BUREAU OF RECLAMATION

Research Updates R&D Office

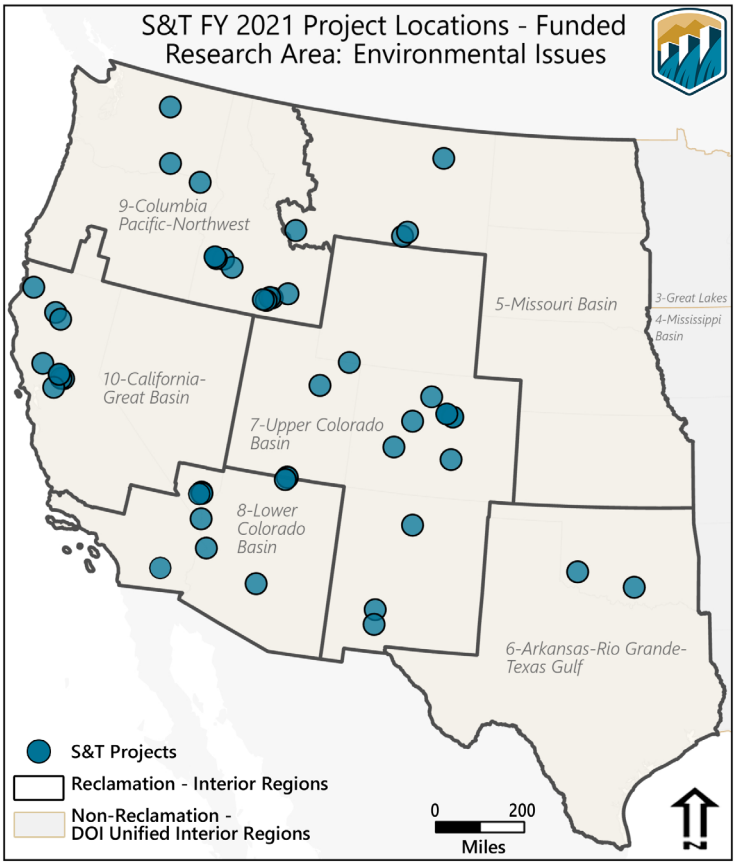
Environmental Issues for Water Management and Delivery

U.S. Department of the Interior

March 2021

Executive Summary

The Environmental Issues in Water Management and Delivery (EN) Research Area of the Science and Technology Program (S&T) examines research in the following categories: Water Delivery Reliability, Invasive Species, Water Quality, Sediment Management, and River Habitat Restoration. In FY21, S&T funded 35 EN Projects approximately totaling $2.3M: 14 were new totaling $1.0M and 21 were continuing totaling $1.3M. A Benefit Cost Ratio calculations (BCR) was estimated for one EN project to demonstrate the value of this research. A BCR of 12.3 was calculated for the Seasonal/ Temporary Wetland/Floodplain Delineation using Remote Sensing and Deep Learning primarily due to the ability to automate wetland and floodplain delineation using machine learning, specifically convolutional neural network architecture in deep learning, when high temporal and spatial resolution remote sensing data is available. As demonstrated, EN research is extremely valuable to Reclamation, both by development of new methods and techniques, as well as by learning about technologies that should not be adopted by Reclamation Program to assist with environmental compliance.



Reclamation's Research and Development Office (R&D) manages the Science and Technology Program (S&T) and is focused on providing innovative solutions for Reclamation water and power facility managers and its western customers and stakeholders, primarily through competitive funding opportunities to Reclamation employees.

The S&T Program has five research areas (listed below) directly related to Reclamation's mission. For more information, visit: https://www.usbr. gov/research/st/needs_priorities/index. html.

S&T Research Areas and Categories

Water Infrastructure (WI)
Dams, Canals, Pipelines, and Miscellaneous Water Infrastructure

Power and Energy (PE)
Hydro Powerplants, Energy Efficiency, Pumping Plants, and Non-Hydropower Renewable

Developing Water Supplies (WS)
Advanced Water Treatment, Groundwater Supplies, Agricultural and Municipal Water Supplies, and System Water Losses

Environmental Issues in Water Delivery and Management (EN)
Water Delivery Reliability, Invasive Species, Water Quality, Sediment Management, and River Habitat Restoration

Water Operations (WP)
Water Supply and Streamflow Forecasting, Water Operations Models and Decision Support Systems, Open Data, and Climate Change and Variability

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Environmental Issues for Water Delivery and Management

FY20 Completed Projects

Photos of the electric fish barrier installed at the East Portal of Gunnison Tunnel in Colorado. Both photos are taken from the location of the slide gate at the inlet of the tunnel.

1722: Effect of Electric Fish Barriers on Corrosion and Cathodic Protection - Daryl Little

The results from the structure-to-water potentials measured show little to no effect from the electric fish barrier on the potential corrosion rate of the temporary structure at this facility. After an hour, the structure-to-water potentials measured at all five locations were only 30 to 40 mV more negative than the native potential. This project showed that the electric fish barrier system at Gunnison Tunnel East Portal did not have a major influence on the structure-to-water potential of the temporary test structure. Based on these results, it is safe to assume that electric fish barriers under similar operational conditions would not have an influence on the corrosion rate of a permanent structure in their vicinity.

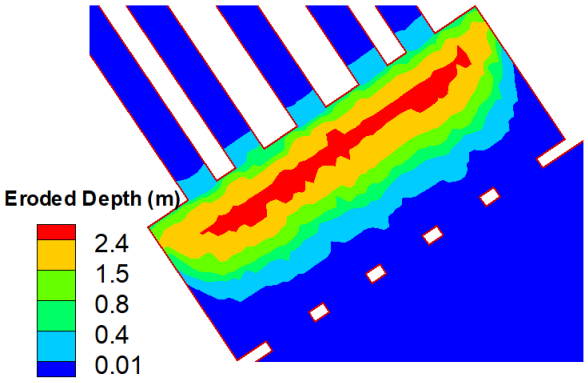
7839: Field deployment of a continuous sediment load surrogate - Ari Posner

Challenges were present during the implementation of the developed technology at the San Acacia site, but with some caveats, the developed technology can be utilized in shallow sand rivers with a changing morphology. The collected data was not always continuous due to the need to install the acoustic instruments a certain distance above the bed to avoid sediment burial. Data was collected, however, during higher discharge events, providing understanding of the suspended sediment movement. For instance, results indicate that more sand sized particles are moved in suspension at this location during the spring snow-melt runoff than at other time periods, becoming mobile around 1,500 cfs, as shown in the figure below. Acoustical measurements also provided median sediment size information, evaluation of suspended sediment peak timing relative to the discharge peak, and observations of the potential for daily suspended sediment samples to under predict the annual cumulative suspended sediment mass.

Photo of mounting structure and acoustic instruments after installation at low water.

1781: Improvement in the accuracy and speed of riparian vegetation simulation - Jianchun Victor Huang

The current Sediment River Hydraulics - One Dimension Vegetation (SRH-1DV) includes simulating changes to vegetation growth and mortality modules caused by river conditions (i.e. groundwater levels) and air temperatures. However, fully two-dimensional (2D) flow models of vegetation growth and mortality models requires excessive computing power to provide long-term simulations. As a solution, a new model called Sediment River Hydraulics One-Dimensional and Vegetation Two-Dimensional (SRH-1D-VEG2D) is constructed that uses the hydraulic model of SRH-1D to develop inundation over a 2D grid on which vegetation computations can be performed.



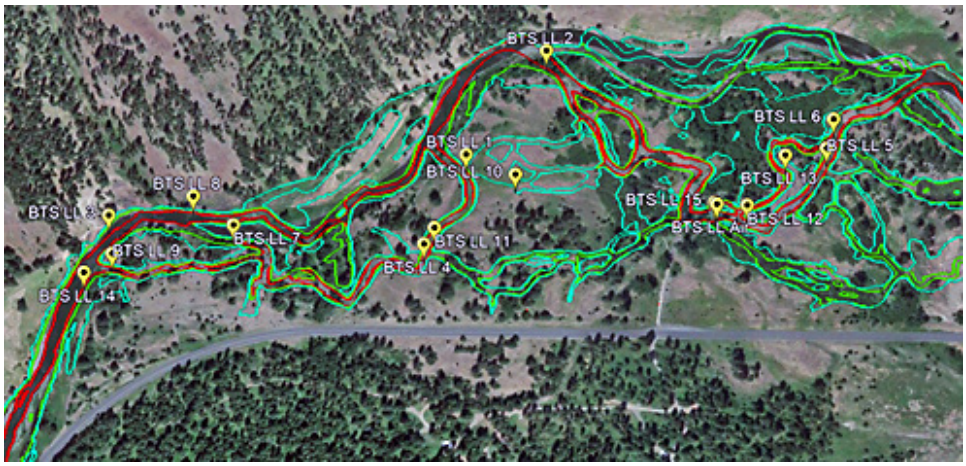
Plan view of the simulated erosion upstream of intake in Cherry Creek Reservoir in Colorado.

1754: Prediction of Reservoir Sediment Pressure Flushing - Blair Greimann

The objective of the research was to develop and test a three-dimensional numerical model to simulate pressure flushing of sediment from reservoirs. A three-dimensional hydraulic and sediment transport model, U2RANS, has been developed through funding provided by Taiwan Water Resources Agency and has been applied to other sediment transport problems. The model was extended to simulate the case where the reservoir pool is nearly full, but dam outlet gates are opened to pressure flush sediments from the vicinity of the gates.

1798: River restoration freeboard design requirements - Bryan Heiner

During the data collection period, six inflow events were identified that correlate to an expected low, March median, winter high, 1.25-yr and two 50-yr flow events. Data from these events were extracted from the water surface elevation logged data series at 8 locations and compared to previously generated numerical model results that were part of a separate study. Refined inflow data at the site was not available for direct comparison of all flow events, which makes it difficult to compare exact numerical model simulations to the collected field data. From the analysis, differences between the numerical model results and the field data was between -1.21 and 0.35-ft. Given that exact matching of exact discharges was not possible for all storms, researchers considered this a good comparison.



Locations where loggers were installed at the Bird Track Springs restoration area in Oregon.

1867: Seasonal/Temporary Wetland/Floodplain Delineation using Remote Sensing and Deep Learning - Zach Leady

Seasonal wetlands are an important habitat for many aquatic species, including some endangered species. In the past, the delineation of seasonal wetlands has been very limited and often inaccurate by traditional methods used by Reclamation. A new methodology was created to automatically delineate seasonal wetlands from satellite imagery using machine learning methods. While additional research is needed to verify the accuracy of the results, this methodology has the potential to identify seasonal wetlands over a large area at a much lower cost than traditional methods.

Flow (left to right) in the Arroyo de los Pinos during a July 2020 monsoon event. (Photo_K. Stark)

1871: Measuring and Monitoring Sediment Transport in an Ephemeral Stream; Physical and Surrogate Data Collection - David Varyu

Once a reliable relationship between physical and surrogate methods is defined, the surrogate method (cheaper than physical) can be deployed in many other ephemeral streams. With improved estimates of sediment delivery from ephemeral streams, the design of an instream or along-stream structure will account for geomorphic processes and ensure the facility provides the intended service. The advancement of reliable surrogate techniques can allow for deployment across many ephemeral streams to improve confidence in baseline data and therefore design.

20043: Scoping of future research opportunities to reduce impacts of fugitive dust on Reclamation's lands at the Salton Sea and understand impacts of a receding Salton Sea on the Colorado River basin - Meghan Thiemann

The literature review identified dust control measures (DCMs) in use at the Salton Sea, DCMs evaluated for Owens Lake, as well as a few other DCMs. Future research opportunities were previously suggested by a panel evaluating DCMs at Owens Lake. If conducted, this research could also benefit the Salton Sea. In addition, future research on enzyme-induced carbonate precipitation (EICP), an emerging dust suppression technique, was recommended from a previous Reclamation S&T project and could benefit the Salton Sea. Previous studies suggest that evaporation contributes to baseline precipitation amounts within a basin. Future research could include a regional atmospheric modeling study to predict the impacts of a receding Salton Sea on the basin.

Photo of the Salton Sea from Salton Sea Photo Gallery. (https://www.usbr.gov/lc/images/gallery/Saltonsea/index.html)

20070: Utilizing Acoustic Sensors to Detect Streambed Mobilization - Rebecca Braz

The Wild and Scenic Rio Chama receives a significant supply of fine sediments from its tributaries and from bank erosion. These fine sediments smother and fill the interstitial spaces within the gravel streambed and restrict oxygen transport in the bed which negatively affects brown trout habitat. Environmental flows released from El Vado Dam are used to initiate streambed mobilization in the Rio Chama to clear fine sediment. This scoping project sought to evaluate the use of hydrophone technology to detect when streambed mobilization occurs and correlate this occurrence to a range of flow rates. These flow rates would be used by water managers to plan more effective environmental flows. The scoping literature review found that hydrophones have been used by the USGS to detect incipient motion in a similar study on the Upper Colorado River. A conducting proposal for an in-river study was prepared in collaboration with the USGS and submitted to the S&T Program.

View facing downstream on the Wild and Scenic Rio Chama.

1883: Development of a GPU Accelerated Salinity Module for the SRH-2D Platform - Zach Leady

Reclamation's mission is designed around delivering usable agricultural water for the West. Therefore, being able to simulate salinity in a 2-D finite-volume model in a realistic timeframe would be of significant value to Reclamation. The goal of this project was to develop a salinity module to simulate salinity using SRH-2D, a two-dimensional (2D) flow hydraulic and mobile-bed sediment transport model for river systems that is frequently used by Reclamation. Additionally, this research sought to improve the efficiency of SRH-2D using graphics processing unit (GPU) acceleration methods. Unfortunately, neither goal was achieved during the timeframe of this project, but the research laid the groundwork for future research in this area.

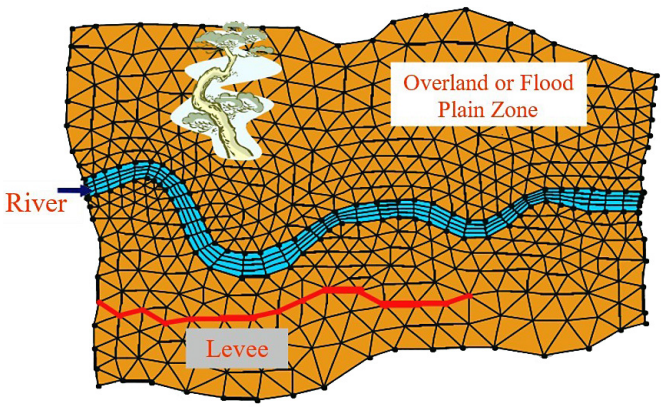


Illustration of zonal partition and mesh layout in SRH-2D. From Lai (2008).

FY21 New Projects

21013: Stakeholder Outreach and Exploration of Dust Mitigation and Suppression Strategies for Exposed Playa at the Salton Sea – Meghan Thiemann

This project will work with stakeholders to prioritize testing of new dust control strategies and develop an approach and methodology that considers the biological, political, and social conditions at the Salton Sea.

21054: Abrasivity of Slurry-Transported Sediment: Development of a Laboratory-Based Test System – Evan Lindenbach

Reservoir sedimentation is a problem that has been recognized in the past at a select few of our structures (Paonia for example) but is becoming "main-stream" with many other projects operating at a reduced capacity. As we look towards the need to remove the sediment or manage it through our existing infrastructure of gates, valves, turbines, etc., we need to understand the effect that the sediment-laden slurry will have on the design life of our equipment. This proposal seeks to fund research that will answer an important question in that effort – how do we quantify the abrasivity of the slurry material for use in our designs? This research will approach the question with both small-scale and large-scale testing devices. In this manner, correlations will be developed between scales allowing for: 1) An understanding of slurry abrasivity, and 2) how to economically test the abrasivity potential for a variety of projects.

21088: Sediment effects on river restoration habitat features: physical processes and guidelines for effective and sustainable design, planning, and maintenance – Drew Baird

This research will develop guidelines to plan, design, construct, adaptively manage, and maintain habitat features to reduce effects of sediment deposition. This research goes beyond using historical observations to understand how these features evolve over time. Applying sediment transport modeling will provide knowledge of the physical processes governing sediment effects to effectively plan and design habitat restoration to maximize long-term habitat benefits.

21084: Cost Estimating Guidelines for Dam Decommissioning Alternative – Jennifer Bountry

This project will develop a cost estimating guideline for dam removals by drawing upon Reclamation and partner dam removal experience. This guidance will not only benefit staff performing technical consultations on dam removals and low-head dam modifications, but will also contribute to dam safety alternative analyses that require dam removal as one possible solution.

21075: Modeling Riverine Pool Temperature Stratification and Reservoir Selective Withdrawal for Fish Spawning and Rearing Habitat – Yong Lai

This research will address whether Reclamation 3D model, U2RANS, can be extended to create an advanced high-order temperature model for simulating complex thermal processes. Then, the project will study whether thermal stratification in deep pools and selective withdrawal at reservoirs through temperature control devices can be predicted.

21078: Chemical Fingerprinting of Delta Smelt for Sensitive Detection in the Environment - Daniel Deeds

Delta Smelt are a small, Endangered Species Act-listed fish native to the Sacramento-San Joaquin Delta and upper San Francisco Estuary. Low population density, combined with their preference for turbid, shallow regions of the Delta, make Delta Smelt difficult to find, hindering accurate surveying of the remaining wild population and complicating adaptive management of Central Valley Project pumping operations. It is also common knowledge in the Delta science community that Delta Smelt smell like cucumber. This project will verify the chemical responsible for Delta Smelt smell and assess its strength by number and age of fish. Once the smell is identified, fieldwork in the Sacramento-San Joaquin Delta in collaboration with California Department of Water Resources (DWR) staff will test the capabilities of state-of-the-science measurement techniques to detect Delta Smelt in the wild. Chemical fingerprinting will be compared to environmental DNA (eDNA) detection of Delta Smelt already under study by DWR, Reclamation and UC Davis researchers. This research aims to produce a method for rapid environmental detection of Delta Smelt that will help surveying efforts and will provide a tool to adaptively maximize CVP exports without jeopardizing the remaining wild Delta Smelt population.

21046: Reservoir Delta Morphology and Effects on Tributary Fish Passage and Habitat – A Scoping Study - Caroline Ubing

Channel morphology frequently changes in tributaries to Reclamation's storage reservoirs in response to hydrology, sediment, and fluctuating pool elevations. This dynamic environment presents challenges to threatened and endangered aquatic species by causing shallow depths, disconnected surface flow, and channel obstructions, thereby blocking upstream fish passage. These changes have occurred in the channels between the minimum and maximum pool elevation and within the reservoir delta, which extends upstream into the contributing tributaries. Reservoir operations and the associated effects on water level and channel morphology are especially difficult during dry years. Spawning grounds are located upstream within contributing tributaries, making fish passage crucial for local salmonid population survival. The purpose of this scoping study is to understand the problem, data, tools, and models currently available for reservoir tributary sediment budgets and delta development. Information will then be used to evaluate restoration and fish passage projects that are successful with existing processes to make future projects more sustainable. The preliminary analysis will encompass all five Yakima basin reservoirs.

21016: Laboratory and Field Testing of Enzyme and Microbially Induced Carbonate Precipitation for Mitigation of Fugitive Dust at the Salton Sea – Angel Gutierrez

Enzyme induced carbonate precipitation (EICP) and microbially induced carbonate precipitation (MICP) are two emerging technologies that offer the potential for sustainable, cost effective mitigation of fugitive dust. Currently, fugitive dust has negative impacts on nearby communities along the Salton Sea. The project will result in a demonstration of the efficacy and potential environmental impact of EICP and MICP for fugitive dust control, including the potential impact of residue from agricultural runoff in the Salton Sea playa on the effectiveness of these techniques. Potential reduction in fugitive dust using these technologies may lead to reduced health hazards.

21015: Physical and Surrogate Data Collection of Sediment Transport in Ephemeral Systems - David Varyu

A method to adequately quantify sediment delivery from ephemeral tributaries in a reliable and cost-effective manner does not exist. River maintenance and other in-channel projects – whether for water delivery, public safety, river stability and habitat restoration, or other – need to be designed and implemented with knowledge of river processes and channel morphology to ensure project success. Process and morphology are a result of the magnitude and timing of water and sediment delivery to the channel. This research will benefit any office charged with rivers that have ephemeral tributaries. The work to be completed under this proposal expands on the knowledge gained so far and aims to continue data collection at the Pinos site; compare the data collected at the Pinos site to established modeling methodologies; including Reclamation's BORAMEP program as well as at least one watershed modeling tool for estimating sediment yield; cooperate with project partners to identify and select a new site for data collection; hypothesize the relationship between surrogate and physical measurements based on basin characteristics such as drainage area, average slope, lithology, bed material size distribution; and design a data collection platform at a new site so the hypothesis can be tested.

21008: Resolving Spatiotemporal Distribution of Suspended Sediment Concentration over the Columbia and Snake River Using Remote Sensing - Kendra Fallon

The goal of this collaborative project is to provide actionable science and user-friendly tools to natural resource and water managers to evaluate the distribution of Suspended Sediment Concentration (SSC) along the Columbia and Snake River (CS River) in face of a changing climate, increased wildfires and evolving land management strategies. This research effort will leverage advances in the field of remote sensing and cloud computing to: (1) Develop a robust remote sensing-based machine learning model to accurately infer SSC levels using Landsat and Sentinel satellite imagery, (2) Apply this model to derive a comprehensive picture of hotspots of sediment sources and sinks along the CS River between 1984-present, and (3) Provide a user friendly, freely available Google Earth Engine (GEE) APP that can readily estimate SSC levels along the CS River for collaborative land management planning and post disturbance rehabilitation. This project would provide a bridge between management and science as a GEE-based APP is user friendly and allows land managers or non-scientists to not be encumbered by difficultly in navigating complex models.

21092: Utilizing Hydrophones to Detect Streambed Mobilization in the Wild and Scenic Reach of the Rio Chama - Rebecca Braz

The Rio Chama is a tributary of the Rio Grande in northwestern New Mexico. The Chama receives a combination of native water and inter-basin transfer water from the San Juan-Chama Project. Because of climate change, native water flows in the Rio Chama are expected to decrease by one-third and inter-basin transfer flows by one-quarter over the next century. The stretch of the Rio Chama between El Vado Dam and Abiquiu Dam was designated Wild and Scenic in 1988. This stretch of the Rio Chama is a high-sediment system with a significant amount of fine sand, silt and clay (mud) deposited on gravel-cobble (coarse) bed material. This mud restricts oxygen transport in the gravel streambed, reducing food sources and affecting spawning habitat of the brown trout, a key species in the designation of the Wild and Scenic reach. The area for this research would be a site referred to as "Archuleta" located approximately 7.3 miles downstream of El Vado Dam.

Hydrophone systems would be placed in various locations within the Archuleta site. Continuous data collection would occur and sediment samples would be taken at each hydrophone site at the beginning and end of the data collection period to provide another means of evaluating if and what changes occurred in the streambed during higher flows. A turbidity monitor would also be installed at the Archuleta site to give insight into fine sediment transport; this would be compared to the coarse sediment transport information recorded by the hydrophones. Through the collection and analysis of this data, it is the intention of this proposal to better understand the range of flows that will initiate and most effectively mobilize streambed sediments for the benefit of brown trout in the Rio Chama and to advance the research of using hydrophones for this purpose.

21077: Predicting Reservoir Drawdown Flushing to Improve Reservoir Sustainability - Victor Huang

Reservoir sedimentation is impacting all Reclamation (and other public and private) facilities as water storage and supply become increasingly threatened with the aging infrastructure. Drawdown flushing can be used to remove reservoir sediment in small gorge-shaped reservoirs and to extend the reservoir life span. A 2D sediment transport model will be used to study the effectiveness, timing, and the downstream impact of reservoir flushing. The research will develop and improve guidelines for drawdown flushing for Reclamation reservoirs.

FY21 Active Projects

ID	Final Year	Title	Lead	FY21 Funding Amount*
1734	2021	Robust Eco-Hydraulic 3D Modeling Tools for Rivers with Complex In-Stream Structures	Yong Lai	$33,271
1792	2021	Using beryllium-10 derived erosion rates as a proxy for reservoir sedimentation	Melissa Foster	$19,140
1809	2021	Mercury Loading to Streams and Reservoirs: A Process-Based Approach	Yong Lai	$166,155
8101	2021	Measuring Gravel Bar Mobility in Large Rivers with Tracer Gravel	Nate Bradley	$32,345
19080	2021	Aging Reservoirs, Climate, Operations, and Potential Cumulative Impacts to Water Quality, Clarity and Fisheries and Recreation	Mike Horn	$11,203
19105	2021	Fish Passage at River Diversion Juncture: A Science-Based Approach	Yong Lai	$102,499
19112	2021	Monitoring the Movements of Juvenile Pacific Lamprey in the Yakima River using Acoustic Telemetry	Patrick Monk	$ -
19225	2021	Quantifying Fish Biomass X Distance from Environmental DNA Samples in a Hydrodynamically Complex Environment	Andrew Schultz	$41,000
19266	2022	Side channel evolution and design: achieving sustainable habitat for aquatic species recovery	Nathan Holste	$74,777
19290	2021	Improving predictions of scour in the vicinity of vegetation in habitat rehabilitation areas	Daniel Dombrowski	$7,000
19306	2021	Side channel evolution, geomorphic diversity, and sediment transport on the Bighorn River following larger dam releases between 2008 and 2018	Melissa Foster	$25,825
20019	2021	Development of a platform for wildfire incident support and evaluation of post-fire impacts	Kendra Fallon	$69,000
20031	2022	The potential for restoring thermal refuges in rivers for cold-water salmonids	Caroline Ubing	$66,037
20042	2022	Threat Assessment and Evaluation of Burrowing Crayfish in Reclamation Canals	Aaron Murphy	$126,903
20045	2022	A Methodology for Rockwad Velocity and Predator Habitat	Jenna Paul	$60,000
20052	2022	Quantifying the Development and Dynamics of Reservoir Delta and Related Backwater Vegetation in the Context of Physical Drivers	Nathan Holste	$68,000
20057	2021	Modeling effects of wildfire and fire retardant on nutrients downstream in a watershed scale	Jun Wang	$42,155
20060	2022	River restoration interactive geospatial database to inform future river rehabilitation design	Melissa Shinbein	$84,621
20064	2023	Monitoring Detritus Deposition and Scour Downstream of Minidoka Dam with Implications to Snake River Physa Snail Habitat and Irrigation Canals.	Daniel Dombrowski	$29,500
20067	2021	Evaluating Chirp Technology for Measuring Reservoir Sedimentation Thickness and Stratigraphy	Daniel Dombrowski	$761
20069	2022	Monitoring Suspended Sediment: An Investigation Coincident with the Cherry Creek Reservoir Annual Flush	Daniel Dombrowski	$7,000
20091	2022	Determining the capabilities and limitations of Unmanned Aircraft Systems (UAS) equipped with Light Detection Ranging (LiDAR) sensors when applied to hydrologic studies, infrastructure, mapping, and general land data collection	Meyer Jay	$172,444
20094	2022	Cyanophage treatment development for mitigating freshwater Harmful Algal Blooms caused by cyanobacteria	Christopher Waechter	$73,657
21016	2023	Laboratory and Field Testing of Enzyme and Microbially Induced Carbonate Precipitation for Mitigation of Fugitive Dust at the Salton Sea	Angel Gutierrez	$86,500
21088	2023	Resolving Spatiotemporal Distribution of Suspended Sediment Concentration over the Columbia and Snake River Using Remote Sensing	Drew Baird	$73,000
21054	2023	Abrasivity of Slurry-Transported Sediment: Development of a Laboratory-Based Test System	Evan Lindenbach	$108,000
21084	2022	Cost Estimating Guidelines for Dam Decommissioning Alternative	Jennifer Bountry	$76,000
21013	2021	Sediment effects on river restoration habitat features: physical processes and guidelines for effective and sustainable design, planning, and maintenance	Meghan Thiemann	$55,000
21075	2023	Modeling Riverine Pool Temperature Stratification and Reservoir Selective Withdrawal for Fish Spawning and Rearing Habitat	Yong Lai	$110,986
21046	2021	Reservoir Delta Morphology and Effects on Tributary Fish Passage and Habitat – A Scoping Study	Caroline Ubing	$30,000
21078	2021	Chemical Fingerprinting of Delta Smelt for Sensitive Detection in the Environment	Daniel Deeds	$84,875
21015	2023	Physical and Surrogate Data Collection of Sediment Transport in Ephemeral Systems	David Varyu	$129,000
21008	2022	Resolving Spatiotemporal Distribution of Suspended Sediment Concentration over the Columbia and Snake River Using Remote Sensing	Kendra Fallon	$42,533
21092	2022	Utilizing Hydrophones to Detect Streambed Mobilization in the Wild and Scenic Reach of the Rio Chama	Rebecca Braz	$94,000
21077	2023	Predicting Reservoir Drawdown Flushing to Improve Reservoir Sustainability	Victor Huang	$90,000

* For projects with no funding, these projects are nearly complete and received funding in past years for this work.