Water and Environmental Research Center
University of Alaska-Fairbanks

Annual Technical Report
2019

Reporting Period: June 18, 2019 – December 31, 2020
University of Alaska Fairbanks

(1) Products

Jason Clark and Ken Tape, 2019, Quantification and Partitioning Of Evapotranspiration in Arctic Tundra

Clark, JA, UAF Water and Environmental Research Center (WERC) Seminar SpeedTalk, September 13, 2019, oral presentation with Earl Greene in attendance.

Clark, JA, December 2019. The role of tundra vegetation in the Arctic water cycle (Doctoral dissertation).

Clark, JA; Tape, KD; Robertson, JM, *In prep.* Deciduous Shrub Stem Water Content in Arctic Alaska.

Clark, JA; Tape, KD; Robertson, JM; Ogle, K, *In prep.* Environmental Controls on Transpiration in Arctic Tundra Shrub Communities.

Clark, JA; Tape, KD; Robertson, JM, *In prep.* Quantifying evapotranspiration from dominant arctic vegetation types using lysimeters.

Barbara Johnson and Erin Whitney, 2019, Rural Alaskan households' economic energy-water nexus

Johnson, B., UAF WERC Seminar SpeedTalk, September 13, 2019, oral presentation with Earl Greene in attendance.

Johnson, B., Schmidt, J. (2020, April 30) *Navigating the Ferry Cutbacks.* MicroFEWs. https://ine.uaf.edu/microfews/blog

Johnson, B., Schmidt, J. (2020) *Community Report – Food, Energy & Water. https://ine.uaf.edu/media/284327/microfewsreport_foodenergywater_august2020-2.pdf*

Johnson, B., Schmidt, J. (2020) *Community Report – Renewable Energy.* https://ine.uaf.edu/media/284326/microfewscommunityreport_re_july62020.pdf

Johnson. B. Whitney, E. *In prep.* The Alaska Permanent Fund Dividend as a subsidy for rural water services.

Johnson. B. Whitney, E. *In prep.* Examining the Household Water-Energy Nexus in Rural Alaska – a PMG ARDL Approach.

Schmidt. J. I., Johnson. B., Huntington H. P., Whitney, E. *In prep.* A framework for assessing food-energy-water security: a FEW case studies from rural Alaska.

Johnson, B., *In prep.* Doctoral Dissertation

Fawad Naseer and Debu Misra, 2019, Laboratory Investigation of Infiltration Process of Non-Newtonian Fluids through Porous Media in a Non-Isothermal Flow Regime for Effective Remediation of Adsorbed Contaminants

Fawad Naseer, MS Thesis: Laboratory Investigation of Infiltration Process of Non-Newtonian Fluids through Porous Media in a Non-Isothermal Flow Regime for Effective Remediation of Adsorbed Contaminants, December 2019.

Kristin Gagne and Jen Guerard, 2019, Statistical Approach to Photochemical Reactivity of Sub-Arctic Permafrost Natural Organic Matter and its Implications of Surface Water Biogeochemistry

Gagne, K., UAF Water and Environmental Research Center (WERC) Seminar SpeedTalk, September 13, 2019, oral presentation with Earl Greene in attendance.

Gagne, K.R., Influence of Permafrost Extent on Photochemical Reactivity, Functional Group Composition, and Geochemical Cycling of a Sub-Arctic Discontinuous Permafrost Alaskan Watershed, University of Alaska Fairbanks, Dissertation. 2020.

Gagne, K.R,, et. al., Composition and Photo-Reactivity of Organic Matter from Permafrost Soils and Surface Waters in Interior Alaska. *Environmental Science Processes & Impacts*, 2020, 22, 1525-1539. Invited. (NIWR grant paid for the completion and publication)

2018, Kelsey Dean and Sveta Stuefer, Snowmelt Hydrology in the Upper Kuparuk Watershed, AK: Observations and Modeling

Stuefer, S. L., Kane, D. L., & Dean, K. M. (2020). Snow water equivalent measurements in remote Arctic Alaska watersheds. Water Resources Research, 56, e2019WR025621. https://doi.org/10.1029/2019WR025621

2017, Anne Gaedeke and Chris Arp, Assessment of climate and land-use change impacts on surface water runoff and connectivity in a continuous permafrost watershed in the National Petroleum Reserve - Alaska

Anne Gädeke, Christopher Arp, Anna K. Liljedahl, Ronald P. Daanen, Lei Cai, Vladimir Alexeev, Benjamin Jones, Mark Wipfli, Jörg Schulla, *In prep.* Modeled streamflow response to documented tundra lake water withdrawal and climate perturbations, Arctic Coastal Plain, Alaska.

2016, Lei Zhang, Removal of Toxic Heavy Metals from Contaminated Water Using a Metal-Organic Framework (MOF)-Graphene Oxide (GO) Hybrid Material

Tonoy Chowdhury, Lei Zhang, Junqing Zhang, and Srijan Aggarwal, Pb(II) adsorption from aqueous solution by aluminum-based metal organic framework-graphene oxide nanocomposite, Material Advances (accepted 19 March 2021), https://doi.org/10.1039/D1MA00046B.

(2) Information Transfer Program

There were no projects specifically focused on information transfer during this reporting period. However, a portion of the administrative component of the awards was generally allotted to information transfer, in the form of supporting the development and maintenance of the Institute website. Moreover, many of our information transfer-related activities were characterized as research. For instance, the projects above list peer-reviewed papers and community reports (which were directly aimed at stakeholder communities in Alaska). In-person visits were made to communities for Barbara Johnson's project (part of the larger NSF-funded FEW project) as well. These activities are considered to be an important component of the research project, but are also information transfer related activities.

The WRRA/NIWR website is linked directly on the Water and Environmental Research Center's front page and has been updated with the 2019 and 2020 projects. The website will continue to grow, adding researchers and content as new projects are funded and current projects publish their results. The website can be found at: http://ine.uaf.edu/werc/niwr/.

A two-sided glossy flyer was created in February 2020 for dispersal to stakeholders and legislators. The flyer contained information about WRRA /NIWR funded graduate student projects underway and showcased the upcoming projects for 2020. This flyer includes a brief statement of the critical water problem being researched and the scope and benefit of each project. The flyer was distributed to interested Alaskan stakeholders, Congressional offices in Washington DC, and legislators in Alaska.

In addition, in September 2019, 4 graduate students funded through the 104b base grant gave SpeedTalks (5 minutes each) about their projects in a public WERC Seminar. WERC Seminars have occurred for years and tend to reach a wide audience of academics, federal agencies, and stakeholder groups. The seminar was in person but also transmitted by Zoom for those who could not attend in

person. Alaska is a large state, and in order to be inclusive and reach as large an audience as possible video conferencing was “the norm” at UAF even before the pandemic.

(3) Student Support

three PhD graduate students, with one transitioning to a postdoctoral researcher
one MS graduate student

(4) Notable Achievements and Awards

2019, Jason Clark and Ken Tape, Quantification and Partitioning of Evapotranspiration in Arctic Tundra
Clark obtained PhD in December 2019

2019, Barbara Johnson and Erin Whitney, Rural Alaskan households' economic energy-water nexus
Around the time Johnson received the NIWR grant, the economics department and the RAP fellowship, both of which she was associated with, were eliminated because of budget constraints. NIWR enabled Johnson to start working with the Alaska Center for Energy and Power and continue her research. Working with ACEP was an invaluable experience, helped increase her understanding of issues concerning rural water utilities, and opened new opportunities for her. Barbara’s dissertation is in process.

2019, Fawad Naseer and Debasmita Misra, Laboratory Investigation of Infiltration Process of Non-Newtonian Fluids through Porous Media in a Non-Isothermal Flow Regime for Effective Remediation of Adsorbed Contaminants
Naseer received the Alaska Chapter of American Water Resources Association scholarship for $1,000 (2019)
Naseer’s M.S. degree was awarded in December 2019

2019, Kristin Gagne and Jen Guerard, Statistical Approach to Photochemical Reactivity of Sub-Arctic Permafrost Natural Organic Matter and its Implications of Surface Water Biogeochemistry
Gagne received her doctorate in May 2020 (defended December 2019)
Gagne was invited to submit a paper to *Environmental Science Processes & Impacts*

2018, Brittany Blood, Debasmita Misra, and Srijan Aggarwal, A low-cost alternative to mitigate heavy metal and phosphorus contamination in water
Blood defended M.S. thesis in March 2021

2018, Caroline Brisbois, Roman Dial, and Jason Geck, How do nitrogen and phosphorous affect glacier algae growth and snowmelt in an Alaskan watershed?
This information was not included in the previous annual report. The project, "How do nitrogen and phosphorous affect glacier algae growth and snowmelt in an Alaskan watershed?" although not successful, involved a spectacular experimental design, visible from space with high-resolution imagery.

The project consisted of four replicate experimental blocks, each with 49 plots with variable Phosphorous, Nitrogen, and Potassium. Unfortunately, powdered fertilizer was used without mixing it with water, and the powder colors led to substantial melt and run-off before the algae could use the fertilizer and bloom. The student went on to pursue a structure from motion photography project to measure mass balance on the Eklutna Glacier and its contribution to runoff into Eklutna Lake.

2017, Anne Gaedeke and Chris Arp, Assessment of climate and land-use change impacts on surface water runoff and connectivity in a continuous permafrost watershed in the National Petroleum Reserve - Alaska
The postdoctoral fellow PI (Gaedeke) of this project is now a Senior Scientist at the Potsdam Institute for Climate Impact Research.

2016, Mat Wooller, Initiating a network of long-term records of lake-level fluctuations in interior Alaska in relation to climate change
An undergraduate student on this project, Stormy Fields, has been recruited as a Masters student in the Interdisciplinary program at UAF to work with Wooller (PI of this project). Stormy is also working part time in the Alaska Stable Isotope Facility, which Wooller directs. Both of these are major advances in the career of a junior academic.

Quantification And Partitioning Of Evapotranspiration In Arctic Tundra

Project Type: Annual Base Grant
Project ID: 2019AK002B

Project Impact:

We designed and deployed a network of electronic automated weighing micro-lysimeters (n=58) on the North Slope of Alaska to partition ET between major vegetation components of tussock tundra. We found moss evaporation and tussock evapotranspiration to each contribute approximately 45% of total ET with mixed deciduous and evergreen shrubs contributing the remaining 5%. This ET partitioning allows us to predict future changes in water flux associated with observed and predicted future vegetation change. Changes in the composition and cover of mosses and vascular plants will not only alter tundra ET dynamics, but also affect the significant role that mosses, their thick organic layers, and vascular plants play in the moisture regime and thermodynamics of arctic permafrost soils. Our study clarifies the prominent role moss plays in facilitating water and heat efflux to the atmosphere.

Rural Alaskan Households' Economic Energy-water Nexus

Project Type: Annual Base Grant
Project ID: 2019AK014B

Project Impact:

Food, water, and energy (FEW) securities are intertwined, impacting each other. This is especially true in rural Alaska, where numerous communities are off the road system and can only rely on their own infrastructure. We investigated the FEW nexus using a combination of qualitative and quantitative methods. We developed a FEW security framework with four components: (1) availability and stability, (2) access, (3) quality and utility, and (4) preference. Using the framework, we then assessed the drivers of FEW security in three remote Alaska communities through community meetings and 118 household interviews. We found that low water security negatively impacted health, and that water insecurity problems were generally due to access and availability issues, such as freezing pipes or lack of infrastructure. Residents felt most secure with respect to water when they had access to alternative water sources, such as rivers and ponds. Water security was high across the communities, even in Kongiganak, where residents do not have in-home water services and must haul their water. Using econometrics methods, we also investigated the water-energy nexus in Alaska Rural Utility Collaborative member communities. We found evidence that in-home water services and electricity are complementary goods. In other words, an increase in the price of electricity will result in a decrease in demand for water services. We also found that the Alaska Permanent Fund Dividend (PFD) is linked to a significant increase in revenue for water utilities and could be construed as an indirect subsidy for water utilities.

Laboratory Investigation Of Infiltration Process Of Non-Newtonian Fluids Through Porous Media In A Non-Isothermal Flow Regime For Effective Remediation Of Adsorbed Contaminants

Project Type: Annual Base Grant
Project ID: 2019AK015B

Project Impact:

The objectives of the project were to:
• Study the effect of temperature on rheological properties of Guar gum and Xanthan gum of different concentrations.
• Study the flow characteristics of Newtonian and non-Newtonian fluids under different thermal regimes.
• Comparison of Newtonian and non-Newtonian fluid for remediation of adsorbed contaminant.

Major findings include:
Rheological Analysis
• In terms of viscosity, the effect of temperature change was higher on Guar gum than Xanthan gum, especially at mid to high concentrations.
• Xanthan gum behaved as non-Newtonian shear-thinning fluid for all the selected range of temperature and concentration. Guar gum also displayed non-Newtonian shear thinning behavior only for mid to high concentrations.
• An increase in non-Newtonian shear thinning behavior was observed with increase in temperature for mid to high concentrations of Xanthan gum. However, non-Newtonian shear thinning behavior of mid to high concentration of Guar gum showed neither decrease nor increase with change in temperature. Both polymers displayed improvement in shear thinning behavior with increase in concentrations.

Flow Experiments
• Infiltration depth of both Newtonian and non-Newtonian fluids decreased with the decrease in the temperature because of the change in their properties like dynamic viscosity, density and angle of contact. Infiltration of Xanthan gum solution is less compared to the Guar gum solution and water.

Contaminant Remediation
• With the limited set of experiments conducted at 19°C, water was most effective in remediating the 2, 6-Dichlorobenzonitrile from synthetic porous media in comparison to 0.5g/l Guar gum and 0.5g/l Xanthan gum.

Statistical Approach To Photochemical Reactivity Of Sub-Arctic Permafrost Natural Organic Matter And Its Implications Of Surface Water Biogeochemistry

Project Type: Annual Base Grant
Project ID: 2019AK016B

Project Impact:

Permafrost soils were determined to be heterogeneous in functional group composition and photo reactivity both intra-watershed and inter-watershed. There were no statistically significant trends observed within the permafrost soils based on radiocarbon dating of the soil material. Leachability of organic matter and metals depends primarily on the pH and ionic strength of the leaching material, however aliphatic functional groups remained for the majority absorbed onto the soil matrix and did not release into the leaching media.

This study determined that during winter there was a significant difference in functional group composition, photoreactivity, and metal composition. Winter isolated organic matter showed differences in functional group composition with decreased aromatic content and increased photoreactivity for reactive oxygen species. Winter also observed statistical differences in select metal concentrations thermokarst lake waters. Metal sources were observed to be majority from lateral flow through active layer and thawing permafrost layers. Conditions underneath of the ice were deemed to be a statistically important piece to the geochemical cycle.

In addition, optical indices allowed for the determination of permafrost influence on surface waters through the use of statistical analysis to observe correlations between permafrost degradation and these analyses. Additionally, metal concentrations were observed to have the highest concentrations in the 75 – 100% frozen permafrost underlain thermokarst lake due to the potential of high metal concentrations leaching in from lateral flow through actively thawing permafrost.