State of Washington Water Research Center
Washington State University

Annual Technical Report
2018

General Information

Products

2018WA438B:
Steenstra, P.J. 2019. Natural tungsten in Washington's surface waters: controls and modeling. M.S. Thesis, Washington State University (MS Thesis)

Steenstra, P.J., N. Strigul, and J.A. Harrison. In Revision. Tungsten in Washington State Surface Waters. Chemosphere (Journal Article)

Steenstra, P.J., N. Strigul, and J.A. Harrison. 2019. Natural Tungsten in Washington's Surface Waters: Controls and Modeling. Proceedings of the Society for Environmental Toxicology and Chemistry Meeting. Portland, OR, USA (Published Abstract)

N. Strigul, P.J. Steenstra, and J.A. Harrison. 2019. Understanding controls on mobility, toxicity and speciation of tungsten. Proceedings of the European Geophysical Union Annual Meeting, Vienna, Austria (Published Abstract)

2018WA434B:
Kittisack-Crain, Elizabeth and Amanda K. Hohner, 2019, Optimizing Coagulation Treatment to Adapt to Variable Water Quality Following Wildfire in Proceedings of the American Water Works Association Annual Conference and Exposition, Denver, Colorado. (Conference Proceeding)

2017WA429B:
Mortuza, R., E. Moges, Y. Demissie, and H. Li, 2018, Historical and Future Drought Risk in Bangladesh using Bivariate Regional Frequency Analysis, Theoretical and Applied Climatology, 135, 855-871. (Articles in Refereed Scientific Journals)

Wan, W., J. Zhao, H-Y, Li, A. Mishra, M. Hejazi, H. Lu, Y. Demissie, and H. Wang, 2018. A Holistic View of Climate Change and Water Management Impacts on Future Droughts: A Global Multi-Model Analysis, Journal of Geophysical Research – Atmospheres, 123, 5947–5972. (Articles in Refereed Scientific Journals)

Demissie, Y. M.R. Mortuza, H. Li, 2017. Comprehensive Characterization of Droughts to Assess the Effectiveness of a Basin-Wide Integrated Water Management in the Yakima River Basin, AGU Fall Meeting, LA, Dec. 11-15. (Conference Presentations)

Mortuza, M.R., E. Moges, Y. Demissie, E. Yan, H-Y. Li, 2017. The Complex Relationship between Heavy Storms and Floods: Implication on Stormwater Drainage design and Management, AGU Fall Meeting, LA, Dec. 11-15. (Conference Presentations)

Mortuza, M.R, Y. Demissie, 2018. New Drought Index to Characterize Droughts Within a Snowmelt and Reservoirs Dominated Watershed. AGU Fall Meeting, Washington DC, Dec. 10 – 14. (Conference Presentations)

2017WA428B:
Stahl, A. T., A. K. Fremier, B. Cosens. In review. Mapping legal authority for riparian conservation corridors. Conservation Biology (Impact Factor: 6.2) (Peer Reviewed)

2016WA412B:
Momtanu Chakraborty. 2017. Developing rapid crop canopy assessment methods using ground and aerial remote sensing techniques. MS Thesis. (WSU MS Thesis)

Quiros Vargas, J., L. R. Khot, R. T. Peters, A. K. Chandel and B. Molaei. 2019. Low orbiting satellite and small UAS based high resolution imagery data to quantify crop lodging: A Case Study in irrigated Spearmint. IEEE Geoscience and Remote Sensing Letters, 1545-598X: 1-5. https://doi.org/10.1109/LGRS.2019.2935830 (Peer-reviewed)

Chakraborty, M., L. R. Khot and R. T. Peters. 2019. Assessing suitability of modified center pivot irrigation systems in

corn production using low altitude aerial imaging techniques. Information Processing in Agriculture, https://doi.org/10.1016/j.inpa.2019.06.001 (Peer-reviewed)

Osroosh, Y., L. R. Khot and R. T. Peters. 2018. Economical thermal-RGB imaging system for monitoring agricultural crops. Computers and Electronics in Agriculture, 147: 34–43. https://doi.org/10.1016/j.compag.2018.02.018 (Peer-reviewed)

Chakraborty, M., L. R. Khot and R. T. Peters. 2018. Assessment of crop growth under modified center pivot irrigation systems using small unmanned aerial system-based imaging techniques. Proc. of ISPA 14th International conference on Precision Agriculture (June 24-25, 2018) ICPA full paper # 5308. (Proceeding)

2016WA411B:
Mehnaz Shams, Linda M. Guiney, Lijuan Huang, Mani Ramesh, Xiaoning Yang, Mark C. Hersam and Indranil Chowdhury 2019. Influence of functional groups on the degradation of graphene oxide nanomaterials - now published in Environmental Science: Nano https://pubs.rsc.org/en/content/articlelanding/2019/en/c9en00355j (Published paper)

2015WA402B:
Moges, E., A. Jared, Y. Demissie, E. Yan, 2018. Bayesian Augmented L-Moment Approach for Regional Frequency Analysis, World Environmental and Water Resources Congress, DOI: 10.1061/9780784481417.016 (Articles in Refereed Scientific Journals)

Mortuza, R., 2015, Regional frequency analysis and copula multivariate statistics for characterizing extreme precipitation and drought, “MS Dissertation,” Civil and Environmental Engineering, Washington State University, Richland, WA, p. 77. (Dissertation)

Demissie, Y. and M.R. Mortuza, 2015, Runoff Intensity-Duration-Frequency Curves for Washington State considering the change and uncertainty of observed and anticipated extreme rainfall and snow events, AGU Fall Meeting, San Francisco, CA, Dec. 14-15. (Conference Presentation)

Demissie, Y. and M.R. Mortuza, 2015, Updated and Forward Looking Rainfall and Runoff Intensity- Duration-Frequency Curves for Washington State, 6th Annual Pacific Northwest Climate Science Conference, Coeur d'Alene, ID, Nov. 3-5, 2015. (Conference Presentation)

Mortuza, M.R. and Y. Demissie, 2015, A multivariate drought assessment of the Yakima River Basin under historical and future climate change, 6th Annual Pacific Northwest Climate Science Conference, Coeur d'Alene, ID, Nov. 3-5, 2015. (Conference Presentation)

Mortuza, M.R. and Y. Demissie, 2015, A multivariate and probabilistic assessment of drought in the Pacific Northwest under historical and future climate change, AGU Fall Meeting, San Francisco, CA, Dec. 14-15. (Conference Presentation)

Information Transfer Program

[The WRC did not request funding for information transfer in 2018. The following were supported by cost-share and other non-extramural grant funds. Other information transfer activities of all other categories supported by extramural grants are not include, though 104B funds provide critical base-funding as support for staff necessary for extramural grant success and productivity and information transfer.]

WRC Director Yoder is on the Board of Directors of the Universities Council on Water Resources, and is President Elect of that organization. Padowski holds the following service positions: Northwest Climate Adaption Science Center, University Advisor; Consortium of Universities for the Advancement of Hydrologic Science, WSU Delegate; University Council on Water Resources, WSU Delegate; Engineers without Borders- Faculty Mentor, WSU;

Co-Organizer, Palouse Basin Aquifer Committee Colloquium. Pullman, WA. 2018. Sept. 27.
Conference co-sponsorship: Spokane River Forum, April, 2019.

Conference co-sponsorship: 2018 Palouse Basin Water Summit. October 18, Pullman, WA.

Presentation: Yoder, Jonathan. 2018. State of Washington Water Research Center: Activities and Roles for the Joint Legislative Task Force for Water Supply. Presentation to the Washington State Joint Legislative Task Force on Water Supply. Mount Vernon, WA, 11 December.

WRC co-administers the Graduate and Undergraduate Certificate in Water Resource Science and Management through the WSU School of the Environment.

Student Support

The 2018 104B seed grant program directly supported 3 graduate (Masters) students and one undergraduate.

Extramural grant funding indirectly supported by 104B funds provides support for an additional seven graduate students who would not have been funded without the indirect support of the 104B program.

Notable Achievements and Awards

The 104B base funding provided the necessary foundational support for a great deal of extramural grant success. In 2018, we were awarded a $5 Million grant from USDA NIFA Water for Agricultural Production Systems challenge area (WRC is the lead entity). The WRC is the lead Washington State entity for a new (2018) $30 Million USAID grant to develop a Water Center of Excellence for Egypt. We also acquired and completed a project for the Washington State Department of Ecology to provide technical guidance for assessing mitigation strategies to offset streamflow and salmonid impacts of exempt-well groundwater pumping ($91,000). WRC is also the home institute for a Department of Ecology grant to study modified flows irrigation depletion ($500,000). Padowski is co-PI on: NSF, 2018: “CNH-RCN: A research network for the resilience of headwater systems and water availability for downstream communities across the Americas” ($499,914) NSF, 2018: “SUSRN-Advancing Conference: The Next Urban Giants: Building Resilience and Equity into Growing Megapolitan Regions by Greening the Urban Human-Natural System” ($50,000). PBAC, 2018: “A physically based decision-making support tool for the upper Palouse Basin aquifer” ($65,000).

Projects

Washington wildfires disrupt water quality: Are drinking water systems resilient to climate change?

Project Type: Annual Base Grant **Project ID:** 2018WA434B

Project Impact: The Naches River serves as the primary source water for Yakima, Washington and generally provides high quality water, which has allowed for direct filtration treatment. Yakima's water supply was threatened in 2017, when the Norse Peak fire burned over 10% of the hydrologic drainage for their water supply. To address the concerns of increased turbidity and dissolved organic carbon (DOC) following the fire, the Naches River water intake was monitored from April- October 2018. Raw water quality was characterized, and coagulation tests were performed for the evaluation of turbidity and DOC removal. Jar tests were used to compare two aluminum-based coagulants: aluminum sulfate (alum) and aluminum chlorohydrate (ACH). Further, direct filtration and conventional treatment conditions were considered. Raw water turbidity ranged from 2.1- 39.2 NTU throughout the season. For bench-scale tests, ACH was used with direct filtration conditions, and consequently turbidity of the coagulated water remained high, only decreasing by 9.9% on average. Whereas conventional treatment with alum effectively decreased the turbidity (average = 77.0%). The raw water DOC ranged from 0.9- 2.2 mgC/L. ACH was as effective for DOC removal at lower doses compared to alum. ACH appeared to perform comparably to alum at lower doses and had little effect on the pH, providing advantages for low alkalinity source waters. ACH may remove more aromatic organic matter than alum, which may be beneficial for meeting disinfection byproduct regulations. Further, ACH may provide advantages such as reduced solids production compared to traditional coagulants, which is an important consideration following fire.

Frequency Analysis of Historic and Future Droughts in Yakima Basin

Project Type: Annual Base Grant **Project ID:** 2017WA429B

Project Impact: We have developed a nonstationary and comprehensive drought index (NCDI) by considering water availability from rainfall, runoff, reservoirs, and snowpack. The new index ability to capture drought severity and duration was evaluated using historical droughts in the Yakima River Basin (YRB) during 1983-2016. The performance of the index was also compared with that of traditional drought indices which mostly use either rainfall or runoff to determine the drought conditions. The index varies over time as a function of large-scale climate fluctuations (AMO, PDO, ENSO, NAO). The new index accurately characterized the severity and duration of historical droughts in the YRB. For example, compared with the traditional indices like Standardized Precipitation Index (SPI), the NCDI was able to identify the 1992-1994, 2001-2002, 2004-2005, 2015 drought more accurately in terms of both duration and severity. In general, the drought durations identified by SPI were consistent with NCDI but have large differences in the severities. NCDI identified 2000-2006 as the longest drought spell while the drought condition in 1993 was the most extreme. The nonstationary index performed reasonably well compared to the traditional stationary indices as significant non-stationarity was identified in the available water within the YRB. Overall, the NCDI can be used to monitor drought and wet events over various time scales and different climatic conditions. It is particularly effective in capturing drought condition in snow-dominated and highly managed river basins, where the traditional drought indices fail to account the different sources of water in a river basin.

Understanding controls on mobility and toxicity of tungsten, an emerging threat to Washington's waters

Project Type: Annual Base Grant **Project ID:** 2018WA438B

Project Impact: At high concentrations, tungsten can be toxic to humans, animals, and the environment, yet little is known about the patterns and controls of natural tungsten (W) concentrations in surface waters. In order to improve the understanding of tungsten in surface waters and to develop a model to predict tungsten concentrations as a function of geochemical proxies, we conducted a synoptic sampling effort wherein we collected water and sediment from 77 distinct water bodies located in 20 different watersheds in Washington State, USA. We found aqueous tungsten concentrations spanning two orders of magnitude (range: 10.3 ng L-1 - 2.05 µg L-1), though the highest

concentrations are still low compared to the standards set by the former Soviet Union—the only country so far to set a limit for tungsten in drinking water (50 μg L-1). Average tungsten concentrations in both water and sediments were more than two-fold higher in watersheds with tungsten-bearing underlying rock types (average: 0.217 μg L-1 and 0.669 mg kg-1; range: 0.010 – 2.05 μg L-1 and 0.0713 – 4.691 mg kg-1 for surface waters and sediments, respectively) than in watersheds without such underlying geology (average: 0.068 μg L-1 and 0.352 mg kg-1; range: 0.010 – 0.211 μg L-1 and 0.0349 – 2.399 mg kg-1 for surface waters and sediments, respectively). We also conducted tungsten dissolution experiments, evaluating the solubility and dissolution kinetics of elemental tungsten and 4 tungsten-bearing minerals.