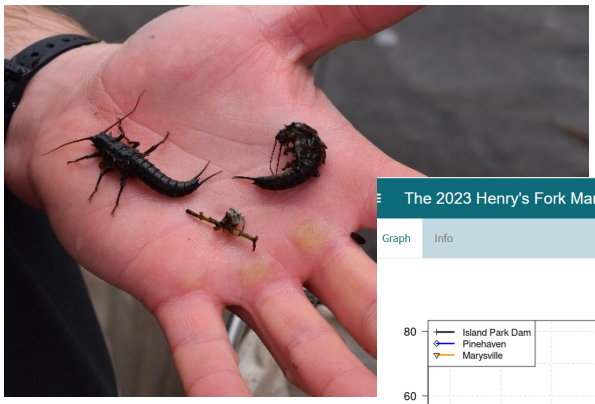
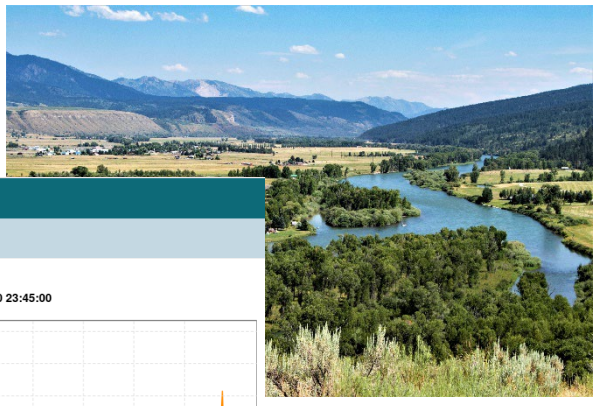
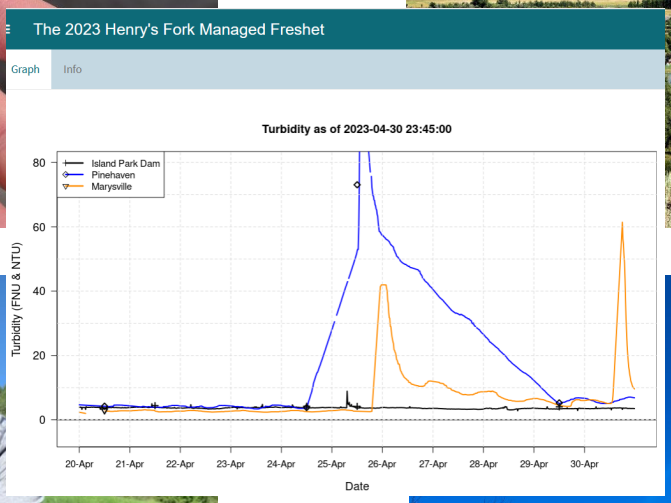
Optimizing data collection, data availability, and streamflow forecasting to enhance fisheries in the Snake River Watershed

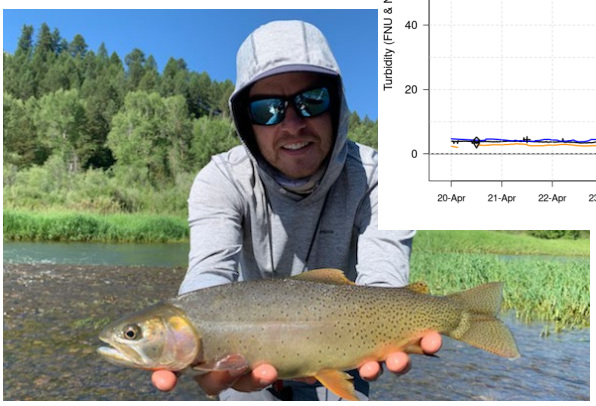
U.S. Bureau of Reclamation WaterSMART Applied Science Grant Proposal

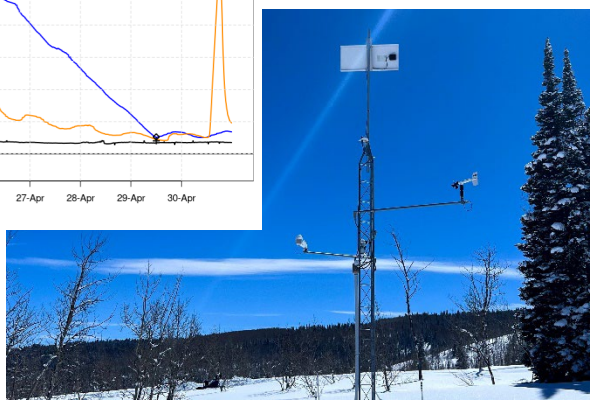
October 16, 2023











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List of Abbreviations and Acronyms

CWA	Clean Water Act
ESA	Endangered Species Act
FMID	Fremont-Madison Irrigation District
FTR	Friends of the Teton River
GIS	Geographic Information System
HFF	Henry's Fork Foundation
HFWC	Henry's Fork Watershed Council
NRCS	Natural Resources Conservation Service
NOFO	Notice of Funding Opportunity
Reclamation	U.S. Bureau of Reclamation
SRWM	Snake River watershed upstream of Menan, ID
SWE	Snow water equivalent
USRB	Upper Snake River basin

Technical Proposal and Evaluation Criteria

Executive summary

APPLICATION: Oct. 17, 2023 | PROJECT: START Oct. 1, 2024; END Sep. 30, 2026

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The Henry's Fork Foundation (HFF), a nonprofit watershed conservation organization, proposes to partner with Fremont-Madison Irrigation District (FMID) on a two-year project to benefit important fisheries in the Snake River basin, Idaho and Wyoming, through the development of new data infrastructure and expansion of hydrologic modeling. The world-renowned and economically important trout fisheries of the upper Snake River basin, including those in the Henry's Fork and South Fork, exist within a hydrologic system that is highly managed for irrigation storage and delivery. Work on the Henry's Fork funded by a previous WaterSMART Applied Science grant found substantial fisheries and water quality benefits associated with reduced reservoir drawdown and increased winter flows at Island Park Reservoir. Other work suggests these same benefits may apply to the South Fork. To support further improvements in water management on the Henry's Fork and expand them to the South Fork, this project will provide stakeholders and managers with the data, models, and short-term streamflow forecasts needed to more precisely manage storage reservoirs. To this end, we will: 1) expand an existing model and supporting data to predict water supply, irrigation demand, and water right priorities for the whole watershed upstream of the Henry's Fork-South Fork confluence at Menan, ID; 2) install six new weather stations that collect wind speed, humidity, soil moisture, precipitation, snow depth, air temperature, and incoming and outgoing radiation data that are not currently available for high elevations of the upper Snake River watershed, and 3) use these datasets to create short-term streamflow forecasts that integrate physically-based snowmelt processes using the iSnobal energy balance snow model. The data generated through this project will be made publicly available in near real-time. This project directly addresses the three objectives of this NOFO: improve access to and use of hydrologic data, develop and improve water management tools, and improve modeling and forecasting capabilities. Four of the five storage reservoirs on the Snake River upstream of the Henry's Fork-South Fork confluence are Reclamation facilities, and the one with the greatest impact on an important fishery is Island Park Reservoir, which stores water for FMID. Thus, Reclamation and FMID are participating partners in the project. We propose to fund the project with $400,000 in federal funds, $150,010 in costs paid directly by the applicant, and $52,740 in third-party contributions. Federal funds will be used to pay web-development and modeling contractors and staff, fund a full-time postdoctoral research position, and purchase four of the weather stations. The applicant will contribute staff and intern time, post-doc housing and office space, computing hardware and software, web-hosting and data transmission fees, travel, and consulting fees associated with permitting and environmental compliance. In-kind contribution consists of stakeholder outreach and input on technical aspects.

The proposed project is not located on a federal facility. Weather stations may be located on federal lands managed by the U.S. Forest Service or other federal agencies.

Technical project description

The project applicant is the Henry's Fork Foundation (HFF), a 501(c)3 non-profit fisheries and watershed conservation organization based in Ashton, Idaho. We are a Category B applicant as defined in this NOFO. Our Category A partner is Fremont-Madison Irrigation District (FMID), which serves 1,900 spaceholders and agricultural water users in the Henry's Fork of the Snake River watershed. FMID is the sole entity that holds storage water rights in Grassy Lake and Island Park Reservoir, the two Reclamation storage reservoirs in the Henry's Fork watershed. The project will inform management of these two Reclamation facilities. In addition, the project will provide data and information that will inform management of other Reclamation facilities in the upper Snake River basin (USRB), with direct relation to FMID's operations, given the single, basin-wide system of water rights that governs administrative water availability in the basin.

Project goals

The economically important and ecologically significant trout fisheries of the Snake River watershed upstream of Menan, ID (SRWM)—including those in the Henry's Fork, South Fork, and Snake River in Wyoming—exist within a hydrologic system that is highly regulated, primarily for irrigation storage and delivery, and secondarily for hydroelectric power generation and flood control (Figure 1). Operation of Island Park Dam on the Henry's Fork and Palisades Dam on the South Fork affect downstream fish populations directly through flow-dependent recruitment and indirectly through degradation of water quality and alteration of geomorphic processes in the stream channel and floodplain downstream. Similar effects downstream of Jackson Lake have been documented and are currently under investigation.

On the Henry's Fork, hydrologic modeling, water-supply forecasting and data provisioning—funded in part by a previous WaterSMART Applied Science grant to HFF—have saved an average of 26,000 ac-ft of water (19% of reservoir capacity) annually in Island Park Reservoir. These savings have demonstrably increased trout populations and improved water quality, while providing increased water-supply reliability and improved operational precision for water users. In part because of the scientific and technical expertise housed at HFF, stakeholders with an interest in fisheries conservation elsewhere in the SRWM have approached HFF to expand its modeling and data capabilities to the whole SRWM. Thus, the goals of this project are:

1. Provide continuously updated daily-scale and real-time hydrologic data to support science and management throughout the SRWM;
2. Develop subwatershed-scale seasonal predictive models of (unregulated) water supply and reservoir operations in this watershed; and
3. Support development of the next generation of physically based short-term snowmelt runoff models to improve reservoir operations during the spring and early summer.

To achieve these goals, we propose to: 1) expand existing models and supporting data to predict water supply, irrigation demand, and water right priorities from its current geographic scope of the Henry's Fork watershed to the whole SRWM, 2) install six new weather stations that collect wind speed, humidity, soil moisture, precipitation, snow depth, air temperature, and incoming and outgoing radiation data that are not currently available for high elevations, and 3) use these datasets to create short-term streamflow forecasts that integrate physically-based snowmelt processes using the iSnobal energy balance snow model (timeline appears in Table 1). The data generated through this project will be made publicly available in near real-time.

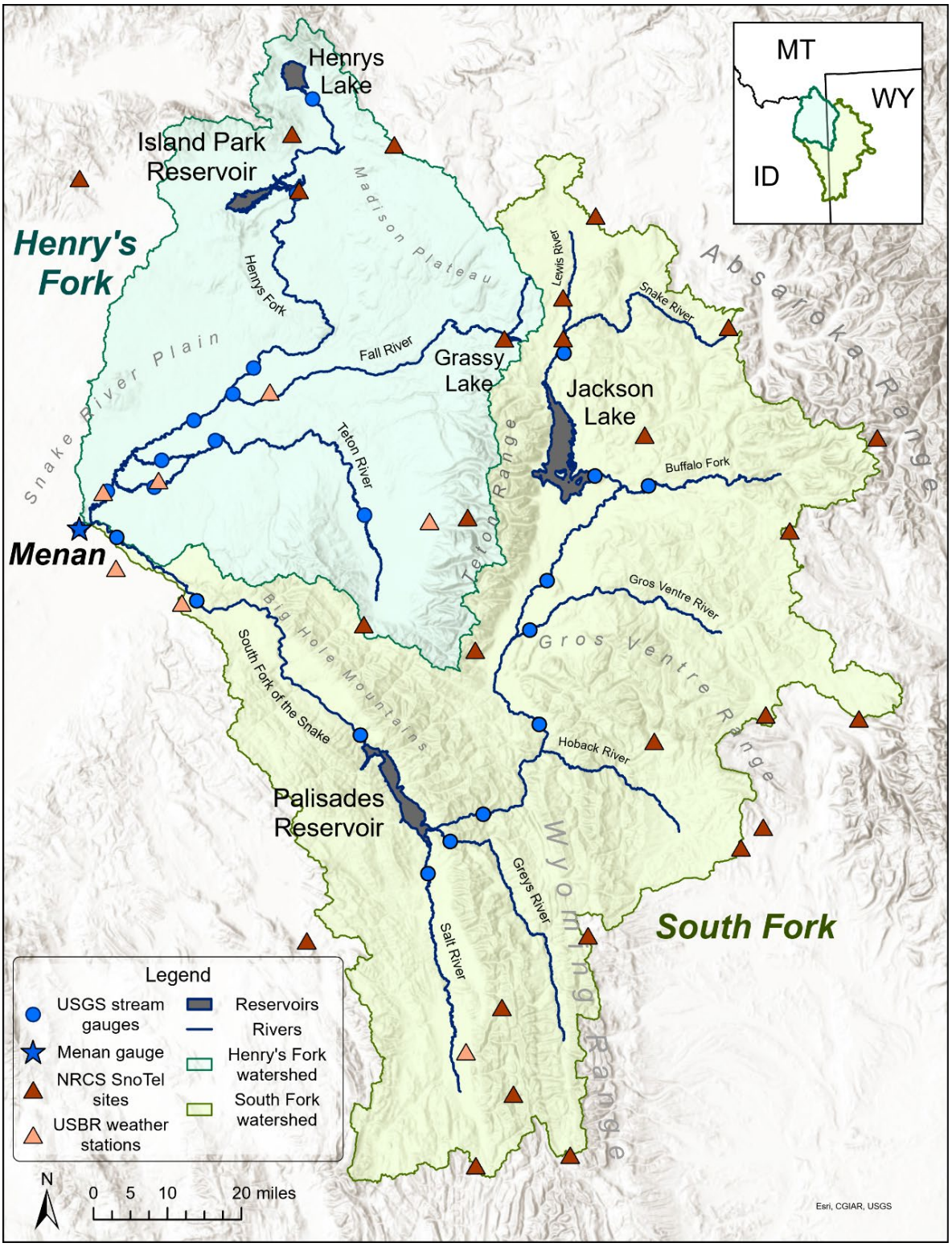


Figure 1. Map of the study area, referred to as the Snake River Watershed upstream of Menan (SRWM). Existing weather stations are located at the red and pink triangles and stream gaging infrastructure at the blue circles.

Water-supply and irrigation models

Water supply.
We propose to expand the current water-supply models and data we developed for the Henry's Fork with a previous WaterSMART grant, to the SRWM. The first step is to compile and format existing climate, regulated streamflow, and reservoir storage data from all long-term weather, stream gaging, reservoir level, and irrigation diversion stations in the study area. These data will then be used to estimate natural (unregulated) streamflow and related parameters. Information-theoretic regression modeling will then be used to develop seasonal predictive models of natural streamflow at the subwatershed and watersheds scales. All data compilation and provisioning will occur daily via automated code running in a cloud server, with automated upload to a public website, so that the most up-to-date data are available to scientists and managers on a daily basis.

Water rights priority.
Springtime reservoir operations, as well as irrigation demand, depend on water-rights priorities across the upper Snake River basin. We propose to develop a predictive model of water-rights priority based on publicly available data from the Idaho Department of Water Resources and Water District 1. This model will calculate water-rights priority from projected natural flow.

Irrigation demand.
Because headwater reservoir operations, which have the greatest effect on proximal fisheries, are determined in large part by irrigation demand, we propose to use regression modeling to predict surface-water irrigation demand for the SRH ahead of the irrigation season. This modeling will include time-series analysis of trends in surface-water irrigation, which previous research has shown decreased substantially throughout the 1980s-1990s due to increased irrigation efficiency.

Weather stations

Station description and parameters.
Existing seasonal streamflow predictions made by HFF utilize NRCS SnoTel precipitation and snow water equivalent (SWE) data, as well as evapotranspiration data collected at Reclamation AgriMet stations from around the watershed. To develop the short-term water supply forecasts needed to inform reservoir operations during spring runoff, this project will enhance existing data infrastructure to collect new data needed to model snowmelt rate and timing. We will do this by installing six new weather stations distributed throughout study area. Each station will collect incoming and outgoing longwave and shortwave radiation, wind speed and direction, relative humidity, air temperature, barometric pressure, soil moisture, precipitation, and snow depth. Collectively, these datasets are crucial for calculating the energy balance of the snowpack and ultimately modeling the melt dynamics needed in the next generation of water supply forecasting. So that the data will be available and integrated into streamflow forecasts in near-real time, each station will record the sensors data on a Campbell Scientific CR-series data logger with built-in Verizon 4G modem to transmit the data. If the site is in an area where cell service is inadequate, we will use an Iridium satellite connection. The instruments will be powered with a 12-V DC supply and housed in an accompanying instrument box. The cell or satellite signal from each of these stations, as well as that from existing equipment at Henry's Fork locations, will be received by Campbell's proprietary LoggerNet software, running on a Linux OS cloud-based server that HFF developed with the previous WaterSMART grant.

Station location.
In the first months of the project, we will engage with stakeholders to select weather station locations that will maximize utility of the data. To improve spatial representation and reduce model bias, we will install several weather stations at aspects, elevations, and land cover types that are underrepresented by current SnoTel sites. However, project partners and HFF have many other ongoing projects that would benefit from these new datasets. For example, water quality in Island Park Reservoir is linked to reservoir dynamics driven in part by wind-driven currents. In this instance, installing a weather station near Island Park Reservoir or working with NRCS to add additional sensors to the existing Island Park SnoTel site would support multiple objectives.

Station installation.
After identifying site locations, we will work with the appropriate landowners and federal agencies to conduct the permitting and environmental compliance required for each station. All permitting and compliance will be completed before any installation occurs.

Short-term streamflow forecasts

Initial development and proof of concept.
To prove the utility of short-term water supply forecasts that have been calibrated specifically to the Henry's Fork and South Fork watersheds, we will first apply the SNOW17 temperature index snowmelt model and Sacramento Soil Moisture Accounting runoff model that are used operationally by the National Weather Service. Since SNOW17 requires only air temperature and precipitation data, we will calibrate this model with the 30 years of available SnoTel and USGS streamflow data. Given the distinct streamflow generation processes found in the Henry's Fork and the South Fork, it is likely that a different flow routing model is more appropriate. Through this initial model development period, we will refine our flow routing model selection through calibration and conversations with collaborating scientists. Once calibrated, we will produce weekly water supply forecasts using NOAA's High-Resolution Rapid Refresh (HRRR) and the National Weather Service's publicly available 6–10-day climate outlooks.

Though temperature-index snowmelt models are becoming less accurate as climate change alters snow accumulation and ablation dynamics, applying the SNOW17 as an initial snowmelt model will provide the groundwork and framework to integrate short-term forecasts into HFF's existing models. We will also elicit water manager and stakeholder feedback on how best to disseminate short-term water supply forecasts during this initial development period.

iSnobal model calibration process.
Reclamation's *Emerging Technologies in Snow Monitoring 2021 Report to Congress* identified the snow energy balance model, iSnobal, as a promising modern snow model that is only operational in a handful of river basins. As a snow energy balance model, iSnobal uses the radiation, humidity, temperature, soil temperature, and wind data collected at each weather station to model spatially distributed snowmelt dynamics and SWE. Applying iSnobal in the SRH will be one of the largest-scale applications of this model to date and is possible only through collaboration with university research partners, FMID, and other stakeholders.

Running iSnobal requires the weather stations to be complete and reporting near real-time data. Following weather station installation in year one, we will use the weather station data to run and

calibrate iSnobal during the second year of the project. We will use the 29 SnoTel stations across the study area to validate and assess model bias. Fully integrating iSnobal will require a long enough data record to calibrate and validate the model. This calibration will require at least one year of data prior to full implementation. Once calibrated, the iSnobal snowmelt inputs will replace that of the SNOW17 model and integrate with the same flow routing and short-term forecasts that will be refined in year 1 of the project as discussed above. The goal is to develop and calibrate the model for use at the end of the second year, September 2026. Even without full integration of iSnobal with the flow routing and forecasting models, during year two, we will provide weekly maps that show where and how much SWE is in the watershed and how likely the snow is to melt.

Data provisioning and information dissemination

Data website.
All data produced by this project will be incorporated into the existing data website structure developed and maintained by HFF. Raw data are automatically retrieved from agency and HFF stations at least daily and processed with R code running on a cloud server. Processed data are uploaded to R Shiny web applications, where they can be visualized and downloaded by users.

Information dissemination.
In the first months of the grant, the applicant will facilitate stakeholder meetings with a variety of water managers and users, state and federal agencies, university researchers, and nongovernmental organizations (NGOs) to select site locations and to determine how the weather station data should be made available so that it is accessible and usable. As water supply and irrigation models are developed, we will elicit feedback from potential users on the functionality of each tool and delivery modes for water-supply data and predictions beyond those that currently exist for the Henry's Fork. As short-term forecasting models are developed and become ready for use, we will present a forecasting model overview and workshop at meetings of the Henry's Fork Watershed Council (HFWC) and a similar watershed group currently being organized in the Wyoming portion of the SRWM. These meetings will provide a brief technical background on the model and generate feedback on the best way to share the forecasts.

Throughout the project, the HFF communications teams will share updates on river conditions and project development with stakeholders on the Henry's Fork and South Fork through social media, email, and blog posts. The communications team will also facilitate monthly HFWC meetings and develop communications strategies to advertise new data products.

Project location

All proposed work will occur in the drainage basin of the Snake River upstream of the confluence of the Henry's Fork and South Fork (Figure 1). We use the term "South Fork" as colloquially used in Idaho to refer to the stretch of the Snake River between Palisades Reservoir and the Henry's Fork confluence. Under this definition, the South Fork watershed encompasses the Snake River upstream of Heise and tributaries such as the Salt, Greys, Hoback, and Gros Ventre Rivers (Figure 1). Here, we refer to the study area encompassing both the Henry's Fork and the South Fork as the Snake River Watershed above Menan, ID (SRWM). The SRWM is a subbasin of the larger upper Snake River basin (USRB), defined by Idaho Department of Water Resources as the drainage area above King Hill, ID. Despite making up only 25% of the

geographic area of the USRB, the SRWM has an annual yield of 7.6 million ac-ft, which is 69% of the annual USRB water supply—46% from the South Fork and 23% from the Henry's Fork. This disproportionate contribution comes from the water stored in high-elevation, mountain snowpack throughout the SRWM. When this snow melts, it provides the natural streamflow that fills reservoirs, provides irrigation water, and recharges groundwater. Since water management objectives and water rights administration are implemented at the scale of the USRB, all scientific products resulting from the proposed project apply directly to the whole basin.

The most economically important and popular recreational trout fisheries are located on the Henry's Fork and its tributaries and lakes upstream of and including the Teton River, the South Fork downstream of Palisades Reservoir, and the Wyoming portion of the Snake River. A study published in 2006 estimated annual angling effort on these water bodies at nearly 500,000 angler-days and annual fishing-related income in the region at $85 million. A more recent study reported similar angling effort on the Henry's Fork but greatly increased effort on the Teton River, which likely implies similar increases on the Wyoming portions of the Snake River, geographically adjacent to the Teton River. Important populations of native Yellowstone Cutthroat Trout are found in the Teton River and its tributaries as well as the South Fork of the Snake and the entire watershed upstream of Palisades Reservoir in Wyoming. Ecologically valuable aquatic, wetland, floodplain, and riparian habitats are found throughout the SRWM, particularly along the Snake River near Jackson, WY, the South Fork, and lower Henry's Fork.

In the median irrigation year, natural streamflow is insufficient to fill all surface-water rights in the USRB from early July through mid-September. During this period, storage water is required to meet crop needs. Storage need is met by five storage reservoirs in the study area and three others downstream. Reservoirs in the study area are one private reservoir—Henry's Lake (90,000 ac-ft)—and four Reclamation facilities: Grassy Lake (15,180 ac-ft), Island Park Reservoir (135,205 ac-ft), Jackson Lake (847,000 ac-ft) and Palisades Reservoir (1.2 million ac-ft).

Since Henry's Lake, Island Park, Grassy Lake, and Palisades store rights junior to those in American Falls Reservoir—the largest in the USRB—water rights accounting and management of physical water require basin-wide coordination. Island Park Reservoir shoulders the majority of the burden for storage and delivery in the Henry's Fork and is drafted to around 45% of capacity in an average irrigation season. On the South Fork, Palisades alone makes up 30% of the total USRB reservoir capacity, stores water for a basin-wide water rental program, and is critical in connecting Jackson Lake and the Wyoming portion of the Snake River and to the irrigated regions downstream in Idaho. Given the important role of each of these reservoirs for water management and downstream fisheries, the focus of this project is to provide FMID and other water managers with the data and models needed to support precise operation of Island Park and Palisades reservoirs. All data used in the project will be compiled from existing federal stations in the study area (Figure 1) and from the six new stations proposed. These data will also serve to inform water management improvements basin-wide, beyond the scope of this project.

Project management and administration, office space, housing for temporary researchers, and computing hardware and software will be housed at the HFF office in Ashton, ID.

Data management practices

All data management for this project practices will conform to current data-management practices in HFF's Science and Technology Department. These practices aim to minimize the likelihood of data loss, minimize required electronic memory, facilitate efficient transfer of data among internal and external users, maximize use of open-source software and platforms, document data sources and computational protocols, and maximize use of commonly used file types. All data will be stored electronically on the Dropbox™ cloud structure HFF has already developed. This structure is backed up automatically on a second cloud and locally on a physical drive. All spatial data will be developed in ArcGIS or Google Earth Engine and will be stored in standard GIS formats. We will use open-source platforms and programming languages to the greatest extent possible and store all code as text files. All code and modeling processes will be thoroughly documented. The coupled snowmelt forecast model code, workflow, and versioning will be published on a public software repository such as GitHub. All numerical data will be stored as comma-delimited text files. Appropriate acknowledgment of original sources will appear in metadata accompanying data collected from external sources. Data made available for user download from the web site will be formatted as either comma-delimited or plain text. Static graphical products will be available as either pdf or png files. The expanded data web site will serve as the primary mode of product delivery.

Evaluation criteria

Evaluation Criterion A—Water Management Challenges

*1. Describe the water management challenge(s). Describe in detail the **water management challenge** is occurring within your project area. Describe the severity of the challenge to be addressed with supporting details.*

The 9,100 square-mile SRWM in eastern Idaho and western Wyoming (Figure 1) is a major source of water for irrigated agriculture both locally and regionally. At the same time, the SRWM supports world-renowned trout fisheries in and adjacent to Yellowstone and Grand Teton national parks, some of the largest populations of Yellowstone Cutthroat Trout remaining in their native range, and ecologically important aquatic, wetland, and riparian habitats. The challenge of meeting irrigation needs while maintaining world-class fisheries and aquatic habitat has created substantial conflict among stakeholders in the study area for decades and remains as a critical management issue today. Due to a variety of well understood chemical, physical, biological, and sociological factors, trout populations and recreational fishing experience on reservoirs and in the river reaches immediately upstream and downstream benefit from keeping the SRWM reservoirs as full as possible throughout the year. For example, fine-scale data show that during years when Island Park Reservoir is drafted heavily to meet irrigation demand downstream, low reservoir levels reduce survival of trout in the migratory reservoir-upper river fishery, high irrigation-season outflow increases turbidity and suspended-sediment concentrations in the river downstream, and low outflows during subsequent winter refill reduce survival of juvenile trout downstream. These same types of effects have been documented for Palisades Reservoir.

The 2015 Henrys Fork Basin Study and new analyses have projected additional future water-supply needs at around 340,000 ac-ft per year. This is 13% of the Henry's Fork mean annual yield of 2.54 million ac-ft and 40% more than the 240,385 ac-ft combined capacity of the basin's

three storage reservoirs. The Basin Study also found that meeting these needs will become more challenging in expected future climatic conditions, which will be characterized by increased variability in water supply, earlier snowmelt, and decreased summertime streamflow. While there is no Basin Study for the South Fork, the 2021 Greater Yellowstone Climate Assessment predicts similar regional climate trends for the entirety of the SRWM. The climate assessment concludes that the SRWM is projected to receive more precipitation but less snow and earlier snowmelt. This shift in precipitation is expected to result in earlier peak streamflow and lower late summer streamflow, placing natural-flow water supply further out of alignment with irrigation demand and increasing reliance on stored water. This increased reliance will likely magnify negative effects on fisheries, as documented already for Island Park Reservoir.

*2. Describe the **concerns or outcomes** if this water management challenge is not addressed?*

Without accurate seasonal and short-term predictions of water supply, fisheries and water quality will continue to degrade, as the USRB becomes more reliant on storage water. Decades of research by state and federal agencies, universities, and NGOs has shown that operation of Island Park and Palisades dams affects downstream fish populations directly through flow-dependent recruitment declines and indirectly through degradation of water quality and alteration of geomorphic processes in the stream channel and floodplain downstream. Similar effects downstream of Jackson Lake have been documented and are currently under investigation. Negative effects of reservoir operations on ecological processes downstream are due primarily to alteration of natural hydrologic regimes and to large drawdown of reservoirs. These effects are magnified in years of low water supply, which have occurred much more frequently over the past two decades than in the previous four, degrading the quality of the world-renowned fisheries of the SRWM over the past few decades and potentially in the future.

*3. Explain **how** your project will address the water management issues identified in your response to the preceding bullets and provide support for your response.*

a. **Water supply reliability**. During any given irrigation season, objectives for minimizing draft of Island Park and Palisades Reservoirs are in direct conflict with objectives for maximizing summertime streamflow downstream of irrigation diversions. Recently, collaborative stakeholder groups such as the Henry's Fork Drought Management Planning Committee have recognized the value of precise system operation as a viable way to increase water-supply reliability without construction of economically and environmental costly storage reservoirs. On the Henry's Fork, existing seasonal-scale models are used to set optimal lower-watershed targets at the beginning of an irrigation season, given water-supply data available at that time. Since implementing more precise seasonal water supply forecasting and collaborative management on the Henry's Fork in 2018, Island Park Reservoir carryover has averaged over 26,000 ac-ft more than expected given water supply and demand. This represents a 50% increase in carryover and has resulted in winter flows that are 117 cfs higher than expected, improving trout recruitment by around 20%. The short-term forecasts proposed by this project will improve management precision even more to meet water-rights and other legal and physical requirements with the minimum amount of reservoir draft and hydrologic alteration. Not only will increasing reservoir carryover benefit aquatic ecosystems as discussed above, but higher carryover also provides more basin-wide management options by increasing the likelihood of full storage allocation the following year

and storing water as high in the system as possible. By expanding to the South Fork, this project will provide the data and forecasts needed to assess watershed targets further down the Snake River. At longer time scales, our models will be used to set objectives for long-term projects such as irrigation demand reduction and managed aquifer recharge, which are designed to reduce demand on the reservoir system.

b. **Management of water deliveries**. As mentioned above, one of the key strategies to increase reliability of water supply is to increase reservoir carryover, which in turn, is accomplished through precise management. The seasonal and short-term models will contribute to increased precision of water deliveries, as described above. More precise deliveries can also reduce costs to canal companies of using storage water that is delivered but not needed during the lag time between reduction in on-farm application and reservoir adjustments.
c. **Water marketing activities**. The project does not directly address water marketing but supports it directly through better data availability and water-supply predictions. The long-term models will help develop quantitative goals needed to attain the 350,000 ac-ft need outlined in the Henrys Fork Basin Study. This project will also provide data that can be used to support development of a Basin Study for the rest of the SRWM.
d. **Drought management activities**. HFF, FMID, and Reclamation are members of the Henry's Fork Drought Management Planning Committee, which was created by a Congressional Act that transferred ownership of the Crosscut Canal from Reclamation to FMID. The Drought Management Plan was completed in 2005 and signed by FMID, North Fork Reservoir Company, Reclamation, HFF, Trout Unlimited, and The Nature Conservancy. These six entities form the core of the Committee and utilize our data or models four times each year to set general operational strategies for managing the reservoir to benefit fisheries as much as possible under the legal system that governs storage and delivery of irrigation water. Other Committee participants include Idaho Department of Fish and Game, Idaho Department of Water Resources, and Fall River Rural Electric Cooperative. It is hoped that data from this project can inform additional drought management activities across the SRWM.
e. **Conjunctive use of ground and surface water**. A primary strategy for stabilizing groundwater levels across the USRB is through managed aquifer recharge. Managed aquifer recharge can occur only when supply exceeds demand. Through the development of weekly water supply forecasts, this project will provide the insight needed to foresee when reservoirs may need to be drafted for flood control days earlier, which will allow for the proactive planning and water rights accounting needed to use the extra water for recharge.
f. **Water rights administration**. This project will not directly address water rights administration, although the seasonal predictive models can be used to predict dates on which given water rights will fall out of priority during the irrigation season, allowing irrigation managers and producers to plan cropping decisions and anticipate need for storage water. By extending model development to include the South Fork, seasonal predictions will occur at a scale more closely aligned with USRB water rights administration and accounting.
g. **Ability to meet endangered species requirements**. The project does not directly address ESA issues, but if the strategies supported by our models keep Yellowstone Cutthroat Trout populations viable in the SRWM, that species is less likely to be listed under ESA. Additionally, 200,000 ac-ft of rental water from Palisades Reservoir is delivered out of the USRB each year to benefit ESA-listed salmon in the lower Snake River, generally to the detriment of within-basin fisheries and water users. Improved predictive models could reduce the impact of this delivery on the USRB, while continuing its benefit to salmon downstream.

h. **Watershed health**. The project will contribute to watershed health by providing real-time streamflow and weather data in numerous ecologically important stream reaches. As already discussed, saving 26,000 ac-ft of water in Island Park Reservoir has resulted in 117 cfs more of winter flow and an 18% increase in trout populations downstream. Not only do fish downstream benefit from reducing reservoir draft, but populations in and above the reservoir also benefit. Kokanee Salmon migrated upstream out of Island Park Reservoir into the upper Henry's Fork in the fall of 2019 in good numbers for the first time in over 20 years. Because fish in the spawning run are three years old, the sudden appearance of Kokanee in the upper Henry's Fork after a 20-year absence is likely due to three consecutive years of higher-than-expected reservoir carryover, showing that ecological response to consistent, modest increases in reservoir carryover can be swift and substantial.

i. **Restore natural features or use a nature-based feature to reduce water supply and demand imbalances, the risk of drought or flood, or to increase water supply reliability for ecological values.** By providing the information needed to manage SRWM reservoirs more efficiently, this project may provide the means to restore natural instream processes such as high spring flows. High spring flows are not a priority for water and reservoir managers; however, due to higher-than-expected Island Park Reservoir carryover in water year 2022 and accurate seasonal predictive models, HFF was able to work with FMID and other stakeholders in 2023 to deliver a spring freshet from the Island Park Dam. Running a freshet realigns the managed and natural hydrologic systems to improve water quality and aquatic insect habitat by mobilizing fine sediment. The 2023 freshet provides an example of how increased reservoir carryover, accurate predictive models, and early collaborative planning can benefit aquatic ecosystems and hydrologic function. Similar improvements are possible downstream of Jackson Lake and Palisades Reservoir in the future.

j. **Conservation and efficiency**. The project will contribute to water conservation and operational efficiency by providing seasonal and real-time data to support precision operation of the reservoir and irrigation system in the SRWM.

k. **Other improvements to water supply reliability**. Through this project, the applicant will pave the way to operationalize the next generation of process-based streamflow forecasting. This will be done through new data infrastructure and model development. Agencies, universities, and NGOs across the west have identified the utility of such models as traditional temperature-based models become less accurate with warmer springs and winters. The collaborations proposed here provide the means to develop the framework needed to integrate a next generation snowmelt model into water management decisions.

Evaluation Criterion B—Project Benefits

*1. Describe how the **need for the project** was identified. Was the proposed project identified using a collaborative process with input from multiple and diverse stakeholders?*

Yes, the need for this project was identified through decades of collaborative stakeholder engagement through the Henry's Fork Watershed Council as well as more recent conversations with stakeholders on the South Fork and in Wyoming. The need for accurate seasonal and streamflow forecasts has been identified through discussion of reservoir management strategies by the Henry's Fork Drought Management Committee.

*2. Describe **how** the tool, method, or information will be applied and* **when** *will it be applied.*

The information will be used by water managers, conservation NGOs, and river users to manage water more precisely, develop conservation strategies, and plan fishing and other recreational use, respectively. As outlined in the project implementation section, climate and water supply products will be available for the South Fork during the first year of the project. These will be available for viewing and downloading on HFF's data website and shared via blogs, emails, and social media posts. The first generation of SNOW17 snowmelt-flow routing forecasting model will be calibrated in the winter of 2025 with provisional 10-day forecasts shared with stakeholders that spring. If the permitting goes as planned, the weather stations will be installed in summer 2025 and the data will be made publicly available in near real-time in the winter of 2026. Finally, the iSnobal data processing workflow and calibration will occur in winter 2026. While calibration of the fully-integrated hydrologic model is occurring in spring 2026, we will produce weekly maps showing basin-wide SWE and the likelihood that the snowpack will melt.

a. Will the tool or information be used immediately or will additional work need to be done before the tool will be used?

Most results from the project will inform water management actions immediately upon completion of each project task. The collaboration, stakeholder organizations, and communication mechanisms needed to immediately use new information are already in place in the watershed. Scientific information and tools produced previously by HFF are already used on a daily basis to inform water management, and we expect information and tools produced by this project to be used immediately upon completion. The only exception to this is the iSnobal-based short-term water supply forecast. This is a model that is just starting to be operationally used and requires significant set-up and calibration. As this project is also building the data infrastructure needed to support this model, we will not begin iSnobal development until year two, and will likely need another winter of data to be fully calibrated. Since this model is an important step towards the next generation of water supply forecasting, during the second year of the project, the Principle Investigator (PI) will automate the data processing workflow and ensure that HFF staff are trained to finish model calibration.

3. Describe, in detail, the extent of benefits that can be expected to occur upon implementation of the project, and provide support for your responses.

*a. Who will use the tool or data developed under this proposal and **how** will they benefit from the project? Support could include but is not limited to letters from stakeholders expressing support for the project and explaining how they will benefit.*

Current users of similar data products provided by HFF include Reclamation, FMID, guides and outfitters on the Henry's Fork, Friends of the Teton River and other NGOs working in the Henry's Fork watershed, Idaho Department of Fish and Game, and hydroelectric power operators. These same users, plus new stakeholders specific to the South Fork and the Wyoming portion of the SRWM, University of Wyoming researchers, Idaho Power Company, and the Idaho Water Resource Board will use and benefit from data provided by this project. Fisheries conservation interests, guides and outfitters will benefit via better fish populations and water quality, scientists will benefit from greater data availability, and others will benefit from more reliable water supply. Letters of support are attached to the proposal.

*b. How will the project improve **water management decisions**?*

HFF has already developed seasonal predictive models that have helped save 26,000 ac-ft of reservoir carryover in the Henry's Fork, and this project will apply the same types of models and analysis to support reservoir operations at Palisades and Jackson Lake. This project will also develop new, short-term models that will provide 10-day streamflow forecasts to FMID and other water managers so that they can manage reservoir operations during runoff.

*c. Describe if the results of your project will be **applicable elsewhere**. What additional work would need to be done to make the project results transferable to others?*

The methodology, and model types will be readily transferrable to other users and locations, although the specific models and outputs generated by this project will be applicable only in the study area. Since the iSnobal model is an emerging technology, this project will be a step in getting it used operationally more widely. We will make our workflow reproducible by publishing an analysis of the model's accuracy.

d. To what extent will the project address the water management challenges described in E.1.1.?

As the SRWM becomes more reliant on stored water, increasing reservoir carryover can increase the reliability of water supply and benefit aquatic ecosystems. Carryover is determined by irrigation-season reservoir operations. The seasonal and short-term models developed through this project will contribute to increased precision of reservoir draft and water deliveries.

4. Explain how your project complements other similar efforts in the area where the project is located.

The proposed project fits seamlessly into ongoing applied science and monitoring activities of the applicant and its partners. These projects include water-quality monitoring watershed-wide, recreational use and economic value studies, and investigations of aquatic ecology and productivity. The project builds directly from the work funded by the previous WaterSMART Applied Science grant, which funded development of the data website and developed the natural supply, water rights priority, and irrigation demand models for the Henry's Fork watershed.

This project also complements four projects recently funded by Reclamation WaterSMART grants. The first of these is the Teton Water Users Association, which was supported by WaterSMART Cooperative Planning Phase 1 and 2 grants. Those grants resulted in the development of the aquifer recharge goals for the Teton Valley aquifer. FMID and Egin Bench Canals recently received WaterSMART Small Infrastructure grants for the installation of remote-controlled headgates at key locations in the watershed. HFF was also recently awarded a WaterSMART Water and Energy Efficiency Grant to line Conant Creek Canal to reduce seepage and install a remote headgate, both of which are expected to reduce the amount of storage water delivered from Island Park Reservoir. Additionally, Idaho Power conducts a cloud-seeding program in the study area, in cooperation with the Idaho Water Resource Board. The weather stations will benefit not only operation of the program but also assessment of its effectiveness. This project will also complement a larger effort to install these types of weather stations across the whole state of Idaho and will complement a statewide project housed at the University of Wyoming to develop climate adaptation strategies throughout the state of Wyoming.

Evaluation Criterion C—Project Implementation

Describe your project implementation plan:

1. *Briefly describe and provide support for the approach and methodology that will be used to meet the objectives of the project.*

Water supply and irrigation models

These models will be developed with the same methodology previously used for the Henry's Fork. Calculation of natural flow as regulated flow plus the sum of upstream change in reservoir storage, reservoir evaporation, and diversion, is conceptually consistent with that already used by Water District 1 for water-rights accounting, although technical aspects such as moving average windows will differ slightly to increase applicability to science and management, versus water-rights administration. All predictive models will use linear regression, with appropriate data transformations and time-series filters as needed, following standard statistical methodology. Model selection will be done with Akaike's Information Criterion, a widely accepted method that favors parsimony and avoids bias associated with over-fitting. The project team has published numerous scientific papers using these methods. The water-rights priority model will be similar to one developed by members of the project team in work completed for the Idaho Water Resources Board in 2016 to estimate availability of water for managed aquifer recharge.

Weather stations

Current weather stations in high-elevation areas of the watershed record only temperature, SWE, and precipitation; some also record soil moisture. None of the agency stations record humidity, wind speed and direction, and net radiation, which are needed for energy-based modeling of snowmelt and resultant streamflow response. Each station will have a net radiometer, which has been identified by Reclamation as one of the ten technologies most likely to improve water supply forecasting.

Short-term streamflow forecasts

Our selection of energy-based snowmelt models is motivated by shortcomings of existing models based on temperature alone. The model proposed here, iSnobal, was also identified by Reclamation as a promising, publicly-available modern snow model. This model is also flexible enough to integrate remote sensing and airborne snow validation measurements as those technologies become more readily available.

Data provisioning and information dissemination

All raw data and derived outputs will be retrieved, processed, stored and backed up in a cloud environment that we developed with the previous Applied Science grant. Cloud computing and storage eliminates vulnerabilities associated with reliance on hardware located in a single building. All data and products will be made available to the public on a website that is also hosted in the cloud and built and automatically updated using R Shiny, which is now a widely used open-source environment for creating and maintaining web-based scientific applications. Based on previous experience, our communications team will disseminate project-related information frequently in small pieces, using multiple media, in order to increase stakeholder understanding, engagement, and participation. We will continue the proven success of using the Henry's Fork Watershed Council to facilitate formal stakeholder input, and our Wyoming partners will expand this successful approach via the Snake River Headwaters Watershed Group.

2. *Describe the work plan for implementing the proposed scope of work.*

The Project Manager will oversee all work performed on the project by staff, contractors, and project partners and will convene regular meetings of the project team so that all members have a common vision for the project and are kept up to date on progress by others. The Project Manager will solicit and encourage input from all team members and facilitate collaborative work, rather than micro-managing the team and its work. Tasks (Table 1) are scheduled logically; for example, models of water supply will be completed before those related to water-rights priority, because priority depends on supply. Stakeholder input on weather station location and data provisioning will occur in the first year of the project, to inform year 2 tasks.

3. *Provide a summary description of the* products *that are anticipated to result from the project.*

The primary products are three water-supply and irrigation hydrologic models, permits and approvals to install weather stations, weather stations installed in the field, short-range snowmelt models, and data live on the web (Table 2). Additional products include outreach and training materials such as blog posts, newsletter articles, technical manuals, and presentations. Semi-annual performance and final reports will be submitted as required.

4. *Who will be involved in the project as project partners? What will each partner or stakeholder's role in the project be? How will project partners and stakeholder be engaged in the project and at what stages? If you are a Category B applicant, be sure to explain how your Category A partners will be engaged in the project.*

Our Category A partner, Fremont-Madison Irrigation District (FMID), is a co-facilitator of the Henry's Fork Watershed Council, which will serve as the primary venue for sharing information about the project and engaging stakeholders. FMID's primarily role will be to facilitate meetings of the Watershed Council. FMID will also participate in discussions about weather station location and data provisioning. Other partners are Boise State University (BSU), University of Wyoming, Idaho Power Company, The Idaho Water Resource Board, Friends of the Teton River, LegacyWorks Group, and Trout Unlimited, with general roles identified in Table 1. The PI will be a postdoctoral researcher at BSU, and her faculty supervisor will contribute guidance and technical expertise on all aspects of data collection, data provisioning, and modeling. Idaho Power, the Idaho Water Resource Board, University of Wyoming, and the NGOs will participate in the project primarily during the first year, in discussions about weather station location and data provisioning. The goal of these discussions will be to design the project so that data and models will serve the needs of researchers and water managers across the Snake River basin. Legacy Works and Trout Unlimited staff involved in the project are based in Wyoming and will facilitate participation and engagement of researchers and managers there.

5. *Identify staff with appropriate credentials and experience and describe their qualifications.*

Rob Van Kirk: HFF Science and Technology Director; Project Manager.

Rob is trained as a mathematical modeler and holds a B.A. in Mathematics, M.S. in Environmental Systems and Ph.D. in Mathematics. He has worked in collaborative water resource research and management in the Snake River basin since 1994, both as a staff member of HFF and as a professor at Idaho State and Humboldt State universities. He has received over $1.7 million in competitive grants, published 40 peer-reviewed scientific papers and book

chapters, and completed over 20 projects as a consultant for a variety of agencies and organizations, including U.S. Fish and Wildlife Service, Idaho Water Resource Board, and The Nature Conservancy. Most of his professional work has focused on the intersection of hydrology, water management, and fisheries, including modeling of groundwater-surface water interactions.

Sarah Newcomb: Boise State University Post-Doctoral Researcher; Principle Investigator. Sarah holds a B.A. in Environmental Geology and Evolutionary Biology and by the project start date will hold a Ph.D. in Geosciences. Her dissertation work at Idaho State University investigates how interactions between climate and vegetation affect mountain streams in the upper Snake River basin through direct observation and modeling approaches. Through professional and research experience, she has installed and maintained remote field sites and weather stations and worked with a diverse range of sensors, datasets, and statistical models. In 2023, she worked with HFF as a Doctoral Research Associate to use remote sensing data to quantify the impacts of changing vegetation and snow dynamics on water supply in the Henry's Fork watershed. Through the postdoctoral appointment at Boise State, she will collaborate with researchers specialized in regional climate forecasting and process-based models.

Table 1. Timeline of project tasks and costs. Shading indicates task performance.

TASKS	FY 2025		FY 2026		Completion	Cost
	Oct-Mar	Apr-Sep	Oct-Mar	Apr-Sep		
Water supply and irrigation models						
Water supply	■	■			Sep. 2025	$ 24,062
Water-rights priority			■		Mar. 2026	$ 12,031
Irrigation demand				■	Sep. 2026	$ 12,031
Weather stations						
Order stations	■				Dec. 2024	$178,162
Determine locations	■				Dec. 2024	$ 22,162
Permitting/compliance	■	■			Sep. 2025	$ 45,333
Installation		■	■		Oct. 2025	$ 66,488
Short-term streamflow forecasts						
Proof of concept		■	■		Mar. 2026	$ 40,333
iSnobal initial calibration				■	Aug. 2026	$ 30,162
Future implementation plan				■	Sep. 2026	$ 22,162
Data provisioning and information dissemination						
Stakeholder input: locations	■				Dec. 2024	$ 10,958
Stakeholder input: data	■	■			Sep. 2025	$ 10,958
Hydrologic data on website			■		Mar. 2026	$ 32,108
Weather station data live				■	Sep. 2026	$ 33,548
End-user outreach/training			■	■	Sep. 2026	$ 54,268
Project administration						
Semi-annual reports	■	■	■	■	As required	$ 3,991
Final report				■	As required	$ 3,991

Table 2. Schedule of task responsibilities and products

Tasks	Primary personnel	Supporting personnel	Products
Water supply and irrigation models			
Water supply	Morrisett	Van Kirk	Hydrologic data, model code
Water-rights priority	Morrisett	Van Kirk	Hydrologic data, model code
Irrigation demand	Morrisett	Van Kirk	Hydrologic data, model code
Weather stations			
Order stations	Newcomb	HFF staff	Station components in hand
Determine locations	Newcomb	Partners, Flores	Proposed installation locations
Permitting/compliance	Newcomb	HFF staff	Certificates of compliance, permits
Installation	Newcomb	Roseberry, intern	Stations installed in the watershed
Short-term streamflow forecasts			
Proof of concept	Newcomb	Flores	Preliminary snowmelt model
iSnobal initial calibration	Newcomb	Flores, intern	Calibrated model
Future implementation plan	Newcomb	Flores	Technical manual
Data provisioning and information dissemination			
Stakeholder input: locations	Newcomb	Partners, Davis	Coordinates of station locations
Stakeholder input: data	Newcomb	Partners, Davis	Data formats
Hydrologic data on website	Muradian	IT staff	Web interface
Weather station data live	Muradian	IT staff	Web interface
End-user outreach/training	Newcomb	Flores, Powell	Training manual
Project administration			
Semi-annual reports	Van Kirk	Team	Reports
Final report	Van Kirk	Team	Report

Christina Morrisett: Climate Adaptation Program Manager
Christina holds a B.S. in Earth Systems from Stanford University, a M.S. in Fisheries and Aquatic Sciences from University of Washington, and a Ph.D. in Watershed Science from Utah State University. She worked in HFF's Science and Technology program as an intern and then research assistant from June 2015 to July 2016, before returning to HFF in 2018 as a Doctoral Research Associate. Her dissertation work investigated how streamflow targets and groundwater-surface water interactions affect reservoir operations and climate resilience in the Henry's Fork watershed. She was a key member of the HFF team that received the previous WaterSMART Applied Science grant. She is currently a water resources consultant for HFF. By the time the proposed project starts, she will be HFF's Climate Adaptation Program Manager, a new position HFF intends to fund in part with a grant from the Murdock Charitable Trust. If that application is not funded by Murdock, HFF has identified other funding to support the position.

Melissa Muradian: Data Website Consultant
Melissa holds a B.S. in Mathematics and a M.S. in Quantitative Ecology and Resource Management. She worked as a Research Associate for HFF from 2015 to 2018, developing and directing HFF's water quality program. During that time, she built a network of 11 automated

water-quality sondes, wrote R code to process 15-minute data from seven sensors in each sonde, and developed a custom data web site that hosts real-time data transmitted from the sonde network. She developed the web site from scratch, writing all of the code herself or with assistance from student interns. Since late 2018, she has worked remotely as HFF's water-quality data consultant, spending much of her time developing a hydrology website and related web applications funded by HFF's previous Applied Science grant.

Amber Roseberry: HFF Conservation Technician
Amber joined HFF as an intern in 2019 and has served as HFF's field and laboratory technician since then. She is responsible for installing, maintaining, and calibrating all of HFF's field instrumentation, including water-quality sondes, stream and groundwater level pressure transducers, and a weather station. She also collects weekly water-quality samples and measures streamflow and groundwater levels in the field. She is familiar with remote data transmission equipment and protocols, power supplies, and control systems.

Jamie Powell: HFF Communications Director
Jamie holds a B.S. in Natural Resources and Environmental Science and a M.S. in Human Dimensions of Ecosystem Science and Management. She has worked at HFF since 2015 and now serves as the Communications and Outreach Director. Jamie helped formalize and further develop HFF's Communications Program, and now manages HFF's communication and outreach efforts. She is co-facilitator of the Henry's Fork Watershed Council.

Alejandro Flores: Professor of Geosciences at Boise State University
Professor Flores holds B.S. and M.S. degrees in Civil and Environmental Engineering from Colorado State University and a Ph.D. in Hydrology from Massachusetts Institute of Technology. He is Director of the Lab for Ecohydrology Applications and Forecasting at Boise State University. A computational ecohydrologist by training, he advances computational tools and techniques to understand integrated land systems where human activity is inextricably coupled to hydrologic, ecologic, and atmospheric processes across a range of scales.

Jasper Davis: HFF Communications Coordinator
Jasper has a B.S.E. degree from Arizona State University in Engineering and an M.S.T. degree from Arizona State University in Environmental Technology Management. She spent several years as a high school Math teacher, as well as 4 years working as a Business Continuity and Disaster Recovery consultant before joining the HFF staff in 2022.

a. *Have the project team members accomplished projects similar in scope to the proposed project in the past either as a lead or team member?*

Yes. The two senior personnel on this project have served as project lead or team member on numerous projects similar in scope or larger than the proposed project. Morriset, Muradian, Roseberry, and Powell have successfully completed numerous projects while at HFF, including one funded by a previous Applied Science grant, and have worked in teams with each other and with the Project Manager.

b. *Is the project team capable of proceeding with tasks within the proposed project immediately upon entering the financial assistance agreement?*

Yes.

Evaluation Criterion D—Dissemination of Results

Explain how project results will be disseminated, including:

1. *Describe how the tools, frameworks, or analyses being developed will be disseminated, communicated, or made available to water resource managers who may be interested in the results.*

The data and models generated and made available on the HFF data website throughout the project will be the primary mode of information dissemination. HFF will summarize results and provide links to web resources via daily, weekly, and quarterly emails and social media posts. New data and modeling products will be presented to the Henry's Fork Watershed Council and the Snake River Headwaters Watershed Group, a similar group in the Wyoming portion of the SRWM. To promote the transferability of the models developed here to other watersheds in the west, the PI will present the model framework at a professional conference.

2. *If the applicant is the primary beneficiary of the project, explain how the project results will be communicated internally, and to interested stakeholders and interested water resource managers in the area, if appropriate.*

All aspects of the project will be communicated at meetings of the Henry's Fork Watershed Council, Henry's Fork Drought Management Planning Committee, and Snake River Headwaters Watershed Group. These meetings are attended regularly by state and federal water managers, local water users and irrigation entities, other government agencies, NGOs, and elected officials or their staffs. HFF and its partners will disseminate information to recreational user groups, including fishing outfitters and guides, via newsletters, social media, and in-person meetings.

a. If the applicant is not the beneficiary of the project describe how project results will be communicated to project partners and interested water resource managers in the area.

NA

b. Explain why the chosen approach is the most effective way to disseminate the information to end users in a usable manner.

The collaborative water management groups in the watershed were formed primarily to address challenging water management issues and have become well established as the primary venue for exchanging information among stakeholders. This project will take advantage of these established groups and their regular meeting schedules.

Criterion E: Presidential and Department of Interior Priorities

1. Climate Change: E.O. 14008 emphasizes the need to prioritize and take robust actions to reduce climate pollution; increase resilience to the impacts of climate change; protect public health; and conserve our lands, waters, oceans, and biodiversity.

a. If applicable, describe how the project addresses climate change and increases resiliency.

With climate change, annual streamflow will become more variable and less reliable across the USRB. As discussed above, through the data and modeling products developed with this project, we will increase water supply reliability by giving water managers the near real-time data and information they need to precisely manage reservoir operations in the SRWM. As evident

through initial model development in the Henry's Fork, precise management reduces reservoir draft and increase reservoir carryover, which supports aquatic ecosystem health and increases resiliency by increasing the probability of a full storage allocation the following year.

In snow-dominated watersheds, snowmelt rates control how snowmelt becomes streamflow. As climate change increases winter and spring temperatures, snowmelt rates and timing will change. This change is not only significant due to a great misalignment of the timing of supply and demand, but long-held statistical relationships between snowmelt and streamflow will become less accurate, necessitating the need for new water supply forecast models that better represent snow accumulation and melt. With this project, we will build the core datasets needed to apply and calibrate a modern, energy-based snow model that will track annual snowpack development and melt. This model will predict streamflow and increase resilience across the SRWM.

b. How will the project build long-term resilience to drought? How many years will the project continue to provide benefits? Please estimate the extent to which the project will build resilience to drought and provide support for your estimate.

As droughts occur more frequently and become more intense, there will be greater reliance on and drawdown of water storage reservoirs across the region. Extensive drawdown will negatively impact fish habitat in the reservoirs and in the river below the reservoirs. With the expansion of water supply and irrigation models, as well as the development of new short-term forecasts, HFF will provide FMID and other water managers with the insights needed to precisely manage reservoir operations based on irrigation demand with a goal of reducing reservoir irrigation season drawdown and increasing carryover and winter flows. This will benefit fish habitat, water quality, and water supply reliability.

The models, model outputs, and weather station data will be integrated into the work of the HFF Science and Technology Program and made publicly available on HFF's data website. This project will develop the infrastructure and automate data delivery so that these products will continue to provide benefits well past the length of the project. The seasonal and short-term forecasts will also be fully automated and will provide water managers with water quantity and climate data for years after the project.

c. Will the proposed project reduce greenhouse gas emissions by sequestering carbon in soils, grasses, trees, and other vegetation? Does the proposed project seek to reduce or mitigate climate pollutions such as air or water pollution? Does the proposed project contribute to climate change resiliency in other ways not described above?

When Island Park Reservoir is heavily drafted, thermal stratification breaks down. When this happens, the occurrence of harmful algal blooms increases, and reservoir outflow is warmer and more turbid, degrading water quality. Suspended sediment export from the reservoir into the river is also greater when reservoir drawdown is higher. Similar processes likely occur in Palisades Reservoir. As such, a key outcome of managing reservoir operations more precisely is to improve water quality in benefit of aquatic ecosystems and downstream water users.

Project Budget

We propose a three-year project budget of $602,750, of which $400,000 (66%) is federal funding requested in this application (Tables 3 and 4). The federal funds will be used to pay for four of the weather stations, the subaward to Boise State University to support the post-doctoral researcher, the data management consultant, a small amount of project staff salary, and indirect costs.

Non-federal match will total $202,750 (34 % of project budget), of which $150,010 will be costs paid by the applicant using nonfederal funds. The applicant's share of match includes salaries, one of the weather stations, supplies, environmental compliance, student internships, web hosting and data transmission fees, office space and housing for the post-doctoral researcher, and a small amount of indirect costs. All of this funding will come from private donations to HFF obtained through HFF's normal fundraising mechanisms and schedules. As indicated in the official resolution, HFF's Board of Directors commits to ensuring that non-federal contributions to HFF will be sufficient over the life of the project to meet the proposed match commitment. HFF's match commitment does not depend on any pending grant or loan requests.

The remaining non-federal match will come from in-kind and cash contributions from project partners. Trout Unlimited will commit $26,000 in cash for one of the weather stations and $3,200 in in-kind contribution to facilitate stakeholder engagement in Wyoming. The other in-kind contributions are from Boise State University ($18,950), LegacyWorks Group ($1,250), Friends of the Teton River ($1,000), Fremont-Madison Irrigation District ($1,200), Idaho Water Resource Board ($500), and Idaho Power ($1,000). The commitment and valuation of these contributions are documented in the attached letters of commitment. All in-kind contributions will consist of technical, scientific, and end-user input to station location, data provisioning, and model interfaces.

Table 3. Total project costs.

SOURCE	AMOUNT	PERCENT OF TOTAL
Non-Federal Entities		
Henry's Fork Foundation (Applicant)	$ 150,010	
Trout Unlimited	$ 29,200	
Boise State University	$ 18,590	
LegacyWorks Group	$ 1,250	
Friends of the Teton River	$ 1,000	
Fremont-Madison Irrigation District	$ 1,200	
Idaho Water Resource Board	$ 500	
Idaho Power Company	$ 1,000	
Non-Federal Subtotal	$ 202,750	34%
REQUESTED RECLAMATION FUNDING	$ 400,000	66%
TOTAL PROJECT COST	$ 602,750	100%

Table 4. Detailed budget.

BUDGET ITEM DESCRIPTION	COMPUTATION		Quantity Type	TOTAL COST
	$/Unit	Quantity		
Salaries and Wages				
Rob Van Kirk, Science/Technology Director	$106,000	40%	salary	$42,400
Christina Morrisett, Climate Adaptation Mgr.	$60,000	40%	salary	$24,000
Amber Roseberry, Technician	$20	400	hour	$8,000
Jamie Powell, Communications Director	$77,200	10%	salary	$7,720
Jasper Davis, Communications Coordinator	$42,000	10%	salary	$4,200
Jack McLaren, Aquatic Ecology Manager	$60,000	6%	salary	$3,600
Shawn Holwegner, IT Specialist	$35	20	hour	$700
Fringe Benefits				
Rob Van Kirk, Science/Technology Director	21%	$42,400	salary	$8,989
Christina Morrisett, Climate Adaptation Mgr.	34%	$24,000	salary	$8,160
Amber Roseberry, Technician	11%	$8,000	wage	$880
Jamie Powell, Communications Director	23%	$7,720	salary	$1,745
Jasper Davis, Communications Coordinator	29%	$4,200	salary	$1,231
Jack McLaren, Aquatic Ecology Manager	34%	$3,600	salary	$1,224
Shawn Holwegner, IT Specialist	24%	$700	wage	$165
Travel				
Local	$0.655	5000	mile	$3,275
Equipment				
Weather stations	$26,000	6	EA	$156,000
Supplies and Materials				
Weather station installation supplies	$1,000	6	EA	$6,000
Contractors/Consultants				
Boise State University (post-doc researcher)				$191,062
Ecosa Consulting (M. Muradian, data mgmt.)	$60	900	hour	$54,000
Third-party Contributions				
Trout Unlimited cash	$26,000		cash	$26,000
Trout Unlimited In-kind	$80	40	hour	$3,200
Boise State University	$18,590	1 month	salary	$18,590
LegacyWorks Group	$125	10	hour	$1,250
Friends of the Teton River	$50	20	hour	$1,000
Fremont-Madison Irrigation District	$60	20	hour	$1,200
Idaho Water Resource Board	$50	10	hour	$500
Idaho Power Company	$100	10	hour	$1,000
Other expenses				
Cloud computing	$685	2	year	$1,370
Environmental Compliance	$5000	1	EA	$5,000
Remote data transmission for 1 year	$240	6	station	$1,440
Undergraduate internship	$8,000	2	summer	$16,000
Postdoctoral researcher office space	$120	24	month	$2,400
Postdoctoral researcher housing	$250	24	month	$6,000
TOTAL DIRECT COSTS				$ 582,300
Indirect Costs				$20,450
TOTAL ESTIMATED PROJECT COSTS				$602,750

Budget Narrative

Salaries and wages

All salaries and wages included in the budget will be paid to regular HFF employees at their current rates.

Dr. Rob Van Kirk, Science/Technology Director and Project Manager
Rob will devote 20% of his total work time to the project in each of the two years, for a total of 40% of his annual salary over the life of the project. As project manager, his time will primarily be spent supervising project staff and consultants, tracking project expenditures, and completing and submitting required reports. Because he was the developer of water supply and irrigation models developed for the Henry's Fork watershed with previous WaterSMART funding, he will devote proportionally more time to development of the analogous models in this project than on the other classes of tasks summarized in Table 2.

Dr. Christina Morrisett, Climate Adaptation Manager
Christina will devote 20% of her total work time to the project in each of the two years, for a total of 40% of her annual salary over the life of the project. She will work primarily on developing the water supply and irrigation models.

Amber Roseberry, Technician
Amber will spend 400 hours on this project over the two years, primarily related to site location, installation, and maintenance of weather stations in the field.

Jamie Powell, Communications Director
Jamie will devote 5% of her work time to the project in each of the two years, for a total of 10% of her annual salary over the life of the project. She will co-facilitate meetings of the Henry's Fork Watershed Council and supervise all communications, outreach, and stakeholder engagement activities.

Jasper Davis, Communications Coordinator
Jasper will devote 5% of her work time to the project in each of the two years, for a total of 10% of her annual salary over the life of the project. She will develop communications and outreach materials and facilitate stakeholder engagement.

Dr. Jack McLaren, Aquatic Ecology Manager
Jack will devote 3% of his work time to the project in each of the two years, for a total of 6% of his annual salary over the life of the project. He will contribute technical input to site selection, modeling, and data provisioning to ensure that the project outputs have maximum applicability to management and conservation of aquatic resources in the Henry's Fork and South Fork.

Shawn Holwegner, IT Specialist
Shawn will devote 20 total hours to the project to ensure that all data transmission, data management, computing, and web development are secure and compatible with HFF's existing cloud computing and backup structures.

Fringe benefits

Benefits will be paid to these employees at their current, respective rates, calculated as a percentage of the total salary each employee will contribute to the project. Fringe benefits include Federal Insurance Contributions Act taxes, health insurance, Individual Retirement Account contributions, and vehicle allowance. Rates differ across employees because of different health insurance coverage, IRA selections, and vehicle allowances.

Travel

Local travel of 5,000 miles will be required to install and maintain weather stations and remote transmission equipment over the two years of the project. This will allow 50 round trips (roughly 8 per site) to installation sites at an estimated average distance of 100 miles per trip. Mileage rate is the current standard federal rate of $0.655 per mile.

Equipment

Six weather stations will be purchased, at a cost of $26,000 per station. Station components consist of a mounting tower and accessories, seven sensors (barometric pressure, relative humidity/temperature, net radiometer, wind speed/direction, snow depth, soil moisture, and disdrometer), power supply (solar panel, battery, charging regulator), data control system (data logger with modem), and environmental enclosure. Cost is based on current vendor-supplied price quotes.

Supplies

Each instrument installation will require an estimate $1,000 in supplies, including concrete for station footing and hardware.

Contractors/consultants

Boise State University, Post-doctoral researcher. Sarah Newcomb, the Principle Investigator, will be employed as a post-doctoral researcher at Boise State University for the two years of the project. The sub-award to Boise State includes two years of salary at $60,000 per year, fringe benefits at 43.44%, and indirect costs at 11%, based on an off-campus project.

Ecosa Consulting (Melissa Muradian, Data Management Consultant): 900 hours over the course of the project at her current rate of $60 per hour. All of her time will be spent on making all data and modeling products publicly available on a web site.

Third-party contributions

Trout Unlimited: $26,000 cash to fund one of the weather stations, plus 40 hours at $80/hour in salary and benefits to facilitate stakeholder engagement in the Wyoming portion of the project area.

Boise State University: Professor Flores will devote 0.5 months of time to the project in each of the two years, primarily as post-doctoral faculty supervisor. His estimated monthly salary is $12,424 in year 1 and $12,796 in year 2. Total contribution includes fringe benefits at 32.82% and 11% indirect costs.

LegacyWorks Group: 10 hours at $125 per hour in salary, benefits, and indirect costs to participate in stakeholder meetings.

Friends of the Teton River: 20 hours at $50 per hour in salary and fringe benefits to participate in stakeholder meetings.

Fremont-Madison Irrigation District: 20 hours at $60 per hour in salary and fringe benefits to facilitate the Henry's Fork Watershed Council, chair meetings of the Henry's Fork Drought Management Planning Committee, and provide input to station location and data provisioning.

Idaho Water Resource Board: 10 hours at $50 per hour in salary and fringe benefits to participate in stakeholder meetings.

Idaho Power Company: 10 hours at $100 per hour in salary and fringe benefits to participate in stakeholder meetings.

Other expenses

Cloud computing expense is 25% of HFF's current annual cloud computing subscription costs of $2,740, for two years. The 25% is the estimated amount of new data and code that this project will add to HFF's existing computing and data management infrastructure.

Environmental compliance: An estimated $5,000 in expense will be required to secure compliance for weather station installation.

Remote data transmission cost is for 12 months of transmission from each of 6 stations at the current Verizon cell service rate of $20/month per station.

Two **undergraduate internships** (400 hours per internship) will be devoted to the project. Each 10-week summer intern is paid a stipend of $5,000 and is housed in HFF's campus dormitory facility. Housing is valued at $125 per week. Total internship value includes administrative cost of $1,750 per internship in HFF staff time devoted to the internship program.

HFF will provide **office space** to the post-doctoral researcher for the duration of the project, valued at $100 per month.

HFF will also providing **housing** for the post-doctoral researcher for the duration of the project, at a value of $250 per month.

Indirect costs

Indirect costs at the *de minimus* rate of 10% of modified total direct costs are requested.

Environmental and Cultural Resources Compliance

A large portion of the proposed work is developing models and improving data-access. This project work will be conducted at the applicant's offices in Ashton. ID. The field work associated with the project is installation and maintenance of new weather station infrastructure. While final site selection will occur in the early stages of the project, all sites will likely be on

U.S. Forest Service, or other federal land managed by the National Park Service or Reclamation. After site selection, we will work with the appropriate entity to ensure environmental and cultural compliance is complete prior to any installation.

Will the proposed project impact the surrounding environment (e.g., soil [dust], air, water [quality and quantity], animal habitat)? Please briefly describe all earth-disturbing work and any work that will affect the air, water, or animal habitat in the project area. Please also explain the impacts of such work on the surrounding environment and any steps that could be taken to minimize the impacts.

Installing permanent weather stations requires digging into the soil to pour a concrete foundation. The area disturbed for the foundation will be approximately 36"x36"x36". Vegetation removal may be required in the area surrounding the foundation. To minimize this, we will visit the site prior to installation to select a final location that reduces the amount of vegetation removal and impact. To protect the sensors, we will also install a fence around the approximately 15' x 15' area that contains weather station infrastructure.

• *Are you aware of any species listed or proposed to be listed as a Federal threatened or endangered species, or designated critical habitat in the project area? If so, would they be affected by any activities associated with the proposed project?*

The Yellow-billed Cuckoo is listed as threatened and is found in the lower watershed. A designated critical habitat area is located in riparian forest along the lower Henry's Fork. No project activities will occur in the designated critical habitat area. Additionally, the North American grizzly bear is listed as threatened and found in much of the study area. As the weather stations will have a small footprint (approximately 15' by 15'), there will be only very minor habitat disturbance. Since sites will be placed near roads for ease of installation and maintenance, they will likely be in areas where habitat alteration has already occurred.

• *Are there wetlands or other surface waters inside the project boundaries that potentially fall under CWA jurisdiction as "Waters of the United States"? If so, please describe and estimate any impacts the proposed project may have.*

Numerous wetlands and waters in the SRWM fall under CWA jurisdiction. However, none of the proposed work will occur near wetlands or any other surface water or stream channel.

• *When was the water delivery system constructed?*

Private systems were built between 1879 and 1930. Reclamation facilities on the Henrys Fork were authorized in 1935 and constructed between then and 1939. On the South Fork, Jackson Lake Reservoir and dam were originally constructed in 1912, and Palisades facilities were authorized in 1941 and constructed between 1951-1957.

• *Will the proposed project result in any modification of or effects to, individual features of an irrigation system (e.g., headgates, canals, or flumes)? If so, state when those features were constructed and describe the nature and timing of any extensive alterations or modifications to those features completed previously.*

No.

• *Are any buildings, structures, or features in the irrigation district listed or eligible for listing on the National Register of Historic Places? A cultural resources specialist at your local Reclamation office or the State Historic Preservation Office can assist in answering this question.*

NA. The applicant is not an irrigation district, and none of the proposed field work will take place on lands or infrastructure within the partnering irrigation district.

• *Are there any known archeological sites in the proposed project area?*

Not that we know of. After site selection is finalized, we will work with the appropriate agency to complete necessary cultural compliance.

• *Will the proposed project have a disproportionately high and adverse effect on low income or minority populations?*

No

• *Will the proposed project limit access to, and ceremonial use of, Indian sacred sites or result in other impacts on tribal lands?*

No

• *Will the proposed project contribute to the introduction, continued existence, or spread of noxious weeds or non-native invasive species known to occur in the area?*

No. Potential for spread of noxious weeds and invasive species will be minimized through standard practices of cleaning field equipment between site installations.

Required Permits or Approvals

As with the environmental and cultural compliance, once we engage with stakeholders to select proposed weather station sites, the applicant will work with the appropriate agencies to undergo the permitting and approval process before installation occurs.

Overlap or Duplication of Effort Statement

The tasks proposed by this project do not duplicate any tasks currently planned by the applicant. The only project staff position that overlaps with a pending funding application is HFF's Climate Adaptation Program Manager, which will be filled by Dr. Christina Morrisett by the time this proposed project is scheduled to begin. We have submitted a grant application to the Murdock Charitable Trust to support that position in FY 2024, 2025, and 2026, at the rates of 100%, 66%, and 33%, of the total position cost for these three fiscal years, respectively. In the budget for this project, we propose that 20% of Dr. Morrisett's total time over FY 2025 and 2026 be funded by this request. Thus, this request complements rather than duplicates the pending funding request to Murdock. The work performed by Dr. Morrisett under this request will not duplicate work she will perform with the other portion of her time.

Letter of support

Attached: University of Wyoming

Letter of partnership and funding commitment

Attached: Fremont-Madison Irrigation District

Official resolution

Attached: Henry's Fork Foundation Board of Directors

Letters of support and funding commitment

Attached:

Boise State University

Friends of the Teton River

Idaho Power Company

Idaho Water Resource Board

LegacyWorks Group

Trout Unlimited

Wyoming EPSCoR
Wyoming Hall, Room 422
Dept 3622, 1000 E University Ave
Laramie, WY 82071-2000

Phone: 307-766-2033
Fax: 307-766-2061
www.uwyo.edu/epscor
epscorwy@uwyo.edu

October 16, 2023

Dear Ms. Morgan,

I am writing to express the support of WyACT (Wyoming Anticipating Climate Transitions) for the application of the Henry's Fork Foundation (HFF) to the Bureau of Reclamation's WaterSmart Applied Science Grant Program. WyACT is a 5-year (2022-2027) project funded by the NSF EPSCoR program and led by the University of Wyoming. WyACT will build high resolution downscaled climate simulations focused on the next 20-50 years to drive hydrologic, ecological and socioeconomic models representing conditions and scenarios co-produced with key stakeholders. WyACT is developing a dynamic data portal (wyadapt.org) that will provide information on current and projected future changes in watershed conditions relevant to policy makers, water managers and communities.

WyACT will support Henry's Fork Foundation on their proposed WaterSmart project in three ways. First, WyACT will install and operate meteorological stations and snow observation sites in Wyoming's headwaters areas of the upper Snake, and at least at one of these sites WyACT will include measurements of the full suite of energy fluxes needed for the hydrologic modeling effort led by HFF and Boise State University. WyACT will freely share data and observations from these meteorological stations. Second, WyACT will provide technical support to HFF for site selection, installation, and data management of their meteorological stations located in Wyoming in the upper Snake River headwaters areas. Finally, WyACT will provide access to meteorological towers for the placement of HFF's sensors required for monitoring energy fluxes where appropriate. More broadly, during HFF's proposed two-year WaterSmart project, WyACT will participate in meetings of basin-wide stakeholders for the purposes of determining optimal locations for new weather stations and the most useful format for the new weather station data and models.

We are enthusiastic about expanding the collaboration between WyACT and HFF with the proposed BoR WaterSmart project and the development of common methods and tools for understanding changes in water availability in the headwater's areas of the upper Snake River basin supporting needs of the BoR.

Sincerely,

Brent E. Ewers, Professor and Head, Botany
Director, WyACT and Biodiversity Institute
1000 E. University Ave, 3165
University of Wyoming
Laramie, WY 82071

Fremont-Madison Irrigation District

350 North 6th West
PO Box 15
St. Anthony, Idaho 83445
Phone: (208) 624-3381 Fax: (208)624-3990
Email: fmid@myidahomail.com

October 13, 2023

Bureau of Reclamation
Water Resources and Planning Office
Attn: Ms. Avra Morgan
Mail Code: 86-63000
P.O. Box 25007
Denver, CO 80225-0007

Dear Ms. Morgan,

This letter of partnership confirms that Fremont-Madison Irrigation District (FMID) supports the application of the Henry's Fork Foundation (HFF) to the Reclamation's WaterSmart Applied Science Grant Program. The proposed project will build on existing hydrologic models and data availability developed by HFF under a previous WaterSmart grant. The goal of the project is to improve seasonal and short-term water-supply forecasts to improve precision of water management in the upper Snake River basin.

FMID works closely with the HFF and Reclamation to best manage water resources within the Henrys Fork Watershed for the benefit of all those who depend on it. One of the avenues for this collaboration is through the Henry's Fork Drought Management Committee (HFDMC). The HFDMC includes representatives from the conservation community including HFF, the Nature Conservancy and Trout Unlimited. Additionally, it includes representatives from the Hydropower industry and the irrigation community. This committee meets at least quarterly throughout the year. We plan reservoir management and set river flow targets. Through this committee we strive to use the best possible science to guide our decision making.

Specific tasks proposed by this grant are:

1. Expand an existing model and supporting data to predict water supply, irrigation demand, and water right priorities from the Henry's Fork to the whole upper Snake River basin. HFF's current models are based on physical water supply in the Henry's Fork watershed but do not currently include administrative water supply (water rights). Because the upper Snake River basin is managed according to a single, common system of water rights, incorporating administrative supply requires expansion of existing models and data to the entire basin. Incorporating administrative supply into these existing models would improve their utility to water users and managers, especially in our case because FMID's storage rights are junior to most others in the basin.
2. Install five new weather stations that collect wind speed, humidity, soil moisture, precipitation, snow depth, air temperature, and incoming and outgoing radiation data that are not currently available for high elevations of the upper Snake River. HFF's current models have performed very well at predicting overall water supply but not timing of streamflow during the snowmelt period, which is critical to filling and managing reservoirs during that time period. These new weather stations will collect the data needed to construct short-term models of snowmelt that will benefit all stakeholders.

3. Use the data from these new weather stations to create short-term streamflow forecasts that integrate physically-based snowmelt processes using the iSNOBAL energy balance snow model.

As with the data and models developed by HFF with the previous Applied Science grant, the products proposed for development in this grant will be made available to water users, managers, and the general public via websites and web applications.

Based on the improvement in water conservation—and associated fisheries and aquatic ecosystems—made possible by HFF's previous WaterSmart-funded work, we believe that the proposed work will provide even more benefit to all river stakeholders in the Henry's Fork watershed and beyond.

During this two-year project, FMID will co-facilitate two meetings of the Henry's Fork Watershed Council at which stakeholders will have the opportunity to learn about the project and provide feedback. Including preparation time, each meeting requires six hours, for a total of 12 during the project. In addition, FMID will participate in separate meetings of basin-wide stakeholders for the purposes of determining optimal locations for the new weather stations and the most useful format for the new weather station data and models.

In all, FMID will commit 20 hours at a rate of $60 per hour for a total in-kind contribution of $1200 to this project.

In summary, we support HFF's application because it will expand on existing data and information that has already proven to improve water management to benefit all stakeholders in the Henry's Fork watershed.

Sincerely,

Aaron Dalling

Aaron Dalling

Executive Director

RESOLUTION OF THE BOARD OF DIRECTORS OF THE

HENRY'S FORK FOUNDATION

WHEREAS, the mission of the Henry's Fork Foundation is to conserve, protect, and restore the unique fisheries, wildlife and aesthetic qualities of the Henry's Fork and its watershed; and

WHEREAS, the Henry's Fork Foundation uses a science-based, collaborative approach to promote favorable streamflow, good water quality, healthy fish populations, and a positive fishing experience on the Henry's Fork and South Fork Snake River watersheds; and

WHEREAS, the Henry's Fork Foundation has consistently demonstrated its effectiveness at administering federal grants and using federal funds to meet its mission; and

WHEREAS, the U.S. Bureau of Reclamation's WaterSMART program provides opportunities to fund collaborative projects that meet the mission of the Henry's Fork Foundation, and the Board of Directors has reviewed these opportunities and their suitability for the organization; and

Now therefore be it

RESOLVED, that the Henry's Fork Foundation Board of Directors authorizes Brandon Hoffner, Executive Director, to submit applications to WaterSMART funding programs during fiscal year 2024 for projects to restore aquatic habitats and improve water management that will be undertaken in fiscal years 2025-2027; and

RESOLVED, that the Henry's Fork Foundation Board of Directors authorizes Brandon Hoffner, Executive Director, to enter into financial agreements with the U.S. Bureau of Reclamation pursuant to application for, receipt of, and administration of WaterSMART funding; and

RESOLVED, that the Henry's Fork Foundation will adhere to any and all deadlines, timelines, and requirements of said agreements; and

RESOLVED, that the Henry's Fork Foundation will commit the non-federal in-kind and cash contributions as specified in the grant applications, during fiscal years 2025-2027.

I, the undersigned, do hereby certify:

1. *That I am the duly elected and acting Secretary of the Henry's Fork Foundation, and*
2. *That the foregoing constitutes a Resolution of the Board of said organization, as duly adopted at a meeting of the Board of Directors held on the 6th day of October 2023.*

IN WITNESS WHEREOF, I have hereunto subscribed by name, this 6th day of October 2023.

Ron Miller, Secretary
Henry's Fork Foundation

BOISE STATE UNIVERSITY

Department of Geosciences
1910 University Drive
Boise, Idaho 83725-1535
lejoflores@boisestate.edu

phone 208-426-2903
fax 208-426-4061
http://earth.boisestate.edu/lejoflores

October 16, 2023

Bureau of Reclamation
Water Resources and Planning Office
Attn: Ms. Avra Morgan
Mail Code: 86-63000
P.O. Box 25007
Denver, CO 80225-0007

Dear Ms. Morgan,

This letter of support confirms that Boise State University (BSU) supports the application of the Henry's Fork Foundation (HFF) to the Reclamation's WaterSmart Applied Science Grant Program, entitled "Optimizing data collection, data availability, and streamflow forecasting to enhance fisheries in the Snake River watershed." The proposed project will build on existing hydrologic models and data availability developed by HFF under a previous WaterSmart grant. The goal of the project is to improve seasonal and short-term water-supply forecasts that will increase precision of water management in the upper Snake River basin to benefit fisheries and aquatic ecosystems.

Specific tasks proposed by this grant are:

1. Expand an existing simulation model and supporting data to predict water supply, irrigation demand, and water right priorities from the Henry's Fork to the whole upper Snake River basin.
2. Install five new weather stations that collect wind speed, humidity, soil moisture, precipitation, snow depth, air temperature, and incoming and outgoing radiation data that are not currently available for high elevations of the upper Snake River. These new weather stations will collect the data needed to construct short-term models of snowmelt that will benefit all stakeholders.
3. Use the data from these new weather stations to create short-term streamflow forecasts that integrate physically-based snowmelt processes using the iSNOBAL energy balance snow model.

As with the data and models developed by HFF with the previous Applied Science grant, the products proposed for development in this grant will be made available to water users, managers, and the general public via websites and web applications.

Because of BSU's expertise with meteorological instrumentation and process-based hydrologic models, BSU will collaborate with HFF on tasks 2 and 3 above via a subcontract. The subcontract will include two years of salary, benefits, and indirect costs to support a post-doctoral researcher. The researcher will be located in the study watershed at the HFF campus, where HFF will provide office space, logistical support, and a field technician and will facilitate stakeholder engagement via the Henry's Fork Watershed Council and other formal and informal collaborations with long-standing HFF partners in the upper Snake River basin.

In turn, over the course of the project BSU will contribute 0.5 months of faculty time per year, for a total in-kind contribution of $18,590 including fringe and foregone facilities and administration costs to the project. This in-kind contribution to the project will take the form of post-doctoral researcher supervision and guidance on instrumentation, data processing, and model development.

The combination of BSU's expertise in snowmelt dynamics and modeling and HFF's proven record of science-based collaboration with water users and water managers will result in a unique and effective application of cutting-edge science to real-time water management. We are excited about this new collaboration and hope that it will result in measurable improvements in key streamflow metrics important for fisheries and aquatic ecosystems in the upper Snake River basin.

Sincerely,

Alejandro N. Flores, PhD
Professor
Department of Geosciences

FRIENDS OF THE tetonriver

208 354 3871
www.tetonwater.org

18 North Main Street, Suite 310
PO Box 768
Driggs, Idaho 83422

October 12, 2023

Bureau of Reclamation
Water Resources and Planning Office
Attn: Ms. Avra Morgan
Mail Code: 86-63000
P.O. Box 25007
Denver, CO 80225-0007

Dear Ms. Morgan,

On behalf of Friends of the Teton River (FTR), I am writing to express support for the application of the Henry's Fork Foundation (HFF) to the Reclamation's WaterSmart Applied Science Grant Program. The proposed project will build on existing hydrologic models and data availability developed by HFF under a previous WaterSmart grant, and will expand and refine the work of the Upper Snake Farms and Fish Collaborative, of which FTR is an active participant.

The mission of Friends of the Teton River is to restore and conserve the Teton River Watershed, ensuring a lasting legacy of clean water, healthy streams, and a thriving wild fishery. We implement programs and projects founded on sound science, community education, and cooperation with landowners, citizens, and agency partners. As such, the proposed project is directly in line with our mission.

This project will continue to build on the Bureau of Reclamation's highly successful investment in the broader Henry's Fork Watershed, and the work that the BOR has supported in the Teton River sub-watershed. FTR and our partners (including HFF) founded the Teton Water Users Association under a WaterSMART Cooperative Planning Phase I Grant, and utilized the WaterSMART Cooperative Planning Phase II funding program to support implementation of its phase I planning efforts. We have also partnered on BOR-supported work in the Canyon Creek drainage, successfully utilizing WaterSMART funding to act on the goals and priorities identified in the Henry's Fork Basin Study, which was also funded under the WaterSMART Program. We have recently worked with the Henry's Fork Foundation on a successful Applied Science Grant that has benefitted the Teton Basin Aquifer Recharge program and had a beneficial impact on the native Yellowstone cutthroat trout fishery and Teton Basin's aquatic ecosystems.

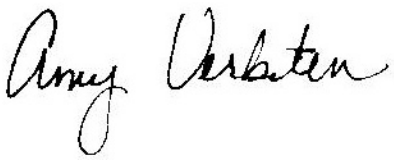
The weather monitoring stations proposed for installation under this grant proposal will have a direct benefit for native fisheries and aquatic ecosystems in the Teton River watershed.

Expansion of existing models, and our ability to predict water supply, irrigation demand, and water right priorities will greatly expand our ability to work collaboratively with diverse water users to balance the needs of fisheries/aquatic ecosystems, irrigators, and development.

During this two-year project, Friends of the Teton River staff will participate in meetings of basin-wide stakeholders for the purposes of determining optimal locations for the new weather stations and the most useful format for the new weather station data and models. In all, Friends of the Teton River will commit 20 hours at a rate of $50 per hour for a total in-kind contribution of $1,000 to this project.

In summary, we support HFF's application because it will improve water management for the benefit of all stakeholders in the broader Henry's Fork and Upper Snake Watersheds, and thus complement the BOR-supported work that is being done in the Teton River Watershed to improve native fisheries and aquatic ecosystems.

Sincerely,



Amy Verbeten

Executive Director

Friends of the Teton River

208.354.3871 ext. 13

amy@tetonwater.org

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Shaun Parkinson, PE, Ph.D.
Water Resource and Policy, Atmospheric Science

(208) 388-2495
(208) 388-6495 (fax)

Bureau of Reclamation
Water Resources and Planning Office
Attn: Ms. Avra Morgan
Mail Code: 86-63000
P.O. Box 25007
Denver, CO 80225-0007

Dear Ms. Morgan,

I am writing to express the support of Idaho Power for the application of the Henry's Fork Foundation (HFF) to the Reclamation's WaterSmart Applied Science Grant Program. The proposed project will build on existing hydrologic models and data availability developed by HFF under a previous WaterSmart grant. The goal of the project is to improve seasonal and short-term water-supply forecasts to improve precision of water management in the upper Snake River basin. Of particular interest to Idaho Power is collection of detailed weather data not currently available from existing agency-maintained stations, as these data will contribute to Idaho Power's cloud-seeding program in the upper Snake River basin and enhance water supply forecasting to support its downstream hydropower operations and resource management related to those projects.

Idaho Power, in collaboration with the Idaho Water Resource Board, operates a cloud seeding program in the Upper Snake, including the Henry's Fork. The underlying objective of the program is to enhance high elevation winter snowpack, ultimately increasing and extending runoff the following spring and increasing baseflows over time. Operation of the cloud seeding program relies heavily on high-resolution computer weather modeling as well as weather observations, both of which are important to understand when conditions are conducive for seeding. Weather observation, are also used forecast runoff and water supply, and to estimate cloud seeding benefits.

Idaho Power relies heavily on water supply forecasts to predict future energy from hydropower, its lowest cost energy resource, as well as plan its required monitoring of water quality, fisheries and invertebrates. Idaho Power's most upstream hydropower project is American Falls, and the remaining 16 mainstem Snake projects are at Milner and downstream. Idaho Power's FERC licenses require monitoring of aquatic resources affected by its hydropower projects. Those resources include water quality at all of the projects and participation in a white sturgeon program in the reach from Shoshone Falls downstream to Lewiston, Idaho. Sturgeon spawning occurs in the spring, and recruitment success is correlated with high spring flows. A skilled data driven water supply forecast of spring flows assists sturgeon biologists in planning their monitoring strategy for the upcoming year. An improved water supply outlook also benefits planning for other aquatic monitoring requirements in the Hells Canyon reach including includes bull trout and fall Chinook salmon.

Specific tasks proposed by this grant are:

1. Expand an existing model and supporting data to predict water supply, irrigation demand, and water right priorities from the Henry's Fork to the whole upper Snake River basin. HFF's current models are based on physical water supply in the Henry's Fork watershed but do not currently include administrative water supply (water rights). Because the upper Snake River basin is managed according to a single, common system of water rights, incorporating administrative supply requires expansion of existing models and data to the entire basin.
2. Install five new weather stations that collect wind speed, humidity, soil moisture, precipitation, snow depth, air temperature, and incoming and outgoing radiation data that are not currently available for high elevations of the upper Snake River. Idaho Power uses data from weather stations to for a number of applications including to assess weather forecast model performance, guiding real-time cloud seeding operations to augment snowpack, and hydrologic modeling to understand near term operations as well as seasonal water supply. Upper Snake operations and water supply both effect Idaho Powers downstream hydropower operations and monitoring of the associated aquatic resources. The amount of weather data available in the Henry's Fork watershed is relatively limited and these sites will reduce the weather-related uncertainty of hydrologic conditions. The inclusion of soil moisture is of particular interest, as there is very little soil moisture data in southern Idaho.
3. Use the data from these new weather stations to create short-term streamflow forecasts that integrate physically based snowmelt processes using the iSNOBAL energy balance snow model.

Because of the expertise in snow hydrology and modeling at Boise State University (BSU), HFF is proposing to partner with BSU via support of a two-year post-doctoral researcher to work on tasks 2 and 3. Idaho Power has collaborated with BSU's H.P. Marshall in the early development of a downward looking radar system with the ability to report snow depth as well as the density structure of the snowpack, giving an indication of Snow Water Equivalent (SWE). These instruments have the potential to be a low cost and low (physical) impact surrogate to snow pillows like the NRCS uses in its SNOTEL network.

As with the data and models developed by HFF with the previous Applied Science grant, the products proposed for development in this grant will be made available to water users, managers, industry, and the general public via websites and web applications. During this two-year project, Idaho Power will participate in meetings of basin-wide stakeholders for the purposes of determining optimal locations for the new weather stations and the most useful format for the new weather station data and models. In all,

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Idaho Power will commit 10 hours at a loaded rate of $100 per hour for a total in-kind contribution of $1,000 to this project.

In summary one of the keys to better use of water supplies is to improve our understanding of the timing, distribution, and magnitude of when precipitation falls within a watershed, and then the following timing and magnitude of runoff. The proposed equipment and the observed conditions it will provide will significantly improve our ability to conduct effective cloud seeding in the Henry's Fork and provide better data from which to estimate water supplies. These improved runoff forecasts will benefit operations decisions as well as monitoring and management of downstream aquatic resources.

Thank you for your consideration,

Shaun Parkinson, PE, Ph.D.

IDAHO WATER RESOURCE BOARD

October 13, 2023

Bureau of Reclamation
Water Resources and Planning Office
Attn: Ms. Avra Morgan
Mail Code: 86-63000
P.O. Box 25007
Denver, CO 80225-0007
Dear Facilities Coordinator,

Dear Ms. Morgan,

I am writing to express the support of the Idaho Water Resource Board (IWRB) for the application of the Henry's Fork Foundation (HFF) to the Reclamation's WaterSmart Applied Science Grant Program. The proposed project will build on existing hydrologic models and data availability developed by HFF under a previous WaterSmart grant. The goal of the project is to improve seasonal and short-term water-supply forecasts to improve precision of water management in the upper Snake River basin. Of particular interest to the IWRB is collection of detailed weather data not currently available from existing agency-maintained stations, as this data will contribute support for the Collaborative Cloud Seeding Program (Collaborative Program) in the Upper Snake River basin. The IWRB as a State agency has taken leadership of the Collaborative Program for purposes of augmenting snowpack to support its Managed Aquifer Recharge (MAR) program and overall long-term water supply sustainability in the basin.

Idaho Power Company (IPC) operates the Collaborative Program in partnership with the IWRB, including the Henry's Fork reach of the Upper Snake Basin. The underlying objective of the program is to enhance the high elevation winter snowpack, ultimately increasing and extending runoff the following spring and increasing baseflows over time. Operation of the cloud seeding program relies heavily on high-resolution computer weather modeling as well as weather observations, both of which are important to understand when conditions are conducive for seeding. Weather observations are also used to forecast runoff and water supply, and to estimate cloud seeding benefits. Increased water supply in the Upper Snake River basin supports all water uses, including support for fisheries and aquatic ecosystems.

Specific tasks proposed by this grant are:

1. Expand an existing simulation model and supporting data to predict water supply, irrigation demand, and water right priorities from the Henry's Fork to the

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whole upper Snake River basin. HFF's current models are based on physical water supply in the Henry's Fork watershed but do not currently include administrative water supply (water rights). Because the upper Snake River basin is managed according to a single, common system of water rights, incorporating administrative supply requires expansion of existing models and data to the entire basin.

2. Install five new weather stations that collect wind speed, humidity, soil moisture, precipitation, snow depth, air temperature, and incoming and outgoing radiation data that are not currently available for high elevations of the upper Snake River. Idaho Power Company (IPC), as the operator of the Collaborative Cloud Seeding Program, uses data from weather stations to for a number of applications including to assess weather forecast model performance, guiding real-time cloud seeding operations to augment snowpack, and hydrologic modeling to understand near term operations as well as seasonal water supply. Augmenting snowpack in the Upper Snake River basin supports the IWRB's Managed Recharge Program and its objective of working to ensure the long-term sustainability of water supply in the basin. The amount of weather data available in the Henry's Fork watershed is relatively limited and these sites will reduce the weather-related uncertainty of hydrologic conditions. The inclusion of soil moisture is of particular interest, as there is very little soil moisture data in southern Idaho.

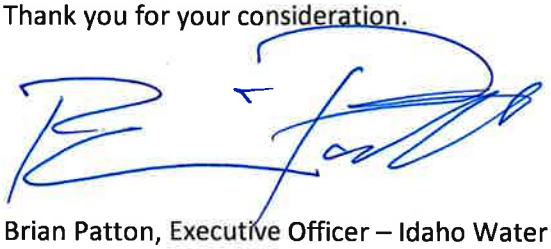
3. Use of the data from these new weather stations to create short-term streamflow forecasts that integrate physically based snowmelt processes using the iSNOBAL energy balance snow model.

Because of the expertise in snow hydrology and modeling at Boise State University (BSU), HFF is proposing to partner with BSU via support of a two-year post-doctoral researcher to work on tasks 2 and 3. The IWRB has collaborated with BSU's H.P. Marshall in the early development of a downward looking radar system with the ability to report snow depth as well as the density structure of the snowpack, giving an indication of Snow Water Equivalent (SWE). These instruments have the potential to be a low cost and low (physical) impact surrogate to snow pillows like the NRCS uses in its SNOTEL network.
As with the data and models developed by HFF with the previous Applied Science grant, the products proposed for development in this grant will be made available to water users, managers, industry, and the general public via websites and web applications.

During this two-year project, IWRB staff will participate in meetings of basin-wide stakeholders for the purpose of determining optimal locations for the new weather stations and the most useful format for the new weather station data and models. In total, the IWRB will commit 10 hours at a rate of $50 per hour for a total in-kind contribution of $500 to this project.

In summary, one of the keys to better use of water supplies is to improve our understanding of the timing, distribution, and magnitude of when precipitation falls within a watershed, and then the following timing and magnitude of runoff. The proposed equipment and the observed conditions it will provide will significantly improve our ability to conduct effective cloud seeding operations in Henry's Fork and provide better data from which to estimate water supplies. These improved runoff forecasts will benefit operations decisions as well as monitoring and management of downstream aquatic resources.

Thank you for your consideration.



Brian Patton, Executive Officer – Idaho Water Resource Board

October 16th, 2023

Bureau of Reclamation
Water Resources and Planning Office
Attn: Ms. Avra Morgan
Mail Code: 86-63000
P.O. Box 25007
Denver, CO 80225-0007

Dear Ms. Morgan,

I am writing to express the support of LegacyWorks Group (LWG) for the application of the Henry's Fork Foundation (HFF) to the Reclamation's WaterSmart Applied Science Grant Program. The proposed project will build on existing hydrologic models and data availability developed by HFF under a previous WaterSmart grant. The goal of the project is to improve seasonal and short-term water-supply forecasts to improve precision of water management in the upper Snake River basin. Although improved water management benefits all stakeholders, we are particularly supportive because the improvements proposed in this grant are aimed at benefiting fisheries and aquatic habitats affected by reservoir operations in the headwaters and the upper Snake River basin.

LWG partners with the HFF on several projects in the region, including the Upper Snake Collaborative and in advancing efforts of the Teton Basin Water Users Association. LWG is currently facilitating the design and launch of the Snake River Headwaters Watershed Group, intended to "bring public and private partners together to share their knowledge and work collaboratively to ensure clean and sufficient water to sustain the iconic Snake River Headwaters ecosystem's function and meet the needs of water users today and into the future." A core desire of this group is to expand the collection, availability and analysis of data across the headwaters in order to inform best management and decision making. With this grant, the HFF will be supporting those interests while continuing to be leaders in the communication of watershed-wide data for the public. LWG is pleased to support this effort by building connections between the stakeholders in the headwaters to align data collection and reporting needs.
Specific tasks proposed by this grant are:

1. Expand an existing simulation model and supporting data to predict water supply, irrigation demand, and water right priorities from the Henry's Fork to the whole upper Snake River basin. HFF's current models are based on physical water supply in the Henry's Fork watershed but do not currently include administrative water supply (water rights). Because the upper Snake River basin is managed according to a single, common system of water rights, incorporating administrative supply requires expansion of existing models and data to the entire basin. This expansion will add Jackson Lake, Palisades Reservoir, and the main Snake/South Fork reaches upstream of the HF-SF confluence.

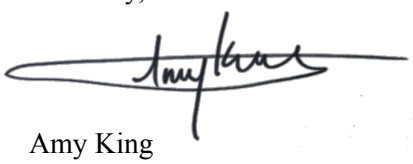
2. Install five new weather stations that collect wind speed, humidity, soil moisture, precipitation, snow depth, air temperature, and incoming and outgoing radiation data that are not currently available for high elevations of the upper Snake River. Locate at least one station in the Teton River watershed and one on the Wyoming side in the Snake headwaters.

3. Use the data from these new weather stations to create short-term streamflow forecasts that integrate physically-based snowmelt processes using the iSNOBAL energy balance snow model. This new generation of snowmelt models has the potential to greatly increase precision of reservoir operations in the spring, when river systems in the upper Snake River basin depend on a springtime freshet to maintain stream channel and riparian habitat.

As with the data and models developed by HFF with the previous Applied Science grant, the products proposed for development in this grant will be made available to water users, managers, industry, and the general public via websites and web applications.
During this two-year project, our LWG staff will participate in meetings of basin-wide stakeholders for the purposes of determining optimal locations for the new weather stations and the most useful format for the new weather station data and models. In all, LegacyWorks Group will commit 10 hours at a rate of $125 per hour for a total in-kind contribution of $1250 to this project.

In summary, LegacyWorks Group fully supports the Henry's Fork Foundation's application to the Reclamation's WaterSmart Applied Science Grant Program. The proposed project, building on previous efforts, aims to enhance seasonal and short-term water-supply forecasts in the upper Snake River basin. While improved water management benefits all stakeholders, LegacyWorks Group is particularly enthusiastic about the project's focus on benefiting fisheries and aquatic habitats impacted by reservoir operations in the headwaters and upper Snake River basin. Collaborating with the Henry's Fork Foundation on various regional projects, including the Upper Snake Collaborative, we are excited to see these efforts align with the goal of expanding data collection and analysis across the headwaters to inform best practices. This grant's tasks, such as expanding simulation models, installing weather stations, and creating streamflow forecasts, hold the potential to significantly enhance reservoir operations and benefit the entire ecosystem. LWG is happy to expand further on how these projects intersect with our regional vision. Thank you for your consideration.

Sincerely,



Amy King
amy@legacyworksgroup.com
Teton Region Project Director
LegacyWorks Group

October 13, 2023

Bureau of Reclamation
Water Resources and Planning Office
Attn: Ms. Avra Morgan
Mail Code: 86-63000
P.O. Box 25007
Denver, CO 80225-0007

Dear Ms. Morgan,

On behalf of Trout Unlimited, I would like to express our support for the Henry's Fork Foundation (HFF) application to the Bureau of Reclamation's WaterSmart Applied Science Grant Program.

The proposed project will build on existing hydrologic models and data availability developed by HFF under a previous WaterSmart grant. The goal of the project is to improve seasonal and short-term water-supply forecasts to improve precision of water management in the upper Snake River basin. Although improved water management benefits all stakeholders, we are particularly supportive because the improvements proposed in this grant are aimed at benefitting fisheries and aquatic habitats affected by reservoir operations in the upper Snake River basin, including the Wyoming side of the basin where TU's Snake River Headwaters Initiative and associated conservation projects and programs are based.

In addition to the investments TU has made in the Snake River Headwaters watershed for native cutthroat trout – $6.65M since 2016 to restore 10 miles of habitat and reconnect 33 miles of stream together with over 65 partners – we are also helping to lead the formation of a new watershed group in the area, the Snake River Headwaters Watershed Group (SRHWG). This has been driven by the recognition that the growing complexity of the challenges faced by the watershed, including drought and other climate impacts, water quality and habitat degradation, and changing demands, require collaborative solutions that a watershed group is best suited to identify and rally around.

One area that has been already identified by SRHWG stakeholders as an area of need is increased data and information sharing and modeling. The Henry's Fork Foundation's data, modeling, and public dashboard have been viewed as examples that we seek to replicate, complement, and build on in the Snake River Headwaters through involvement in the HFF's current WaterSmart Applied Science scope of work and other partnership efforts. The products proposed for development in this grant will complement existing data and monitoring efforts in the Snake River Headwaters, including climate and water supply modeling and projections, and will be made available to water users, managers, industry, and the general public via websites and a public dashboard.

During this two-year project, our staff will coordinate stakeholder meetings with the HFF team and the SRHWG's Data and Monitoring working group for the purposes of determining optimal locations for the new weather stations in the Wyoming portion of the HFF's project area as well as the most useful format for the new weather station data and models. In all, Trout Unlimited will commit 40 hours at a rate of $80 per hour for a total in-kind contribution of $3,200 to this project, and will fund one weather station in Wyoming for a total cash contribution of $26,000 to this project. TU will also work with the HFF and other members of the SRHWG to identify potential sources of funding for additional weather station locations in Wyoming.

To summarize, TU supports HFF's application because it will improve water supply forecasts and water management for the benefit of all stakeholders in the upper portion of the Upper Snake River Basin, as well as the native fisheries and aquatic ecosystems in the area.

Sincerely,

Leslie Steen
Trout Unlimited
NW Wyoming Program Director