three children in 2019.

KEYNOTE SERIES 1 SPEAKER BIOS (continued)

Brian Ertel

Fisheries Biologist, National Park Service, Yellowstone National Park

Brian Ertel is a fisheries biologist with the National Park Service in Yellowstone National Park. He grew up in Philadelphia and received his BS in Biology with a concentration in Environmental Science from Kutztown University of Pennsylvania. He began work as a Student Conservation Association volunteer in Yellowstone NP in 1996 and progressed to lead technician a few years leader. He received his MS from Montana State University studying the life history and abundance of Yellowstone Cutthroat Trout in the Yellowstone River headwaters. His current area of focus is Yellowstone Cutthroat Trout restoration and preservation in the Greater Yellowstone Ecosystem. He is also current President of the Montana Chapter of the American Fisheries Society.

KEYNOTE SERIES 2 SPEAKER BIOS

WEST YELLOWSTONE GROUNDWATER PANEL DISCUSSION

Alan English

Research Hydrologist, Montana Bureau of Mines and Geology

Alan English is a research hydrogeologist with the Montana Bureau of Mines and Geology in Butte. Alan has a BS in Geology from the University of Montana and an MS in Hydrogeology from Montana Tech. His past work experience includes working as a consulting geologist at an underground gold mine in Colorado, and as an abandoned mine inspector in Montana. He also served as the Senior Water Quality Specialist for the Missoula Valley Water Quality District, and most recently spent 13 years serving as the Manager of the Gallatin Local Water Quality District in Bozeman.

Kerri Strasheim

DNRC Bozeman Water Resources, Regional Manager

Kerri was born and raised on a flood-irrigated farm (tubes and gated pipe) in Terry, Montana, appreciating water starting at a young age. She received a BS in Earth Sciences from MSU-Bozeman, emphasizing in geohydrology with a microbiology option. Kerri completed an MS in Earth Sciences from MSU-Bozeman, studying septic system influence on water quality in surface water and ground water. She has been employed with DNRC (in the Bozeman office) since June of 2005, starting in the adjudication program. In February of 2008, Kerri started training to move into the new appropriations program, and in August of 2008, was promoted into the Manager position. Previous to DNRC, Kerri worked for the USFWS investigating New Zealand Mud Snails and performing lab work with relation to fish health.

James Patterson

Superintendent of Public Services, West Yellowstone, MT

James Patterson is the Public Works Superintendent for the City of West Yellowstone. Prior to the Public Works position, James was in the private sector and owned an excavation business that installed water and sewer mains and completed site grading and excavation.

KEYNOTE SERIES 2 SPEAKERS (continued)

Tom Osborne

Vice President, HydroSolutions

Tom was born and raised in Wisconsin. He holds Bachelor of Science degrees in Forestry and Natural Resources Management. Tom attended graduate school at the University of Wisconsin-Madison, and in 1974 earned a Master of Science degree in Water Resources Management. Tom served in Vietnam with the 101st Airborne Division and the 2nd of the 327th Infantry, and honourably discharged with a Bronze Star and Campaign medals.

In 1976 Tom and his wife, Angie, moved to Lame Deer, Montana where he worked on coal hydrology research studies for the Northern Cheyenne Indian Tribe. They moved to Butte in 1980, where Tom worked briefly at MERDI, before joining the Bureau of Mines and Geology. Tom conducted hydrogeologic investigations of agriculture water issues, and acid mine drainage mitigation. Tom left in 1986 to become the first Director of the Central Wisconsin Groundwater Center at the University of Wisconsin-Stevens Point. In 1990 he returned to Billings to open an environmental consulting office where he led many industry and governmental projects related to water, energy and mineral resource development in Montana and Wyoming.

In 1997, Tom founded his own consulting business which in 1999 became HydroSolutions Inc., with offices in Billings and Helena. He is a Registered Professional Hydrologist with 42 years of experience working on water quality, mining hydrology, water rights, water supplies, contaminant cleanup, energy and agricultural water issues, and provides expert services in litigation. He has authored and co-authored over 50 professional publications and presentations. Tom was recognized with the "Water Legend" award given by the Montana Chapter of the American Water Resources Association (2013), and by Montana Tech and Bureau of Mines and Geology with the Uuno Sahinen Silver Medallion award in 2017.

He and Angie have three adult children and nine grandchildren and live in Absarokee, and Helena, Montana. His hobbies include hiking, floating, hunting and Nordic skiing. For the last 10 years, Tom and his wife have been active philanthropically and personally with water development and humanitarian aid projects in Africa.

SPECIAL SPEAKERS

Wyatt Cross

Director, Montana Water Center

Wyatt Cross is the Director of the Montana Water Center, and a professor in the Department of Ecology and Montana State University. He's working to focus and grow the water center as the nexus between the Montana Universities and water resource professionals across the state. When he's not working on Water Center business, his research laboratory is focused on understanding how stream ecosystems respond to various human perturbations, including river regulation, climate change, and nutrient pollution.

Jason Mohr

Research Analyst, Legislative Environmental Policy Office

Larry Dolan

Surface Water Hydrologist, Montana Department of Natural Resources and Conservation

Larry Dolan is a surface water hydrologist with the Montana Department of Natural Resources and Conservation in Helena where he has been employed during the past 29 years. Prior to DNRC, he was a Research Associate with the Wyoming Water Research Center in Laramie where he obtained his Master's Degree in Geography/Water Resources from the University of Wyoming. He also has a Bachelor's Degree in Earth Sciences from Frostburg State University in Maryland.

Larry has worked on water resources projects and issues throughout Montana, and has provided technical support on international river apportionment concerns with Alberta and Saskatchewan. The most rewarding part of his career has been working with water users to better understand and manage water resources, especially in the Boulder, Ruby, Shields, Sun, Sweet Grass Creek, Tongue, and Milk River watersheds.

ABSTRACTS FOR ORAL AND POSTER PRESENTATIONS

LISTED IN ALPHABETICAL ORDER, BEGINNING ON NEXT PAGE

Using sediment maps to understand fluvial sediment dynamics associated with in-channel, deformable structures

Student poster presentation

John Allard[1], Sharon Williams[1], Rebekah Levine[1]

[1]University of Montana Western

In the snowmelt-dominated watersheds of southwest Montana, channel incision is disconnecting streams from floodplains and reducing associated riparian habitat. Incision can also result in: 1) loss of meandering, thus increasing velocity and decreasing aggradation 2) lowered channel and water table elevation 3) bank instability and increased sediment loads 4) increased water temperatures from vegetation loss. Installation of structures that intentionally alter fluvial processes has been successful in reconnecting channels to flood-plains. Channel elevating riffle-grade-control-structures (RGCS) were installed by The Nature Conservancy (TNC) and partners on Long Creek in the Centennial Valley of southwest Montana in late August of 2016. Brush structures, built primarily from on-site materials such as conifer and willow, were installed along Robb Creek, a tributary of the Ruby River in southwest Montana, in 2015 and 2017. The goal of RGCSs and brush structures is to create riffle-pool morphology, encouraging sediment storage upstream and increased velocity downstream, ultimately promoting aggradation through induced meanders and re-establishing flood-plain connectivity. Broader floodplains and aggrading channels promote longer water residence times, thus increasing infiltration and potentially increasing alluvial aquifer storage. Ultimately, the hydrological shifts have the potential to enhance late summer discharge. The University of Montana Western's 2017 Hydrology Course used base maps of stream banklines overlain by 2 x 2 m grids to map sediment patches. Each patch was classified into a sediment class and the entire stream bottom was mapped where possible. Sedimentation patterns from maps are being used to determine how RGCSs are impacting channel morphology and hydrologic function. On Long Creek, we compared mapped sediments to pre-installation data from one year prior. We found an increase in fine sediments and aquatic vegetation in the channel, and an areal reduction in gravel. On Robb Creek, our mapping provided pre-installation baseline data to assess impacts of the brush structures installed during, and following, our project work.

Funding Projects that Benefit Natural Resources

Oral presentation

Heidi Anderson Folnagy[1], Lindsay Volpe[1]

[1]MT DNRC

The Montana Department of Natural Resources and Conservation (DNRC) Resource Development Bureau administers two grant programs to fund projects that benefit natural resources. The Renewable Resource Grant and Loan (RRGL) Program funds projects that conserve, develop, manage, and preserve natural resources. Projects that repair and reclaim damage to natural resources from mineral development or develop and ensure the quality of public resources for the benefit of all Montanans are funded through the Reclamation and Development Grants (RDG) Program. Applicants present many different types of projects to DNRC for funding. Here we discuss results from three very different projects to highlight the many types of projects that receive funding from the Resource Development Bureau.

Ninemile Creek Reclamation - Missoula County
Ninemile Creek, in the Clark Fork River watershed near Missoula, Montana was extensively mined from the late 1800s to the 1940s using manual placer, hydraulic mining, and dragline dredge methods resulting in a excessive erosion and a stream and floodplain with poor fish and wildlife habitat values. With support from the DNRC RDG Program, Ninemile Creek and its associated floodplain and tributary connections are being reclaimed through restoring the stream to a natural channel configuration, regrading placer tail piles and dredge ponds, and reconnecting tributary confluences.

Contaminant Cleanup and Wetland Restoration at the Harlowton Roundhouse - City of Harlowton
Historic fueling operations at an abandoned Milwaukee Roundhouse in Harlowton, Montana released diesel fuel to soil and groundwater in the floodplain of the Musselshell River. Diesel contamination has impacted approximately 25,000 cubic yards of soil and free-phase diesel is present on the groundwater surface over approximately 2 acres of the site. With support from the DNRC RDG and RRGL programs, the City of Harlowton will remove contaminated soils and design a restored wetland that the City plans to turn into a park.

Vaughn Wastewater System Improvement Project - Vaughn Cascade County Water Sewer District
The Vaughn Cascade County Water and Sewer District wastewater system currently has 259 year-round sewer connections. With funds from the DNRC RRGL Program, the existing wastewater treatment system was expanded with a new aeration cell to treat discharge between October 1-April 30 and to spray irrigate incoming treated wastewater May 1-September 30. A UV disinfection system will be added to the treatment system to ensure E. Coli limits are consistently met. This project addresses multiple wastewater treatment options with a single system.

The DNRC Resource Development Bureau also has funding for irrigation development, watershed management, and project planning activities. If you have a project in mind that will benefit Montana’s natural resources, please contact Heidi Anderson Folnagy, RDG Program Manager, hfolnagy@mt.gov or Lindsay Volpe, RRGL Program Manager, lmvolpe@mt.gov.

Little Bitterroot Lake Association - 20 Years

Oral presentation

John N Babcock[1]

[1]Water & Environmental Technologies

The Little Bitterroot Lake Association was formed in 1988 with the purpose of preserving the recreational value of Little Bitterroot Lake, maintaining its aesthetic integrity, and to educate users about the value of the lake as a recreational resource. Since 1999, water quality monitoring has been conducted on the lake and surrounding watershed to provide a baseline of nutrient data, to analyze trends, and to help prioritize management decisions that may effect water quality of the lake. Sampling has primarily included nutrients, chlorophyll-a in water and on benthic substrate, field parameters, and depth profiles to evaluate stratification. Additional sampling has been conducted for metals, sediment, radioactive elements, and aquatic invasive species as water quality issues emerge.

This presentation will discuss the water quality status of Little Bitterroot Lake and trends over the past 20 years of monitoring, including recent sampling and prevention measures for aquatic invasive species. This talk also showcases the unique collaboration between members of the lake association, the community of Marion, regional scientists, and local elementary schools.

Analyzing the Efficacy of Flow Restrictor Plates in Denil Fishways for Passage of Arctic Grayling

Student oral presentation

Tyler Blue[1]

[1]Montana State University

Habitat connectivity is imperative in the preservation of access to habitat, food, and refuge for fish and other aquatic species. The Arctic Grayling (Thymallus Arcticus) is a population of fish that has seen the impact that cutting off upstream habitat has on the life cycle of a species. A species once abundant in the rivers and lakes of Michigan and Montana, the Arctic Grayling now resides only in the Big Hole River watershed. To help preserve the Arctic Grayling, 63 Denil fishways have been installed on irrigation diversion structures throughout this watershed. However, this style of fish ladder requires higher flow levels to facilitate passage, but irrigators need every bit of water they can get. In an attempt to meet the need of Arctic grayling and irrigators, a study was conducted to test the efficacy of flow-control weirs ('flow-restrictor plates') installed at the upstream end of the Denil fishway to decrease the required flowrate needed to pass Arctic grayling. This study investigated three distinct restrictor plate designs in addition to a control (no plate installed). Each treatment received the same five trials in order to better compare flow restriction, passage efficiency, and several other hydraulic and ecologic factors. Upon the completion of the data collection phase, analysis was done to assess the efficacy of installing any of these plates to the upstream end of the Denil fishway. The end goal was to develop a model that could predict passage efficiency in a Denil fishway for a given plate based on a set of other variables. After several iterations, it was found that the sole predictor of passage efficiency will be the amount of water running through the fish ladder. Work will continue to develop a standard for the installation of these flow control weirs, but at this time, it appears that these plates may in fact inhibit passage.

Using groundwater models to explore how beaver-mimicry stream restoration affects dynamic seasonal water storage

Oral presentation

Andrew L Bobst[1], Robert A Payn[2], Glenn Shaw[3]

[1]MBMG, [2]Montana State University, [3]Montana Technological University

Beaver-mimicry stream restoration (BMR) seeks to simulate the effects of beaver activity on stream ecosystems. One common objective of this type of restoration is to increase seasonal water storage, which will in turn increase late-summer stream flows. However, the specific hydrologic mechanisms by which BMR would promote higher late summer flows remain poorly understood.

We used GMS and MODFLOW to develop relatively simple numerical models of groundwater and surface water exchanges in fluvial systems, and assessed the magnitude and timing of changes in dynamic seasonal storage and stream flow resulting from BMR. Models were loosely based on headwater streams with a snowmelt-driven hydrograph and a valley gradient of about 0.005. Baseline models were developed for three different groundwater connection scenarios, where the simulated reach was gaining, losing, or strongly losing. A control and five types of BMR treatments were simulated in each setting, including: (1) no BMR, (2) creating a pond in the active channel, (3) activating a proximal and a (4) distal remnant side-channel, (5) inundating the flood plain, and (6) creating surface water storage ponds connected to the channel only by groundwater flow paths. Thus, a total 18 of models were developed and used to calculate differences in net late-summer stream gains before and after restoration. Finally, sensitivity analyses using the baseline and distal channel reactivation scenarios in the gaining, losing and strongly losing settings evaluated the effects of substrate composition and evapotranspiration on the late-summer stream flow changes created by BMR.

Active-channel ponds caused calculated late-summer net stream gains to increase by 0.06 Ls-1 (0.9 gpm) for the gaining stream, to increase by 0.07 Ls-1 (1.1 gpm) for the losing stream, and to decrease by 0.02 Ls-1 (0.3 gpm) for the strongly losing stream. Additional effects from activating remnant side-channels, or inundating the floodplain during high flows were modest, with the greatest gain being 0.01 Ls-1 (0.2 gpm) more than from the pond alone. Creating surface-water storage was more effective at increasing late-summer flows, with net stream gains increasing from 0.35 to 0.50 Ls-1 (5 to 8 gpm) above baseline. It should be noted that while these changes are calculable, they would be difficult to measure.

Sensitivity analysis showed that aquifers composed of silty sand to coarse sand provided the best conditions for increasing late-summer flows. Similarly, streambeds composed of silty sand to sand provided for the greatest increase in late-summer flows. Simulation of evapotranspiration effects showed that the increase in groundwater table elevations (increased storage) created by BMR may allow more subsurface water to be used by riparian plants, potentially resulting in slight reductions in late-summer stream flow.

In general, modeled scenarios suggest that BMR designs that recharge the aquifer farther from the channel lead to more seasonal storage. Creating seasonal storage in ponds that are connected to the main channel only through the subsurface strongly increases the potential for dynamic seasonal storage.

Epilithic Biomass Abundance and Composition: Influences on Allochthonous and Autochthonous Nitrogen Sources

Student oral presentation

Kimberly Bray[1], Marc Peipoch[2], H. Maurice Valett[1]

[1]University of Montana, [2]Stroud Water Research Center

Excessive nutrient inputs can cause algal and cyanobacterial blooms in river systems. Elevated concentrations of phosphorus (P) and nitrogen (N) in the Upper Clark Fork River (UCFR) of MT promote extensive mid- summer blooms of green algae (i.e. Cladophora), with some evidence of late-summer cyanobacteria proliferation. In addition to nutrient loading, the UCFR suffers from major metal contamination. Algal form and abundance may play a critical role in metal movement through the food web. Research addressing N availability, the relative abundance of N-fixing cyanobacteria and Cladophora in the periphyton community, and their interactions was addressed to determine the implications of nutrient enrichment. Summer-long assessment of N- fixation rates revealed fluxes ranging from 0.7 to 45.4 ugNm-2h-1 while biofilm abundance varied by almost 80-fold (0.456 to 36.1 g AFDM/m2) over six weeks of sampling. Comparisons with nitrate uptake rates during changing periphyton composition were used to determine the role of allochthonous and autochthonous N sources on epilithic biomass abundance and composition.

H20 Tools: An Online Platform for Collaboration and Data Integration

Oral presentation

Sharon Brodie[1]

[1]Four Corners Community Foundation

H2O Tools is a comprehensive water management tool as well as a platform for collaboration and education. It is a prototype information system designed to bring together water experts and other key stakeholders for the purpose of making informed and far-reaching decisions regarding water use. 1. H2O Tools helps people understand water in the natural world ‘where it comes from, where it goes, and how much of it there is. 2. It incorporates human impacts on the

Watershed and helps us project water availability based on both human and natural factors. 3. This information gives us the ability to compare and contrast options regarding water use. Because a key goal for the Platform is to integrate data across many sources, we are able to provide intuitive visuals that combine many layers of data in one spot. For instance, the Platform can provide information and mapping across geographic, political, economic, census, and watershed boundaries. This provides information and insight while saving the time, effort, and cost that's often associated with visiting multiple sites. It is not our intention to reinvent the wheel or produce redundant work or data but to integrate existing data and information into one useful Platform. There are many highly qualified people and agencies working on water quality and availability issues, our goal is to support their work. For instance, a farmer or rancher might want to know when his water is likely to be shut off in the coming season. A fisheries biologist might want to know when spring runoff is likely to occur and what storage options are available to slow that water down as it passes through the watershed. City managers might want to know how much water will available for use by their municipalities and how they can mitigate that water use. And everyone needs to understand how the decisions they make regarding water use influence others. Sometimes big challenges require big solutions. H20 Tools is a big solution for helping all of us work together to meet the water related challenges that lie ahead.

The Surface Water Assessment and Monitoring Program (SWAMP) and the MBMG Data Center

Oral presentation

Luke Buckley[1]

[1]Montana Bureau of Mines and Geology

The Data Center at the Montana Bureau of Mines and Geology (MBMG) is comprised of 50 databases and more than 40 web sites and applications. Each public-facing system (a database paired with a website) is designed to store and deliver information collected by researchers about Montana's natural resources. Beginning with the Ground Water Information Center (GWIC) database in 1999, the MBMG has maintained an integrated online data presence. During the last 19 years, publicly available data have been published through either websites (e.g., GWIC, Catalog, Earthquakes, Abandoned Mines, Mapper), or GIS web services (e.g., Geothermal, GWIC, Abandoned Mines, Proppant, Earthquakes, Geology). As part of the MBMG data-integration philosophy, database reports contain the requested data as well as other available MBMG data for the request area.

The newest addition to the Data Center is the Surface Water Assessment and Monitoring Program (SWAMP) database. After three years of concept development, the 2017 Montana Legislature officially created SWAMP as a new program. The database was populated initially by real-time and other existing data from MBMG and DNRC. Building on this initial effort, SWAMP is now incorporating data from other agencies and groups that collect surface-water data. Surface-water data (charts, statistics, and data downloads) are available through the SWAMP website (http:// mbmg.mtech.edu/swamp) and can be viewed through a text-and map-based interface.

The MBMG Data Center continues to increase in customer usage. The analytics and usage data for 2017 shows that more than 708,000 users hit the websites more than 33 million times and downloaded more than 6.1 billion pieces of data.

Montana's Precipitation Isotope Network (MTPIN) Montana Bureau of Mines and Geology's (MBMG) Ground Water Assessment Program (GWAP)

Oral presentation

Camela Carstarphen[1]

[1]Montana Bureau of Mines and Geology, Groundwater Assessment Program

Because groundwater originates as precipitation, variations in naturally occurring stable isotopes, 18O/16O and 2H/1H, in precipitation have the potential to be useful for identifying groundwater recharge sources. Although analysis of stable water isotopes in groundwater and surface-water samples is common, their compositions in Montana's precipitation are not well documented. In response to this, MBMG is developing a precipitation network to provide monthly composite stable water isotope concentrations. This network consists of a precipitation sampler paired with a climate station, which is either a Montana Climate Office Mesonet station, or a Natural Resources Conservation Services (NRCS) snow telemetry (SNOTEL) site.

Precipitation is collected in the International Atomic Energy Agency's Global Network of Isotopes in Precipitation (IAEA's GNIP) recommended sampler. Samples are collected following standard protocol, analyzed by MBMG's Analytical Lab, and results are disseminated through the MBMG Ground Water Information Center (GWIC) website. Sites are identified by a unique GWIC ID and GWAP project code (MTPIN).

The network's pilot project consists of 7 sites within southwest and western Montana (the Lolo, Upper Clark Fork, and Blackfoot Watersheds). These locations were chosen because of current hydrologic investigations in those watersheds. The pilot project is focused on developing sampling methods and field techniques. We anticipate network expansion in basins throughout the state. Current partners include Montana Tech, University of Montana, Montana Climate Office, Montana and Idaho NRCS, and Region 1 United States Forestry Service.

From Droughts to Floods and Back Again: Looking back at Montana 2017-2018 Streamflows

Oral presentation

Katherine J Chase[1]

[1]USGS WY-MT Water Science Center

From June 2017 through July 2018, Montana's climate and streamflow conditions shifted from drought to flooding, and then back to drought. After a hot, dry summer in 2017, record-breaking snowfall through the winter and spring led to high snowmelt runoff and flooding across the state. Flooding started in April 2018 along the Montana Hi-Line. Provisional streamflow data collected by the U.S. Geological Survey (USGS) indicate the peak flow at the Milk River near Saco might have tied for the second highest on record at that gage (USGS streamgage 06164510; 40 years of record), and was associated with an Annual Exceedance Probability (AEP) between 10 percent and 4 percent (AEP calculated on 34 years of record, through 2011). Flooding shifted to the Clark Fork and Yellowstone River basins in May. Provisional streamflow data indicate peak flow at the Clark Fork above Missoula might have been the second highest on record at that gage (USGS streamgage 12340500; 98 years) and was associated with an AEP between 4 percent and 2 percent (AEP calculated on 97 years of record, through 2016). Peak flow at the Yellowstone River near Livingston might have been the third highest on record at that gage (USGS gaging station 06192500; 93 years) and was associated with an AEP between 2 percent and 1 percent (AEP calculated on 91 years of record, through 2015). In June, snowmelt runoff and heavy rainfall resulted in high streamflows and flooding along the Rocky Mountain Front. Provisional streamflow data indicate that peak flow at the Dearborn River near Craig might have been the second highest on record at that gage (06073500; 49 years) and was associated with an AEP between 2 percent and 1 percent (AEP calculated on 43 years of record, through 2011). Flooding also impacted communities along Tenmile Creek and the Musselshell River from May through June. Despite the widespread flooding in Spring 2018, drought conditions began to emerge in July across northern Montana.

In addition to summarizing and describing the historical context of streamflow data for 2017 through 2018, U.S. Geological activities and tools related to droughts, floods, and potential trends and changes in streamflow will be discussed during this presentation.

Emerging contaminant increases wetland methane fluxes by stimulating production and potential trophic cascade

Oral presentation

Benjamin P Colman[1], Leanne F Baker[2], Ryan S King[3], Cole W Matson[3], Dana Kazerooni[4], Emily S Bernhardt[5]

[1]University of Montana, [2]University of Waterloo, [3]Baylor University, [4]Virginia Tech, [5]Duke University

The release of methane by wetlands accounts for 55% of natural methane emissions, with factors such as the degree of inundation, vegetation type, and productivity driving those fluxes. Recent work looking at the ecosystem impacts of silver nanoparticles as an emerging contaminant indicated that such contaminants could tilt the balance toward enhanced methane release, though questions remained as to the mechanisms driving this phenomenon and its generalizability to real-world scenarios given that reported observations were from experiments using onetime high-concentration additions of zero-valent silver nanoparticles (Ag0- NPs) while real world releases are likely to be chronic low-concentration additions of weathered and less toxic silver sulfide nanoparticles (Ag2S-NPs). To examine the underlying mechanisms, a microcosm study was conducted with microcosms containing sediment, sediment and submersed vegetation, submersed vegetation, or just water with or without Ag0-NPs to examine the role of plant derived DOC, and whether changes in methane production or consumption were the likely drivers. To test the impacts of the rate of addition or form of silver nanoparticles added, a yearlong mesocosm experiment was conducted comparing a one-time pulse addition of pristine silver nanoparticles (Pulse Ag0NPs) to chronic low-concentration additions of either pristine (Chronic Ag0-NPs) or weathered (Chronic Ag2S-NPs) silver nanoparticles. The microcosm study suggested the underlying mechanism under high concentration exposures was methane production fueled by the release of DOC released by submersed vegetation. The mesocosm study showed that, while the Pulse Ag0-NP treatment had a rapid increase in methane concentration in the first week, the magnitude decreased over time converging with controls within a week. While the chronic treatments had no initial increase in methane, they did significantly increase relative to controls during weeks 28-34 and 42-45 in the Chronic Ag0-NPs treatment, and during weeks 28-30 and 42 in the Chronic Ag2S-NPs treatment, suggesting that even chronic addition of weathered particles could cause an increase in methane. Additionally, we observed that when methane concentrations were higher in chronic exposures, there is evidence of a shift in zooplankton abundance and composition that may have led to a trophic cascade wherein increased grazing by zooplankton depleted the abundance of methane-consuming microbes leading to elevated methane fluxes. In total, these studies show evidence of direct effects of contaminants on methane fluxes and provide evidence supporting potential indirect effects that may exacerbate the underlying direct effects.

Comparison of Satellite-Based, Remote-Sensing Methods for Estimating Evapotranspiration from Irrigated Land in the Flathead and Smith River Basins of Montana

Oral presentation

Chuck E Dalby[1], Troy Blandford[2], Bill Greiman[3], Gerry Daumiller[4]

[1]DNRC Water Resources, [2]Montana State Library, [3]DNRC Water Resources (retd.), [4]Montana State Library (retd.)

Evapotranspiration (ET), a significant part of the annual water balance of most watersheds in Montana, is difficult to reliably estimate at spatial and temporal scales useful for water planning and management. Methods for estimating ET range from simple temperature-driven agricultural engineering equations (e.g. Blaney-Criddle) to sophisticated, process-based, surface-energy balance (SEB) methods (e.g. Penman-Monteith). Over the past 20 years, SEB methods have been developed that integrate detailed weather station (flux tower) observations, with satellite imagery, and allow relatively accurate estimation of ET at fine temporal (daily, weekly, monthly) and spatial (30 meter) resolution. Over the past 10 years several methods have been used to estimate ET for irrigated parcels in the Flathead and Smith River Basins: DNRC Consumptive Use Rules (i.e. Blaney-Criddle); a vegetation-index, with thermal band adjustment method developed by DNRC and used to estimate statewide-consumptive use for the 2015 Montana State Water Plan (MWSI); a simplified, surface-energy balance (SSEB); and the SEB- METRIC model. METRIC (Measured Evapotranspiration at High Resolution with Internalized Calibration) is widely accepted as the most accurate of the satellite-based methods and was used as the basis for comparing the methods.

Application of the Wetted Perimeter Methodology to Identify and Mitigate Potential Impacts from Proposed Exploratory Drilling - Iron Creek, Beartooth R.D., Custer Gallatin National Forest

Oral presentation

James A Efta[1], Clint Sestrich[2]

[1]USDA Forest Service- Bitterroot National Forest, [2]USDA Forest Service- Custer Gallatin National Forest

Exploratory drilling has been proposed in Iron Creek, a high elevation tributary to the West Fork Stillwater River in southcentral Montana managed by the Custer Gallatin National Forest (CGNF). This tributary supports an isolated population of Yellowstone cutthroat trout, a USFS regionally listed sensitive species. Drilling would require water withdrawal from the stream at multiple locations. Given the regulatory requirements for maintenance of in-stream flows and the importance of maintaining aquatic habitat integrity, there is a need to evaluate and mitigate the effects on aquatic ecosystems resulting from water withdrawals.

In effort to address these concerns, in 2017 a collaborative monitoring effort was undertaken by the CGNF and Sibanye Stillwater Mining Company (SSMC). The Wetted Perimeter Method (sensu Nelson 1984; also Annear and Conder 1984; Lohr 1993; California Dept. of Fish and Wildlife 2013) was used to assess potential impacts from water withdrawals on aquatic habitat. A series of pressure transducers were deployed in tandem with staff gages in close proximity to proposed water withdrawal sites. Discharge and staff gage measurements were completed periodically through the field season. Subsequent data analysis linked transducer measurements with on-the-ground validation data to infer stage-discharge and discharge-wetted perimeter relationships. These measurements and relationships were evaluated against proposed withdrawal rates to discern potential drawdown and implications on aquatic habitat.

The flow monitoring methodology implemented during the 2017 field season, for the most part, adequately captured flow variability and stage dynamics while instrumentation was in place. Collected data suggested that even without water withdrawals, the majority of flows during the monitoring period (July-September) fell below levels generally corresponding with optimum macroinvertebrate habitat availability but above levels where macroinvertebrate habitat availability tends to steeply decline. Aquatic habitat was deemed unlikely to be affected by drafting operations at all but one reach. Collected data and associated analyses were used to develop guidelines for water withdrawal rates during exploratory drilling.

Though this monitoring effort demonstrated the informative power of one season of data collection combined with thorough data analysis, there is a strong need to gather and process more data to validate the conclusions drawn from the 2017 monitoring year. Monitoring will continue through the 2019 field season.

Living Filtration Membranes

Student oral presentation

Christina H Eggensperger[1], Katherine Zodrow[1]

[1]Montana Tech

Membrane filtration has become a more prevalent form of water purification due to its ability to remove contaminants of concern from various types of dirty water. Concerns with implementing membrane filtration into water treatment stem from biofouling that occurs on the membrane surface, costs associated with membrane production, and maintenance of membranes due to tears in its surface.

A potential answer to problems that arise with conventional membrane processes is to formulate membranes that are less like traditional polymeric or ceramic filtration membranes and more like the membranes in biological organisms. In fact, although many scientists have studied biomimetic membranes, no one has yet utilized a living biological membrane for drinking water filtration.

This research aims to develop a living biological water filtration membrane. The membranes are grown in a laboratory setting with a culture of yeast and bacteria. Membrane thickness can be controlled by varying the growth conditions and times, and membranes for these experiments were approximately 1 mm in thickness.

Bench-scale experiments using a dead-end filtration cell indicated the membranes have a specific flux of 4.4 g/m2*hr-1. Membranes were further characterized using confocal microscopy, contact angle goniometry, and molecular weight cutoff tests. Finally, membranes were cut with a scalpel and punctured with a needle to test their self-healing properties. Cut membranes exhibited greater than 600% increase in flux. However, after 5 days in a healing solution containing sucrose, the membrane flux decreased to 50% of the starting flux. Thus, living water treatment membranes can be grown in a laboratory setting, and these membranes have demonstrated the ability to filter contaminants out of water and heal themselves after puncture.

Application of Dimensionless Sediment Rating Curves to Predict Suspended-Sediment Concentrations, Bedload, and Annual Sediment Loads for Rivers and Streams

Oral presentation

Chris A Ellison[1]

[1]US Geological Survey

Consistent and reliable sediment data are needed by Federal, State, and local government agencies responsible for monitoring water quality, planning river restoration, quantifying sediment budgets, and evaluating the effectiveness of sediment reduction strategies. Heightened concerns about excessive sediment in rivers and the challenge to reduce costs and eliminate data gaps has guided Federal and State interests in pursuing alternative methods for measuring suspended and bedload sediment. Simple and dependable data collection and estimation techniques are needed to generate hydraulic and water-quality information for areas where data are unavailable or difficult to collect. The U.S. Geological Survey (USGS), in cooperation with the Minnesota Pollution Control Agency and the Minnesota Department of Natural Resources, completed a study to evaluate the use of dimensionless sediment rating curves (DSRCs) to accurately predict suspended-sediment concentrations (SSCs), bedload, and annual sediment loads for selected rivers and streams in Minnesota based on data collected during 2007 through 2013. Multiple measures of goodness-of-fit were developed to assess the effectiveness of DSRC models in predicting SSC and bedload for rivers in Minnesota. More than 600 dimensionless ratio values of SSC, bedload, and streamflow were evaluated and delineated according to Pfankuch stream stability categories of ‘good/fair’ and ‘poor’ to develop four Minnesota-based DSRC models. The basis for DSRC model effectiveness was founded on measures of goodness-of-fit that included proximity of the model(s) fitted line to the 95-percent confidence intervals of the site-specific model, Nash-Sutcliffe Efficiency values, model biases, and deviation of annual sediment loads from each model to the annual sediment loads calculated from measured data. The Nash-Sutcliffe Efficiency values for the Minnesota DSRC model for

suspended-sediment concentrations closely matched Nash-Sutcliffe Efficiency values of the site-specific regression models for 12 out of 16 sites. For predicting annual suspended-sediment loads (SSL), the Minnesota DSRC models for good/fair and poor stream stability sites closely approximated the annual SSLs calculated from the measured data. Practitioners are cautioned that DSRC reliability is dependent on representative measures of bankfull streamflow, SSC, and bedload. Samples of SSC and bedload, which will be used for estimating SSC and bedload at the bankfull streamflow, should be collected over a range of conditions that includes the ascending and descending limbs of the hydrograph. DSRC models should not be used to predict SSC and sediment loads for extreme streamflows, such as those that exceed twice the bankfull streamflow value. Applying these methods, Montana-based DSRCs can be developed using existing sediment data from the USGS coupled with minimum numbers of samples to fill in data gaps. Using these methods, environmental groups, conservation districts, state agencies, tribes and other interested entities in Montana can apply DSRCs for the purpose of stream restoration planning and design, and for estimating annual sediment loads for streams where little or no sediment data are available.

Aqueous metal and semimetal speciation in Silver Bow and Blacktail Creeks

Student poster presentation

Johnathan R Feldman[1], Renee Schmidt[2], Alysia D Cox[2]

[1]LEGEND Lab/Montana Tech, [2]Montana Tech

Mining activities contaminated Silver Bow and Blacktail Creeks with toxic semimetals and metals, resulting in a need for remediation. Determining element speciation will help enable development of effective strategies for managing and remediating contaminants such as arsenic. This work speciates the aqueous chemistry of concerning metals and semimetals, particularly Pb, As, Cu, Fe, and Ba using the chemical speciation program, EQ3. This study focuses on five locations in and below Butte Area One including Silver Bow Creek on Santa Claus Avenue, Slag Canyon, the storm drain behind Quality Inn on Cornell Avenue, Campgrounds of America on Kaw Avenue near Blacktail Creek trail, Upper Silver Bow Creek (USBC) near Blacktail Creek trail and Nevada Ave, and Upper Blacktail Creek near intersection between 9 Mile Road and Continental Drive. Upper Blacktail Creek has been affected less by mining activities and serves as a control.

Aqueous metal and semimetal concentrations have been determined four times a year since fall 2015, but speciation calculations are lacking (LEGEND, unpublished). At Santa in May 2016, the arsenic concentration was 59 nM +/- 6 nM. (LEGEND, unpublished). In order to perform speciation calculations, the full aqueous chemistry at each site is measured in the field and samples are collected for laboratory analysis. Elemental speciation is influenced by many parameters, including pH, and is anticipated to change seasonally. CuO (aq), HAsO42-, and Ba 2+ were expected to be the dominant species because pH values range between 6.3 and 8.5 at all sites.

Chemical speciations have been calculated for USBC May 2016, Slag Canyon August 2016, and Santa May 2016. Speciation calculations to date show that Ba2+, CuO (aq), and HAsO42- dominate at all locations. Calculations revealed that Ba2+ accounts for nearly 100% of the barium species at all sites. Copper speciation is likely pH dominated. In USBC (7.86 +/- 0.01), CuO (aq) occupied 53% of total dissolved copper. Calculations predicted 74% CuO (aq) for Slag Canyon (pH 8.08+/- 0.005) and 48% CuO (aq) for Santa (7.88+/- 0.05). The species HAsO42- occupied more than 93% of all the arsenic in both Slag Canyon and Santa. Additional calculations will be performed to confirm the dominance of CuO, Ba2+, and HAsO4 2- at all sites. Overall, speciation calculations throughout a seasonal cycle will enable informed consideration of effective remediation strategies, as well as providing a foundation for assessing bioavailability.

The Confluence of Law and Science: A collaborative effort to manage water resources on the Teton River, Montana

Oral presentation

Aaron Fiaschetti[1]

[1]Montana DNRC

Over the last one hundred years, disputes have risen over the limited water resources of the Teton River. Recently, water users have taken a different approach to decades-old water management practices by petitioning to enforce a watershed-wide Temporary Preliminary Water Court Decree.

Set by laws as old as the state of Montana, water rights are distributed according to the prior appropriation doctrine. A change in the distribution of water by priority along the 160-mile Teton River required a new understanding of how the river functions.

Hydrologists, water commissioners, and water users are working together to overcome distribution challenges along the Teton River and its tributaries. Part of the solution includes new water planning tools that provide flexibility in a rigid legal system. The result is a distribution project that is rooted in law but uses science and data to help manage water resources as efficiently as possible according to prior appropriation.

Biogeochemical dynamics in a wetland-stream continuum

Student oral presentation

Patrick Hurley[1], H Maurice Valett[1], Marc G Peipoch[2]

[1]University of Montana, [2]Stroud Water Research Center

Linked aquatic ecosystems exhibit spatiotemporally discrete material processing rates and, depending on net biogeochemical and hydrologic properties, may act as either sources, sinks or conveyors of nutrient loads. Along the wetland-stream continuum, hydrogeomorphic and biologic conditions influence nutrient processing at various scales and affect the magnitude, processing efficiency, and fate of nutrients. Ultimately, the interaction of various processes among linked aquatic systems determines loads to receiving waters by dictating net nutrient export form and abundance. Using a mass-balance approach, we developed biogeochemical and hydrologic budgets in a tributary landscape of the Upper Clark Fork River (UCFR) to better understand its substantial influence on nutrient loads to a river undergoing extensive restoration. We measured hydrologic discharge and nutrient concentrations along 22 km to develop budgets that characterized reaches by nutrient production, transformation, and retention. Variable groundwater, hydrogeomorphic, and biologic conditions differentiated reaches along the continuum and identified key drivers of nutrient processing through space and time. We found large disparities in nutrient production and retention rates between wetland- and stream-dominated reaches and identified hydrologic residence time and groundwater inputs as controls of nutrient loads to receiving waters. Spatial variability of biogeochemical processing was primarily driven by hydraulic conditions, while temporal variability was related to seasonal shifts in biologic activity and hydrologic discharge.

Forest Service NHD Stewardship Strategy

Oral presentation

Amy Jensen[1]

[1]USDA Forest Service - Northern Region (R1)

The Forest Service recognizes the value of the National Hydrography Dataset (NHD) and Watershed Boundary Dataset (WBD) to inform most Forest programs and, therefore, is invested in efficient data stewardship to improve the accuracy, consistency, and completeness of NHD/WBD across all Forest Service lands. As such, the Forest Service is developing a National Forest Service NHD Stewardship Strategy to establish common methods, practices and processes to manage, manipulate and share data in a repeatable manner. This strategy will seek to ensure that agency leaders are informed on NHD and WBD, provide appropriate support and training to agency personnel utilizing and stewarding this data, and establish governance authorities and processes to provide products and services that meet the

hydrographic data needs of all. These efforts contribute towards broader national, interagency efforts to provide consistent high-quality, hydrography data across the United States.

State-Wide Groundwater Monitoring Network Assessing Drought Impacts and Ground Truthing Big Data

Oral presentation

John I LaFave[1]

[1] Montana Bureau of Mines and Geology

The Montana Bureau of Mines and Geology (MBMG) maintains a statewide groundwater monitoring network that collects water-level and water-quality data from Montana's principal aquifers. Montana's network design is based on aquifer extents and development, and provides current data about long-term trends in groundwater storage and quality. The systematic, long-term collection of data from the network can be useful to assess impacts caused by climatic conditions and land-use or development impacts.

In 2017, a 'flash drought' gripped Montana brought on by sudden high temperatures and little rain. In less than three months conditions changed from 'Normal' to 'Exceptional' 'the highest ranking on the drought scale. The rapid and intense onset of the drought after a relatively wet spring affected surface, or 'terrestrial water' diminishing stream flows, drying up surface reservoirs, and depleting soil moisture. Droughts tend to propagate through hydrologic systems with impacts to groundwater lagging behind surface water. Data from the state-wide groundwater monitoring network suggests that the drought did not propagate through to the groundwater system. The wet spring delivered groundwater recharge, and the large storage capacity appears to have 'buffered' the groundwater system from the drought.

Also in 2017, a paper analyzing more than 3.7 million water well records across the western United States concluded that "1 in 30 wells constructed between 1950-2015 were likely dry during 2013-2015" as a result of "unsustainable groundwater pumping… depleting many western US aquifers" (Perrone and Jasechko, 2017). Eight areas in Montana were identified as having a "high prevalence of dry wells" (> 20%). A review of: 1) aquifers in the 'impacted' areas, 2) well records from the GWIC database, and 3) long-term groundwater water levels showed no evidence of declining water levels or dry wells.

The study was an excellent compilation of a large dataset that helped raise awareness of groundwater dependence in the rural west, but made some overreaching conclusions. The apparent change reported in the paper was not real in Montana and highlights the importance of direct observations to underpin big-data analyses.

Pre-restoration characteristics of high elevation mesic sites in greater sage grouse habitat

Student poster presentation

Lydia Landau[1], Sharon Williams[1], John Allard[1], Rebekah Levine[1]

[1]University of Montana Western

Successful greater sage-grouse rearing habitat has been found in association with intermediate moisture regime meadows (mesic meadows) that are adjacent to wetter, riparian areas and intermittent colluvial channels fed by high elevation snow patches. Mesic meadows and associated moisture regimes, however, are being impacted by incision of channels and earlier runoff. In order to increase soil moisture, expand mesic vegetation, enhance the abundance of forbs and insects for sage-grouse broods and songbird populations, local and federal agencies are attempting to restore mesic meadows in sage-grouse brood rearing areas. The restoration work is occurring across sagebrush types, but all projects are focused on mesic meadows, seeps and first-order streams. Part of the restoration will include installation of rock and brush structures to spread and slow water as well as structures that will inhibit incision and loss of wet and mesic meadow area. Limited data, however, exist to inform placement of structures, particularly in high-elevation, snow-melt dominated, mountain big sagebrush basins. Our goal was to develop an initial understanding of soil characteristics, underlying geology, and snowpack of the selected restoration sites in southwest Montana. We worked at two project sites collecting on-the-ground observations of landscape variability as well as spring and channel locations. We also assessed degradation and restoration potential across the sites and found that slope morphology was an important characteristic affecting the potential for meadow degradation. Additionally, soil reports, geologic maps, and satellite images of persistent snowpack were compiled and analyzed for each site. At the studied sites, geology and aspect are important controls on site potential for late season persistence of water. We also recommend additional remote sensing work to assess snowpack. Our work has helped develop an understanding of site characteristics, along with supplying baseline data and protocol suggestions for project development and site monitoring.

Mapping, Managing, and Maintaining Data with Survey123 and ArcGis Online

Oral presentation

Jeff M Leprowse[1]

[1]Water & Environmental Technologies

WET developed a custom application for the City/County of Butte-Silver Bow to map, manage, and maintain existing Superfund source areas and remedial storm water infrastructure. This application leverages ESRI's ArcGIS online and Survey123 applications as well as a Microsoft Access front-end database for querying and reporting capabilities. Using ESRI's Survey123, field crews can generate categorized inspections and record county-wide Operation and Maintenance (O&M) activities. Managers can use ArcGIS Online web maps to view inspection details and O&M activities, view high priority sites, and complete work assignments. All activities are synced with a Microsoft Access to efficiently query data, report on infrastructure conditions, and generate status reports and O&M activities. By utilizing ArcGIS Online, ESRI's Survey123 and custom JSON feeds this application and saves the county hundreds of hours per year in labor, allowing them to instantaneously view Superfund storm water inspection and maintenance activities and meet reporting and data management requirements.

Using groundwater modeling to assess groundwater and stream connectivity in a river restoration application

Student poster presentation

John Lunzer[1], Glenn Shaw[1]

[1]Montana Tech of the University of Montana

Historic placer mining tailings along the Middle Fork John Day River north of Galena, Oregon force the current river channel to remain straight with limited structure. The lack of structure in the river channel makes this stretch of river poor habitat for trout and migrating salmon. In order to restore this stretch of the Middle Fork John Day River to ideal trout and salmon habitat, InterFluve Inc. will be performing restoration work on the existing channel. This work will be done in conjunction with the United States Forest Service (USFS) and The Freshwater Trust (TFT). The proposed restoration work will consist of re-routing the channel, constructing a meandering channel and mimicking natural river structures. In preparation for this restoration work, the hydrogeology of the system needs to be characterized. The main focus of which will be characterizing how the wetlands in the area interact with the surface water features. Understanding how the surface water features in the area interact with one another through the groundwater system is crucial for designing a restored channel that does not negatively impact other surface water features. In order to fully characterize the groundwater system that connects the surface water features in the area, a groundwater model will be constructed for the area. This groundwater model will be used to quantify and describe how the surface water features in the area are connected and impacted by one another. A field-monitoring program was designed to fulfill this task and consisted of the installation of monitoring wells, staff gauges and measurements of creek discharge on a regular basis. This data will be collected from April 2018 through October 2018 in order to support a groundwater model. This groundwater model will be constructed in order to replicate existing conditions at the site and then predict the impacts of proposed changes to the site.

Increased drought intensity driven by warming in the Upper Missouri River basin

Oral presentation

Justin T Martin[1], Gregory T Pederson[1], Connie A Woodhouse[2], Edward R Cook[3], Kevin J Anchukaitis[2], Erika K Wise[4]

[1]U.S. Geological Survey, [2]Laboratory of Tree-Ring Research, University of Arizona, [3]Lamont-Doherty Earth Observatory, [4]Department of Geography, University of North Carolina

The 2000-2010 'Turn-of-the-Century Drought' in the Upper Missouri River Basin was more intense than any in the instrumental record including the 1930s Dust Bowl drought. Here, we examine 1200 years of streamflow from a network of 31 new tree-ring based reconstructions for gages across the Upper Missouri Basin and an independent reconstruction of warm-season regional temperature in order to place the recent drought in a long-term climate context. We find that temperature has increasingly influenced the intensity of drought events in the basin since the late 20th century. Recent exceptional warming is responsible for driving drought intensities that rival or exceed any estimated over the last 12 centuries. Future warming is anticipated to cause increasing drought intensities and enhanced water deficits that could prove challenging for operations at existing storage and conveyance infrastructure.

A checklist of the Elmidae (Coleoptera) of Montana, USA, with a description of a new species in the genus Narpus

Student poster presentation

Adrian Massey[1], Michael Ivie[1]

[1]Montana State University

The beetles (Coleoptera) represent the largest and most diverse order in the animal kingdom, with nearly 390,000 described species and more added almost daily. The family Elmidae (riffle beetles), with sub-families Larinae and Elminae, is one of many beetle families with taxa still being added. To date, there are nearly 100 species in 27 genera of these aquatic beetles described in North America. In Montana, the number of recorded species has increased from nine to seventeen, including one new species in the genus Narpus, during this project. The newly recorded species for Montana are: Cleptelmis addenda (Fall 1907), Dubiraphia bivittata (Melsheimer 1844), Dubiraphia quadrinotata (Say 1825), Narpus concolor (LeConte 1881), Optioservus divergens (LeConte 1874), Optioservus seriatus (LeConte 1874), Stenelmis occidentalis (Schmude and Brown 1991), Ordobrevia nubifera (Fall 1901) and Narpus n.sp. These new records are found in 47 counties around the state. This research has greatly enhanced knowledge of Elmidae for the state of Montana.

Evaporative effects of solar absorbers: passive solar evaporation islands (PSEI) reduce water treatment volumes

Student poster presentation

Ross Monasmith[1], Katherine Zodrow[1]

[1]Montana Tech

Free surface water evaporation forms a critical component of many industrial processes. Accelerated evaporation may be desirable in certain water disposal and treatment applications. Currently, large-scale evaporation is achieved through active and costly mechanical means. Passive solar evaporation islands (PSEI) can provide an alternative method of volume reduction by manipulating material interactions with water. Previous research into materials with high solar absorbance, for solar distillation and other phase-change applications, inform PSEI coating structure. In this study, six materials were characterized by solar reflectance, water affinity, and microstructure to inform their evaporative performance. Fibrous carbon filters and fiberglass show high water affinity. Granular activated carbon demonstrates low reflectance and high surface area. In laboratory evaporation trials, floating high-density polyethylene film canisters achieved a 199% increase in evaporation with a granular activated carbon coating. Future work will lead to prototype production and field trials using treatment water from three different mine water treatment facilities.

Ranchers and Natural Water Storage: Are Some More Willing to Adopt Adaptation Strategies?

Student poster presentation

Megan Moore[1]

[1]Montana State University

Drought in Montana, USA has the potential to impact the natural environment and human communities, with specific repercussions for agricultural communities. In the face of changes in the quality, quantity, and timing of water runoff, water storage to mitigate drought is one of the top concerns for many water managers and water users throughout the state. Due to the growing recognition of the negative social and environmental impacts of traditional infrastructure, such as dams, there is a need for alternative forms of water storage. The concept of nature-based solutions, specifically, natural water storage systems, has gained traction as a potential strategy to slow spring runoff, store water, and raise water - often resulting in later season streamflows. This research examines the adoption of these new strategies in the context of changing climate in Montana. Previous research has identified the benefits of natural water storage for ecological communities but has not examined the barriers and opportunities for human communities. Findings from qualitative interviews with 30 landowners and resource managers in the Red Rock Watershed/Upper Beaverhead Watershed in southwestern Montana will be discussed. Results illuminate strategies for preparing for and responding to drought. Additionally, findings highlight barriers and opportunities for landowners in adopting new practices such as natural water storage projects.

Non-resident selenium imports to Lake Koocanusa and Bighorn Lake, MT: Sources, biogeochemical cycling, and tailwater implications

Oral presentation

David L Naftz[1], Elliot PP Barnhart[1], Jason Gildea[2], Craig Stricker[1], Travis Schmidt[1], Mike Ruggles[3], Kent Easthouse[4]

[1]US Geological Survey, [2]US Environmental Protection Agency, [3]Montana Fish Wildlife & Parks, [4]Army Corps of Engineers

Lake Koocanusa straddles the boundary between Canada (British Columbia (BC)) and the United States (Montana, (MT)), while Bighorn Lake straddles the Wyoming (WY)-MT border. Both reservoirs receive most of their selenium (Se) inputs from non-MT sources associated with mining induced disturbance of Se-rich landscapes. The MT Department of Environmental Quality has identified Lake Koocanusa as threatened by Se and both reservoirs are subject to newly established criteria for Se (USEPA, 2016). Annual Se loadings to Lake Koocanusa from areas in BC increased from 2,600 kg in 1992 to over 13,000 kg in 2012. The first active treatment plant to remove Se from waters upstream of the reservoir was installed in 2015; however, the plant has only operated intermittently and is currently (July 2018) offline for repairs. A downward trend in annual Se load entering Lake Koocanusa from areas in BC during 2014-16 has been observed. Bighorn Lake receives most of its water from the Shoshone and Bighorn River watersheds, located in WY. The majority of the annual Se load entering Bighorn Lake is sourced from the Bighorn River watershed, which contains mining operations that disturb large areas of Cretaceous-age marine shales that are enriched in Se.

Biogeochemical samples were collected from multiple sites in Lake Koocanusa during 2015-17.

Results from these sampling programs are being used to populate an ecosystem-scale Se modeling methodology (Presser and Luoma, 2010) to support development of site-specific Se guidelines for the protection of aquatic life. In 2017, dissolved Se concentration in water samples collected south of the international boundary ranged from 0.75 to 1.45 mg/L and Se concentration in suspended particulate material samples ranged from 0.73 to 6.6 mg/g. Water samples collected from Bighorn Lake during two synoptic sampling events in 2015 and 2016 ranged from 0.25 to 1.9 mg/L. The 2016 USEPA Se criterion for lentic systems is 1.5 mg/L (30-day average). Se concentration in fish tissue samples collected from Bighorn Lake during 2015 were < 4 mg/kg (dry weight, dw). In contrast, fish tissue samples collected below Yellowtail dam were substantially enriched in Se, with one sample exceeding the 2016 USEPA chronic criteria of 11.3 mg/kg (muscle tissue, dw). The mean nitrogen (N) isotopic composition of brown trout collected from the tailwater below Bighorn Lake were a full trophic level lower (-3 permil) than the reservoir population. The shift in N isotopic composition combined with the elevated Se concentration exhibited by the tailwater fishery may indicate that the insect biomass in the tailwater is negatively influenced by fine grained Se- and organic-rich detritus released from Bighorn Lake. A similar study is needed to assess Sefish tissue uptake from Lake Koocanusa in the fishery directly below Libby dam.

Monitoring the Impacts of Beaver-Mimicry on Groundwater and Surface Water Interactions in the Blacktail Creek Watershed, Butte

Student poster presentation

Evan Norman[1], Amy Chadwick[2], Glenn Shaw[1], Theodore Dodge[3]

[1]Montana Tech, [2]Great West Engineering, [3]Watershed Restoration Coalition

Beaver-mimicry has become a leading method in the charge toward restoring degraded streams and reconnecting streams with their floodplains. The headwaters of both Blacktail Creek and Basin Creek, located south of Butte, once supported voluminous beaver ponds. Decline in beaver population has led to breaching of the dams and incising of the stream channels. Thanks to landowner involvement, these sites have become available for installation of beaver-mimicry structures aimed to reverse drying trends in the watershed. Since first restoration activity in 2016, data has been collected to quantify stream and groundwater characteristics at both treatment and control reaches. In October 2018, two controls with two years of monitoring data will be restored and continually monitored. With initial investigation at one site, it was found that a gaining control reach transitions to a losing beaver-mimicry treated reach with vertical downward gradients and hydraulic conductivity estimates of 1.5 feet per day. What remains to be completely understood is the impact of beaver-mimicry on stream temperature, discharge and groundwater elevation change in multiple watershed settings. This poster will overview the monitoring methods, data collected thus far, and planned research for eight total control and treatment reaches in the Blacktail Creek Watershed.

Using longitudinal synoptics of water quality along Hyalite Creek and the Gallatin Valley to understand the distribution of groundwater sources to stream flow generation in the Gallatin River Watershed

Oral presentation

Robert A Payn[1], Stephanie A Ewing[1], Florence Miller[1], Sam Leuthold[1], James B Paces[2], Tom Michalek[3], Stephan G Custer[1]

[1]Montana State University, [2]US Geological Survey, [3]RESPEC

Many watersheds in the intermountain west are geomorphically characterized by relatively high-relief mountain headwaters draining onto relatively low-relief intermountain basins. The water provided by the mountain-headwater geomorphic process domain is often critical to human infrastructure that typically dominates the intermountain-basin geomorphic process domain, and transitions between these process domains create characteristic patterns of exchange among streams, irrigation canals, soil water, and groundwater. We suggest that these predictable patterns provide a useful conceptual model for understanding drivers of water quality and the spatiotemporal distribution of recharge necessary to sustain groundwater use and stream flow generation during dry periods. We further suggest that understanding the mechanisms driving exchanges between surface and subsurface water resources within each process domain will be critical for predicting how a changing climate will influence the coupled human-natural systems of the West.

Here, we explore the spatiotemporal distribution of surface-subsurface exchange along transects in the Gallatin River Watershed based on longitudinal synoptic perspectives on water quality. These transects include a mountain-headwater geomorphic process domain (Hyalite Canyon) and its mountain front transition to an intermountain-basin geomorphic process domain (Gallatin Valley). In Hyalite Canyon, we use strontium and uranium concentrations and their isotopic ratios (87Sr/86Sr and 234U/238U) as indicators of water-rock interaction to evaluate stream flow generation from aquifers associated with differing lithologic units along the canyon. We apply repeated end-member mixing analyses to evaluate the cumulative evolution of stream flow and water quality. Also in Hyalite Canyon, we compare longitudinal patterns of d18O and d2H in precipitation, snowpack, and stream water to infer seasonal patterns in connectivity between streamflow generation and precipitation or snowmelt. Comparisons of elevational patterns in the isotopic composition of precipitation and the snowpack appear to help discriminate between groundwater and precipitation sources of stream flow. Finally, exploration of patterns in strontium and uranium solutes are extended from Hyalite Canyon into the Gallatin Valley, where concentrations and isotopic ratios appear to homogenize from the mountain front to the watershed outlet. We suggest this homogenization

reflects increasing contributions from an alluvial groundwater reservoir that is a well-mixed combination of recharge sources along the mountain front, and is also subject to further evolution in water quality driven by human infrastructure.

Hydrologic concerns in the West are driving a transition from understanding the processes that drive floods to understanding the processes that provide sustainable water resources. Most conventional watershed hydrologic models were designed to predict the response of watersheds to precipitation, and thus their ability to predict low flow in dry seasons is often suspect. More spatially explicit studies of surface-subsurface exchanges, such as those presented here, will allow development and parameterization of a new generation of watershed-scale hydrologic models that incorporate the groundwater dynamics necessary to understand reliability of dry season stream flows under future climate conditions.

Assessing Connectivity Benefits of Denil Fishways, an Integrated Approach

Student oral presentation

Nolan Platt[1], Ben Triano[2], Kathryn Plymesser[3], Matt Blank[4], Kevin Kappenman[5], Tom McMahon[2], Joel Cahoon[6]

[1]Montana State University, [2]Montana State University Dept. Ecology, [3]Montana State University Dept. Civil Engineering, [4]Western Transportation Institute, [5]US Fish and Wildlife Service, [6]Montana State University, Dept. Civil Engineering

The project team is currently evaluating the effectiveness of Denil fishways, installed at irrigation diversions, to improve habitat connectivity of Arctic Grayling (Thymallus arcticus) in the Big Hole River drainage. This project is a collaboration between the Montana State University Departments of Ecology and Civil Engineering; other project partners include government organizations and private landowners. An integrated approach consisting of 'indirect' and 'direct' methods is utilized to determine factors that affect fish passage through Denils and model passage windows. To directly evaluate fish passage, Passive Integrated Transponder (PIT) experiments with wild fishes and hatchery grayling will be conducted to monitor fish movement through Denils. The 'indirect' method involves: gauging the hydrology of diversion sites, using HEC-RAS software to model hydraulic conditions around the diversion structure, and predicting fish passage windows over time based on known passage abilities. The hydraulic models are coupled with laboratory passage data collected in 2016 to predict when the specific fishways are passable and inform managers about their benefits and limitations. Design criteria and a design process for Denil fishways are proposed that maximizes the hydrologic conditions and times of year for which the ladder will work effectively. Field work was conducted May-September 2017 and will continue April-October 2018 with results and a publication expected in Spring 2019. Modeling Denil fishways using HEC-RAS, predicting passage windows, and designing Denils with hydrology in mind will be discussed in detail along with a summary of the project and the collaborative efforts that have made it possible.

Geochemistry of metals and nutrients in fine-sediment pore water in Blacktail and Silver Bow creeks, Butte, Montana

Student oral Presentation

Robert Rader[1], Chris Gammons[1], Richelle Carney[1]

[1]Department of Geological Engineering, Montana Tech

Historical mining activities in Butte, Montana have impacted surface and groundwater in the area. Contaminants of concern (COCs) include copper, lead, zinc, cadmium, and arsenic. Although most of the known sources of COCs have been removed or remediated, there is evidence from synoptic sampling by previous workers that metal loading continues to occur in lower Blacktail Creek and upper Silver Bow Creek during baseflow conditions. One possible source for this metal loading is upwelling groundwater. Another possible source is interaction between the stream and fine-grained, metal-rich sediment in the streambed. To assess the importance of fine sediment as a source (or sink) for metals, this investigation is using sediment pore-water diffusion samplers ('peepers'). Peepers are ideal for capturing cm-scale vertical gradients in pore-water chemistry in the top 20–25 cm of the sediment column. To date, we have deployed three peepers in lower Blacktail Creek, two peepers in the 'slag canyon' of upper Silver Bow Creek, and two peepers in shallow ponds on either side of lower Blacktail Creek. Pore-water samples extracted from the peepers were analyzed for dissolved trace metals, major ions, and selected nutrients. Sediment samples collected at each peeper site were analyzed by XRD and portable XRF. Our preliminary data show steady increases in the concentration of dissolved iron, manganese, arsenic, soluble reactive phosphorus, ammonium, and bicarbonate ion with depth in the shallow sediment. These changes are attributed to reductive dissolution of Fe- and Mn-oxides, coupled to organic matter decay, in the anoxic environment of the fine-grained sediment. Copper and zinc behave differently, and generally have very low values in the deeper samples. However, in some cases, there is a zone where dissolved Cu and Zn concentrations pass through a maximum in the top 2–6 cm of the sediment column and decrease to ppb levels at greater depth. Concentrations of Zn can get especially high in this top zone (e.g., > 10 mg/L). Our hypothesis is that the fine 'mucky' sediment is a sink for Cu and Zn in the form of insoluble metal sulfides as long as conditions are anoxic. However, near the top of the sediment column, advection and/or diffusion of dissolved oxygen from the overlying stream causes oxidation of the Cu-Zn sulfides and release of metals back into the sediment pore water. Once mobilized, the metals can then diffuse upwards into the stream.

This project is being funded through the Butte Natural Resource Damages Program (NRDP). Our peeper sampling and data interpretation will continue through the summer and fall of 2018 and a synthesis of results will be reported at the AWRA conference.

Collaborative Science: A Case Study on Mine Reclamation Activities to Improve Ecological Health of Yellowstone's Soda Butte Creek

Keynote presentation

Andrew M Ray[1], Tom Henderson[2]

[1]National Park Service Greater Yellowstone Network, [2]Montana Department of Environmental Quality

Collaborative water resource science is a cooperative process in which interested parties work by integrating data and sharing information in order to seek solutions and achieve a common goal. Collaboration involves sharing resources and information, as well as, risks and rewards. It promotes innovation, mutual learning, and expanded possibilities. Ultimately, collaborative water resource science is an opportunity to improve scientific understanding to inform decision-making. The reclamation of the McLaren Tailings site and assessment of water quality in Soda Butte Creek over the past two decades represents a unique and highly successful collaborative effort between stakeholder groups and multiple state and federal agencies. Nearly 25 years ago, researchers described a layer of unusual bright orange sediments on the floodplain of lower reaches of Soda Butte Creek just upstream of the confluence with the Lamar River inside Yellowstone National Park (YNP). These discolored sediments were traced nearly 15 miles upstream and outside YNP to the abandoned McLaren Mill and Tailings Impoundment located near Cooke City, Montana. Abandoned in the 1950s, the mill was gone but the failing tailings impoundment remained covering the Soda Butte Creek channel and negatively impacting fisheries downstream. The segment of Soda Butte Creek below the McLaren site and downstream to the Montana-Wyoming border was later identified as a Clean Water Act-impaired water body; the only impaired water body entering YNP. In collaboration with National Park Service (NPS) scientists, the Montana Department of Environmental Quality (DEQ) developed the site reclamation plan in 2008-2009, and completed the reclamation work over a five-year period from 2010 through 2014. The 22 million dollar project included excavation and treatment of nearly one half million tons of mine tailings, and the operation of a water treatment system. Following reclamation, the NPS and DEQ conducted water quality sampling throughout the upper Soda Butte watershed. This contemporary monitoring data and subsequent analyses led to a determination by the DEQ Water Quality Bureau that metal conditions in Soda Butte Creek now meet state water quality standards. The EPA concurred with this recommendation and Soda Butte Creek has since been removed from the Montana's 2018 Integrated Water Quality Report. In this presentation, we will discuss ongoing collaborative monitoring activities to investigate remaining metal sources in the watershed and share strategies to integrate historic and contemporary datasets to assess the recovery of ecological health. This case study highlights how a cross-organizational team can work collaboratively to achieve shared goals and successfully support a water resource determination. Montana DEQ's Director Tom Livers summarized this success by stating that "The impressive list of government entities and community partners who worked with us to make this project a success speaks to the power of collaboration."

TMDL Implementation Evaluations from around Montana

Oral presentation

Robert Ray[1]

[1]Montana Department of Environmental Quality

Montana state law requires evaluation of completed TMDLs and attainment of water quality standards. The Department of Environmental Quality's Watershed Protection Section has responsibility for developing and evaluating the implementation of TMDLs. This presentation will provide several "case studies" of TMDL Implementation Evaluations from around the state, including Lone Tree, Cooke City, Swan Lake and Deep Creek watersheds.

Developing a River Restoration Definition and Policy for Montana

Poster presentation

Robert Ray[1], Eric Trum[1]

[1]Montana Department of Environmental Quality

River restoration projects have been funded for many years through various state and federal grant programs. The definition of "restoration", however, has had almost as many interpretations as project proponents. In 2012, Montana's Nonpoint Source Management Plan included a 5-year action item: "Develop an interagency policy for river restoration work, emphasizing restoration of natural processes." This presentation will discuss the implementation of this action and the status of an "Interagency policy supported by a wide range of government, nonprofit and private entities."

Using Detection Dogs to Monitor Environmental Contaminants in Freshwater Ecosystems Via Sentinel Species

Oral presentation

Ngaio L Richards[1]

[1]Working Dogs for Conservation (WD4C)

Various types of environmental contaminants are introduced into freshwater ecosystems through anthropogenic inputs. Preliminary investigations focusing on exposure in organisms high atop the food chain (e.g., piscivores) can yield data complimentary to water quality monitoring efforts and inform more targeted follow-up studies. Both apex predators, River otter and American mink are worthy sentinel species, however they are also notoriously elusive which can make sampling difficult. Fortunately, their fecal matter can be collected non-invasively for screening of environmental contaminants and genetics analyses. Between 2013 and 2015, Working Dogs for Conservation (WD4C) led a study to determine the feasibility of incorporating detection dogs in efforts to monitor and safeguard the health of freshwater ecosystems and their inhabitants. To maximize the number of viable fecal samples recovered for analysis, specially trained conservation detection dogs (aka 'scat detection dogs') paired with professional handlers - themselves biologists - surveyed along five rivers in Montana and collected otter and mink fecal matter for analysis of heavy metals, anthropogenic organic contaminants (AOCs) including pharmaceuticals and personal care products (PPCPs), and polybrominated (PBDE) flame retardants as well as for genetics analyses. Performance comparisons between dog-handler teams and experienced surveyors were conducted for perspective on fecal matter find rates. Overall, dog-handler team surveys yielded more fecal samples for considerably less search effort and all three focal contaminants were detectible in these samples. This presentation discusses our survey and analytical findings, describes the analytical methods and capacity developed specifically for this project and to enable further work to go forward, and provides recommendations for follow-up investigations, based on lessons learned.

An Interactive 319 Projects Map

Poster presentation

Hannah Riedl[1]

[1]Montana Department of Environmental Quality

Each year the Clean Water Act 319 grant program provides approximately $900,000 in funding to local groups to implement nonpoint source pollution reduction projects on streams, rivers, and lakes throughout the state. The Department of Environmental Quality created an interactive map that shows locations, descriptions, and project visuals of past 319 projects. Many visuals on the map include long-term monitoring photopoints that inform what projects continue to achieve their goals over time and why they may be successful. Sharing these projects' successes and lessons learned in this compelling format are essential for improving the effectiveness of and interest in future projects. The map I am using in place of a traditional poster can be found here: https://mtdeq.maps.arcgis.com/apps/webappviewer/index.html?id=97f1b426b66d495f802ddc29a129da43

Reconnection and restoration of Elbow Coulee in the Sun River watershed

Oral presentation

Robert Sain[1]

[1]Kroenke Ranches

The Elbow Coulee Restoration and Enhancement Project is in progress at the Broken O Land and Livestock (Broken O) near Augusta, Montana. The Broken O, which surrounds and contributes to over 50 miles of tributary streams and 24 miles of the Sun River, has a unique opportunity to improve fish habitat, passage and reduce sediment influence on the Sun River. The watershed goal for enhancement and restoration activity is to increase trout habitat and cold-water refuge by removing fish passage barriers and ensuring native flow to coulee tributaries of the Sun River. The objective for Elbow Coulee is to reconnect and restore 7.1 miles to its confluence with School Section Coulee and further downstream to the Sun River.

A three-phased project, Phase I of the Elbow Coulee addresses a unique set of problems that encompass ranch operations, altered watershed hydrology and fish passage. Construction was completed in 2017. A soup-to-nuts operation whereas the in-house restoration program planned, surveyed, designed, permitted and performed construction on a 1,750-foot-long stream channel re-alignment under a large irrigation canal. The realignment reconnects fish passage to 6.1 miles of Elbow Coulee after over 90 years of disconnection. The design approach and challenges to consider for this type of project will be discussed.

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The Big Levers - Management, Soils, and Weather. Interactions

controlling soil water and nitrate loss in a non-irrigated cropping system

Oral presentation

Adam Sigler[1], Stephanie A Ewing[1], Clain A Jones[1], Robert A Payn[1], Marco Maneta[2], Perry Miller[1]

[1]Montana State University, [2]University of Montana

In dryland cropping systems, evaporation and recharge of groundwater via deep percolation below the root zone are typically considered inefficiencies in precipitation use that contribute to the gap between actual and potential crop yield. Deep percolation also transports nitrate from soils to groundwater, which reduces nitrogen use efficiency and can threaten groundwater quality. Chemical fallow is a common practice in central Montana, where vegetation growth is suppressed for a full year with herbicide, in order to store soil water for the subsequent crop and reduce agronomic risk. A common cereal production rotation in the Judith River Watershed of Central Montana is crop-crop-fallow (e.g., winter wheat 'spring grain' fallow), which means approximately one third of cultivated land is likely to be in fallow during any given year. The effect of fallow on precipitation partitioning between crop use, evaporation, and groundwater recharge has been quantified in a limited number of studies and even less frequently as it interacts with soil characteristics to influence groundwater quality. Understanding how weather, soils, and fallow management interact to determine deep percolation and nitrate leaching is critical to make informed decisions to increase agricultural sustainability and mitigate environmental degradation.

We present the results of simulations of vertical water movement with the Hydrus 1D soil water model to explore the hydrologic influence of fallow practices in different scenarios of weather and soil thickness. Atmospheric boundary conditions for the model were adapted from the Agrimet station at the Central Agricultural Research Center at Moccasin and from meteorological observations at the study fields. The model was calibrated by adjusting Van Genuchten soil hydraulic parameters until they produce simulations that match observations of soil moisture measured on the study fields in 2013-2014. Nitrate leaching losses were estimated by coupling modeled deep percolation with observed lysimeters concentrations between 2013- 2016.

During cropped years following fallow years, lysimeter nitrate concentrations are significantly higher relative to fallow years or sequential cropped years. This finding is consistent with the hypothesis that nitrate concentrations in soils are primarily determined by nitrate inputs from mineralization of soil organic matter (high in fallow years) and fertilizer additions (occurring in cropped years). Simulations suggest that fallow years tend to have the highest deep percolation rates, and cropped years following fallow have only slightly higher deep percolation rates than cropped years following crop. The interaction of influences of fallow on nitrate concentrations and deep percolation resulted in the highest nitrate leaching rates during fallow years. Furthermore, nitrate leaching rates in cropped years following fallow are notably higher than in cropped years following crop, due primarily to elevated soil water nitrate concentrations after the fallow year. Our findings reveal how fallow in rotation is a primary driver of precipitation use inefficiency and nitrate leaching. Exploring options for replacing fallow shows promise for increasing sustainability of agricultural operations while simultaneously reducing nitrate contamination of groundwater.

Pollutant Transport in the Sanitary Sewer Collection System

Oral presentation

Kim Snodgrass[1]

[1]Water & Environmental Technologies

I will present on the high metals in Butte wastewater due to historic mining, residential and industrial use, and due to leaching of drinking water pipe materials. I'll present on the interconnectivity of the sewers to ground water and soil. I will talk about recent sampling methods and results to limit the transport of metals into the sanitary sewer. I will also talk about smoke testing and the findings from August and September events.

Groundwater fluoride in Helena, Montana: a function of bedrock geology and geothermal activity

Oral presentation

Valerie Stacey[1], James Swierc[1]

[1]Lewis and Clark County Water Quality Protection District

Fluoride is recognized as an effective method of preventing tooth decay. Consequently, many public water supply systems add fluoride to drinking water to improve public health. Recommendations and regulations are aimed at the public water supplies that either add or remove fluoride from drinking water supplies. However, consumer intake of fluoride from private wells is unregulated and generally unknown, as fluoride is not a standard parameter to test for. This can be problematic in areas where naturally occurring fluoride in groundwater is relatively high, and may have unrecognized health risks to private landowners. In the Helena Valley of Montana, preliminary data revealed fluoride concentrations in groundwater of more than twice the maximum contaminant level set by the EPA. In response, a more comprehensive analysis of fluoride was conducted in the Helena Valley to characterize the naturally occurring concentrations of fluoride in local groundwater, analyzing the potential relationship between fluoride and the bedrock geology, in addition to other chemical parameters. Samples ranged from non-detectable concentrations to 11 mg/l, with an average of 0.60 mg/l and a median of 0.30 mg/l. Fluoride concentrations varied significantly depending on the bedrock geology ($p<0.0001$). We also found evidence of a co-occurrence of fluoride and arsenic in certain geologic categories ($p < 0.0001$, $r = 0.98$). Fluoride concentrations in groundwater sources in the Helena area are higher in Tertiary and Pre-Tertiary sediments than alluvium, and are also influenced by geothermal activity.

Host rock influences metal abundance and speciation in hot springs

Oral presentation

Brian E St Clair[1], Alysia D Cox[1]

[1]Montana Tech

For a site to be habitable to microbes there must be (i) a source of energy, (ii) clement conditions, (iii) liquid water, and (iv) a source of nutrients. Terrestrial hot springs have been found to be ideal habitats for deeply branching microbes, implying the presence of all 4 requirements for life. Many lines of evidence even point to the origin of life in a hydrothermal system (Martin et al., 2008; 2014), suggesting that hot springs may be the archetypal clement conditions. Much progress has been made in recent years characterizing the energy availability in such systems (i.e. Shock et al., 2010). The availability of trace nutrients such as metals, however, is an area of active research. This study characterizes the trace element composition and speciation in two major hydrothermal fields to establish the range of compositions and bioavailability in hot spring ecosystems. The abundance and speciation of trace elements dictate bioavailability to microbes, which take up these metals for enzyme active sites. Terrestrial hot springs are the surface expression of hydrothermal systems that originate deep in Earth's crust. Trace element abundance can vary by more than 5 orders of magnitude. The extreme variability in geochemical compositions observed in such systems is a result of deep water-rock reaction, near-surface groundwater mixing, and surface input. The composition of these hydrothermal fluids is therefore heavily influenced by the host rock. The igneous regions that host hydrothermal systems range from basaltic to rhyolitic end members, differentiated primarily by silica and cation content that results from where the rocks were formed. The seafloor is typically basaltic, whereas continental crust is rhyolitic. Andesite, an intermediate composition, can be produced in subduction zones, where basalt from the seafloor is subducted under continental rhyolite. Together, these three rock types are the most prevalent hosts for hydrothermal systems. Samples were collected from dozens of hot springs in both the Ecuadorian Andes and Yellowstone National Park. The geochemical composition of each location was characterized for hundreds of components, including trace elements. The Ecuadorian Andes are primarily Andesitic in composition, with volcanic activity providing the heat source for hydrothermal systems. These hot springs are typically circumneutral, with significant concentrations of dissolved inorganic carbon and dissolved CO_2 providing a buffer. Apparent iron and arsenic staining is present at many locations. Results from inductively coupled plasma mass spectrometry (ICP-MS) indicate many locations have abundant As, Fe, B, and Mo, but are typically lacking in Zn and Al relative to YNP hot springs. Yellowstone National Park host rock is primarily composed of rhyolite, the result of a continental hotspot supervolcano. The pH is highly variable, from <2 to >9. Trace metal abundances vary to a larger extent than in Ecuadorian springs as a result of this large variability in pH. By comparing these two hydrothermal regions, trends in trace element abundance and speciation emerge that inform how microbial communities may respond to trace nutrient limitation or abundance.

Convective suppression before and during the 2017 Northern Great Plains flash drought: Implications for forecasting

Oral presentation

Paul Stoy[1], Tobias Gerken[2], Gabriel Bromley[1]

[1]Montana State University, [2]Montana State University

Flash droughts intensify rapidly and tend to be disproportionately destructive. We demonstrate that the 2017 U.S. Northern Great Plains (NGP) flash drought was preceded by a breakdown of land-atmosphere coupling. Severe drought conditions in the NGP were first identified by drought monitors in late May 2017 and rapidly progressed to exceptional drought in July. The likelihood of convective precipitation in May 2017 in northeastern Montana, however, resembled that of a typical August when rain is unlikely. Based on the lower tropospheric humidity index, convective rain was suppressed by the atmosphere on nearly 50% of days during March in NE Montana and central North Dakota, compared to 30% during a normal year. Micrometeorological variables, including potential evapotranspiration, were neither anomalously high nor low before the onset of drought. Incorporating convective likelihood to drought forecasts would have noted that convective precipitation in the NGP was anomalously unlikely during the early growing season of 2017. It may therefore be useful to do so in regions that rely on convective precipitation.

Effectiveness of Montana's Streamside Management Zone Law at Protecting Stream Temperatures during Forest Harvesting

Oral presentation

Brian Sugden[1]

[1]Weyerhaeuser Company

An important function of Streamside Management Zones (SMZs) retained during harvest operations is shading for temperature control. In Montana, an SMZs law regulates commercial forestry activities, and requires timber buffer be retained within 15 m of streams, with a steep-slope ground-based equipment exclusion area that can extend up to 30 m. The amount of timber removal in the SMZ is a function of the pre-harvest tree size and stocking, with removals of 0-30% typical. The effectiveness of SMZs for stream temperature control in Montana has not been previously evaluated. Between 1999 and 2004, half-hourly stream temperature data were collected at 30 operational harvest sites bordering perennial fish-bearing streams in western Montana. Temperature data were collected at the upper and lower boundary of the harvest, for a minimum of one summer before and after harvest. A variety of covariate data were collected to describe the harvest, and fish data were also collected. The response measures were analyzed using a linear mixed effects model. No significant harvest effect was found for the six evaluated temperature metrics, with estimates between -0.1 and 0.04 degrees C. Fish population and biomass also had no significant harvest effect. This suggests that operational SMZs being retained in Montana are protective of water temperature.

Exploring the size of contaminants in wastewater

Student poster presentation

Lauren Sullivan[1], Benjamin P Colman[2]

[1]University of Montana- Systems Ecology, [2]University of Montana Department of Ecosystem and Conservation Sciences

Climate change is predicted to cause continuing declines in late-season streamflow, while also increasing the relative contribution of treated wastewater effluent to surface flows. Wastewater effluent represents a critical point source of both metal and nutrient contaminants to aquatic ecosystems, with wastewater lagoons serving as the most common wastewater treatment system in the rural United States. While metal and nutrient contaminants have historically been considered to be either 'particulate' and unavailable if they are retained by a 450 nm filter, or 'dissolved' and bioavailable if they pass through. Recent work has suggested that these operational definitions may be inadequate as there is a continuum of sizes below 450 nm including small stable particles of all sizes and compositions (small colloids), as well as truly dissolved solutes (<1 nm). Additionally, emerging research has shown that the uptake of small-colloids can rival or exceed that of truly dissolved solutes in some organisms. By improving our understanding of the distribution of elements among size fractions in wastewater effluent we can begin to examine how this drives organismal impacts of increased contributions of wastewater to surface flows. It may also help to inform inexpensive management options to enhance lagoon efficacy. To characterize the distribution of metals, N, and P across size fractions in wastewater lagoons, we collected water from six lagoon systems in the Montana's Clark Fork River Watershed. Water samples were filtered allowing us to quantify metals, N, and P in the >450 nm, 1-450 nm, and < 1 nm size classes. We found that Fe, Cu, Mn, Cr, Co, Zn, Al, Pb, Se, and As tended to be

enriched in the 1-450 nm size range by up to a factor of 10, while Ni, V, and Cd were enriched in the < 1 nm fraction. These results suggest that wastewater lagoons serve as a source of both colloidal and truly dissolved contaminants. Next steps will examine how the association of elements in these different size fractions influences the accumulation of these elements by organisms in these systems and receiving waters.

Understanding the relation between energy and water resources in the Williston Basin

Oral presentation

Joanna Thamke[1]

[1]U. S. Geological Survey

The Williston Basin has been a leading source for domestic oil and gas production since the 1950s. This region has recently experienced rapid growth, driven by advances in energy development methods. More than 1 million barrels of oil are produced daily. Even larger volumes of hyper-saline water are produced with the oil and transported to deep disposal wells. Large volumes of freshwater are needed to hydraulically fracture and maintain oil and gas wells.

Multiple ongoing U.S. Geological Survey (USGS) projects are focused on energy and water quality, water availability, and ecology in the Williston Basin. These projects address brine contamination of shallow groundwater, wetlands, and streams; modeling changes in groundwater geochemistry; estimation of water use for energy development; groundwater availability; salt toxicity to plants and invertebrates, and effects to amphibians in the Williston Basin. Integrating the results from these USGS projects can provide a comprehensive understanding of the various issues to consider when managing energy and water resources in the Williston Basin. Information about these projects and publications can be located https://steppe.cr.usgs.gov/
https://www.usgs.gov/centers/wy-mt-water/science
https://www.usgs.gov/centers/dakota-water/science https://pubs.er.usgs.gov/

Consortium for Research on Environmental Water Systems (CREWS): a Montana collaborative effort for integrated research and application

Oral presentation

Maurice M Valett[1]

[1]University of Montana

A new collaboration among Montana University System scientists, State agencies, NGOs, and private companies addressing the dynamics of environmental water systems and water quality issues comprises the Consortium for Research on Environmental Water Systems (CREWS). CREWS expands Montana's research capacity to address water-related issues stemming from land-resource use impacts including hard rock mining, intensive agriculture, and energy extraction. A convergent research approach integrates faculty and students from four teams: 1) systems ecology and earth sciences; 2) molecular engineering and environmental science; 3) environmental synoptic signals and sensors; and 4) natural resource social sciences to respond to nationally relevant water quality problems. To do this, the project focuses on three exemplary study-sites: 1) hard rock mining in the Upper Clark Fork River; 2) agriculture and grazing in the Judith Basin; and 3) energy extraction in the Powder River Basin. A unified research theme addresses the origin, persistence and transformation of contaminants in water, and their impact on ecological and social systems. CREWS builds sustainable research competitiveness and infrastructure by establishing collaborative programs among three Montana University System (MUS) research institutions, two tribal colleges, the private sector, and state government. CREWS integrates interdisciplinary research activities and outcomes to STEM education, inclusion, professional development, commercialization, and partnerships to build the research and education enterprise.

The project will focus on 1) how heavy metals and N enrichment alter aquatic ecosystems, and how nutrients and metals act as subsidies and stressors in the context of river productivity, algal blooms, and ecology; 2) how high levels of nitrate interact with organic pesticides in ground water derived from dryland agriculture and quantification of the mechanism by which intensive agriculture interacts with natural hydrologic dynamics to control nitrate and applied organics in soil, riparian, and stream systems; and 3) the origin, persistence and transformation of sulfate to measure how actions associated with energy development alter surface-groundwater exchange. Mechanistic studies in the biophysical domain link to capstone research on stakeholder and community response to contaminants in water systems and the viability of technological solutions. Associated with these efforts, the project will establish the Montana Water Consortium to link academic researchers with State entities and local business engaged in water quality and environmental water systems issues and policy.

UM BRIDGES National Research Traineeship: Bridging Divides across the Food, Energy, and Water Nexus

Poster presentation

Alisa Wade[1], Andrew Wilcox[1], Laurie Yung[1]

[1]University of Montana

The Nexus of Food, Energy and Water Systems (FEWS) is a framework for understanding and solving environmental challenges that are critical at scales from local to global, in Montana and beyond. At the University of Montana, we are developing an innovative, National Science Foundation-funded graduate training program, UM BRIDGES: Bridging Divides across the Food, Energy, and Water Nexus. Our program is focused on educating future researchers and leaders from diverse backgrounds to advance societally-relevant science toward more sustainable food-energy-water systems. To ensure that trainees and their research can address complex and critical societal needs, our program bridges divides across sectors within the FEWS nexus; scales, from local to global; disciplines, including physical, biological, and social sciences; science, practice, and policy to ensure decision-relevant science and science-informed practice; and audiences, to communicate effectively across diverse constituencies and multiple platforms. Our NRT's moniker, UM BRIDGES, embodies the active and innovative manner in which we approach bridging these divides.

A Groundwater Model for the Meadow Village Alluvial Aquifer, Big Sky, Gallatin County, Montana

Oral presentation

Kirk B Waren[1], James C Rose[1]

[1]Montana Bureau of Mines and Geology

Steady state and transient groundwater flow models are being developed to evaluate how groundwater pumping from the Meadow Village Aquifer in Big Sky, Montana affects the groundwater system and discharge rates in the West Fork Gallatin River. This aquifer, located beneath the Big Sky Golf Course, is the source for five municipal wells that provide water for the Big Sky Water and Sewer District, the primary public water supply for the resort. To construct the model, extensive groundwater and surface water data were collected from 2013-2016. Drilling defined the geometry of the shale that underlies the alluvial aquifer. Groundwater elevations, stream flow and stage monitoring of the West Fork Gallatin River, local weather station data, well pumping volumes, and golf course irrigation data provided information to develop the conceptual model. Groundwater modeling has yielded a more refined understanding of the geometry of the aquifer and its interaction with the West Fork Gallatin River. The models will be useful for water conservation, projecting the effects of increased demands from the aquifer, and guiding management efforts at Big Sky Resort.

Influence of large wood on sediment routing in a mixed bedrock-alluvial stream

Student oral presentation

Robin T Welling[1], Andrew C Wilcox[1]

[1]University of Montana

Large wood often stores sediment in forested mountain streams, mediating its movement from hillslopes through the channel network. In this way, instream wood can alter channel morphology at multiple spatial scales, with implications for fish habitat, flooding, and carbon storage. The distribution and geomorphic impact of large wood within transitional or mixed bedrock-alluvial channels are poorly understood. This project investigated the relationship between large wood and sediment routing in mixed bedrock-alluvial, snowmelt-dominated mountain streams. Within a representative stream reach in the Bitterroot Mountains in southwestern Montana, we measured and characterized large wood, and surveyed the volume of associated sediment. One-dimensional hydraulic and sediment transport modeling provides context for field measurements. Total storage of wood and sediment correlates with channel type and associated hydraulics. The upper portion of the study reach is predominantly alluvial while the lower portion is best described as mixed bedrock-alluvial due to significant bedrock exposure along the channel bed and banks. The latter contains half the volume of wood and one-third the volume of sediment measured in the alluvial subreach. Hydraulic modeling suggests that shear stress, which is driven by channel slope, is about five times greater in the mixed bedrock-alluvial subreach. Together, these results suggest that channel type, and associated transport capacity of large wood and sediment, may partly account for observed differences in wood load and its geomorphic impact. This research builds upon existing frameworks describing the complex interactions between wood and sediment in addressing an important gap within our understanding of sediment connectivity in forested mountain streams.

Multiyear geomorphic response of the Clark Fork River, Montana, to dam removal and floods

Poster presentation

Andrew Wilcox[1]

[1]University of Montana

Dam removal methods, the volume and size distribution of reservoir sediments, post-

removal hydrology, and geomorphic settings can influence river responses to dam removal. Large floods in the years following dam removal may have especially important effects. The 2008 removal of Milltown Dam, from the Clark Fork River (CFR), Montana was one of the largest dam removals to date in terms of reservoir sediment volume and removal cost, and it was also notable because reservoir sediments contained contaminated mine tailings, a portion of which were excavated prior to removal. The Milltown Dam removal lowered base level at the dam site by 9 m and triggered erosion of over 700,000 tonnes of predominantly fine sediment from both the Blackfoot and Clark Fork arms of Milltown Reservoir. Ten years after the dam removal, the river has adjusted to introduction of sediment and wood from the former reservoir, reconnection to upstream sediment supply, and two large flood events including a ~15-year event in 2011 and a ~40-year event in 2018. In the first year following breaching, sand and silt eroded from the reservoir and deposited downstream in bed interstices, along bars, and on the floodplain; aggradation in the main channel was limited, and the greatest deposition occurred in a multi-thread reach 21 to 25 km downstream of the dam site. High flows since then have remobilized this material, however, and have, to a large extent, erased signs of downstream sedimentation induced by reservoir erosion and reset the Clark Fork to a gravel-bed river. Post-breach geomorphic responses on the Clark Fork River have been largely driven by hydrology, in contrast to some other large dam removals where post-breach evolution was primarily governed by antecedent geomorphic conditions and post-breach hydrology played a smaller role.

Passive Evaporation Enhancement of Acidic Mine Water

Oral presentation

Katherine R Zodrow[1], Grant Myhre[1], Ross Monasmith[1], Ryan Moe[1], Jared Geer[1], Courtney Young[1]

[1]Montana Tech

Evaporation is an important component of water balances in mining operations, and mines often utilize evaporation to reduce volumes of liquid mine wastes. In this project, we developed a material that can float on evaporation ponds and enhance evaporation rates. The hydrophilic, photothermal material wicks water up its sides. Then, the material absorbs light, heats up, and evaporates the water. This collaborative project is the result of two senior design teams including students in Environmental Engineering and Metallurgical Engineering at Montana Tech.

High-density polyethylene canisters were coated with a variety of materials- activated carbon (of different sizes), fiberglass, and activated carbon air filters. While the baseline evaporation rate in our bench-scale setup was ~30 g/h, the addition of uncoated canisters lowered the evaporation rate to ~16 g/h. Indeed, this phenomenon is one reason balls or canisters that could deter birds are not used on ponds where evaporation is needed to reduce water volumes. However, a coating of carbon black increased the evaporation rate to ~47 g/h, a 57% increase over the baseline evaporation rate.

The evaporation rate is a result of the materials' light absorbance and affinity for water. Thus, the material properties were observed using scanning electron microscopy, contact angle goniometry, thermogravimetric analysis, and UV-vis reflectance. These analyses were complimented by a water chemistry and precipitation analysis using STABCAL and observation of scalants formed during submersion of the material in water from Horseshoe Bend, a mine-impacted stream in Butte, Montana. The thorough analysis of material properties and their correlation with evaporation rates will assist in further development of materials that enhance evaporation rates.