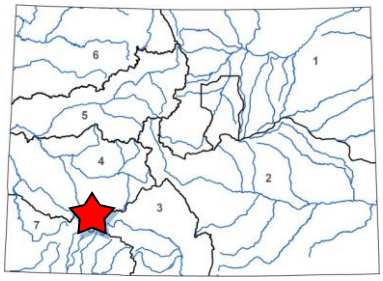
COLORADO
Colorado Water Conservation Board

Water Plan Grant Application

Colorado Dust on Snow Project
Center for Snow and Avalanche Studies

November 2019 Board Meeting



LOCATION	
County/Counties:	Ouray County Base
Drainage Basin:	Statewide

DETAILS	
Total Project Cost:	$520,000
Water Plan Grant Request:	$125,000
Recommended amount:	$0
Other CWCB Funding:	$0
Other Funding Amount:	$395,000
Applicant Match:	$0
Project Type(s): Study	
Project Categories: Water Storage, Conservation and Land Use, Engagement & Innovation, and Environment and Recreation.	
Measurable Result: Information produced used for water management decisions	

The Center for Snow & Avalanche Studies (CSAS) is an independent, not-for-profit 501(c)(3) organization that operates the Colorado dust-on-snow (CODOS) Program. Our Senator Beck Basin Study Area (www.snowstudies.org) serves the mountain science community and regional resource managers by hosting and conducting interdisciplinary research and sustaining integrative 24/7/365 monitoring of weather, snowpack, radiation, soils, plant community and hydrologic signals of regional climate trends. Senator Beck Basin is also the home of the Colorado Dust-on-Snow Program (www.codos.org/#codos) which monitors and forecasts, on behalf of the water management community, dust-on-snow conditions and impacts on Colorado snowmelt runoff behavior throughout the State.

The CODOS Project is an applied science effort on behalf of the Colorado water community. Senator Beck Basin Study Area (SBB) at Red Mountain Pass is the "sentry site" for dust-on-snow monitoring in the Colorado Mountains. This Project spans multiple basins, ten additional passes are monitored throughout the season. In addition to dust presence, severity and location in the snowpack, collected data includes other variables essential to water professionals, streamflow forecasting, and model calibration/verification. Timely CODOS Updates describe conditions, by major watershed, and predict the influence on snowmelt timing/rates. This Project addresses multiple purposes. The dust-on-snow, snowpack, and meteorological information collected is unique to the organization.

Staff review of the application did not show good conformity with section 9.4 of Colorado's Water Plan, Framework for State of Colorado Support for a Water Project. Staff understands the value of the CODOS Program, however it was not deemed a good fit with the Colorado Water Plan grant program.

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Water Plan Grant Application

Instructions

To receive funding for a Water Plan Grant, applicant must demonstrate how the project, activity, or process (collectively referred to as "project") funded by the CWCB will help meet the measurable objectives and critical actions in the Water Plan. Grant guidelines are available on the CWCB website.

If you have questions, please contact CWCB at (303) 866-3441 or email the following staff to assist you with applications in the following areas:

Water Storage Projects	Anna.Mauss@state.co.us
Conservation, Land Use Planning	Kevin.Reidy@state.co.us
Engagement & Innovation Activities	Ben.Wade@state.co.us
Agricultural Projects	Alexander.Funk@state.co.us
Environmental & Recreation Projects	Chris.Sturm@state.co.us

FINAL SUBMISSION: Submit all application materials in one email to *waterplan.grants@state.co.us* in the original file formats [Application (word); Statement of Work (word); Budget/Schedule (excel)]. Please do not combine documents. In the subject line, please include the funding category and name of the project.

Water Project Summary

Name of Applicant	Center for Snow and Avalanche Studies
Name of Water Project	Colorado Dust on Snow Project
CWP Grant Request Amount	$25,000/year, for 5 years $125,000 Total
Other Funding Sources: Six Water Conservation Districts	$46,000/year, for 5 years $230,000 Total
Other Funding Sources: Denver Water/City of Grand Junction	$13,500/year, for 5 years $67,500 Total
Other Funding Sources: Bureau of Reclamation	$10,000/year, for 5 years $50,000 Total
Other Funding Sources: Grand Mesa, Uncompahgre, and Gunnison National Forest	$8,000/year, for 5 years $40,000 Total
Other Funding Sources: USGS In-kind Match	$1,500/year, for 5 years $7,500 Total
Applicant Funding Contribution:	

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Total Project Cost	$104,000/year, $520,000 for 5 years

Applicant & Grantee Information
Name of Grantee(s) Center for Snow and Avalanche Studies
Mailing Address P.O. Box 190, Silverton, CO, 81433
FEIN 132711479
Organization Contact Jeff Derry
Position/Title Executive Director
Email jderry@snowstudies.org
Phone (o) 970-387-5080, (c) 970-231-6595
Grant Management Contact *Same as Organization Contact*
Position/Title
Email
Phone
Name of Applicant (if different than grantee) *Same as Grantee*
Mailing Address
Position/Title
Email
Phone
Description of Grantee/Applicant
Provide a brief description of the grantee's organization (100 words or less).

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Type of Eligible Entity (check one)	
	Public (Government): Municipalities, enterprises, counties, and State of Colorado agencies. Federal agencies are encouraged to work with local entities. Federal agencies are eligible, but only if they can make a compelling case for why a local partner cannot be the grant recipient.
	Public (Districts): Authorities, Title 32/special districts (conservancy, conservation, and irrigation districts), and water activity enterprises.
	Private Incorporated: Mutual ditch companies, homeowners associations, corporations.
	Private Individuals, Partnerships, and Sole Proprietors: Private parties may be eligible for funding.
X	**Non-governmental organizations (NGO):** Organization that is not part of the government and is non-profit in nature.
	Covered Entity: As defined in Section 37-60-126 Colorado Revised Statutes.

Type of Water Project (check all that apply)	
X	Study
	Construction
	Identified Projects and Processes (IPP)
X	Other: Applied Research, Monitoring, Education/Outreach

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Category of Water Project (check the primary category that applies and include relevant tasks)		
X	Water Storage - Projects that facilitate the development of additional storage, artificial aquifer recharge, and dredging existing reservoirs to restore the reservoirs' full decreed capacity and Multi-beneficial projects and those projects identified in basin implementation plans to address the water supply and demand gap.. *Applicable Exhibit A Task(s):Tasks 1-3*	
X	Conservation and Land Use Planning - Activities and projects that implement long-term strategies for conservation, land use, and drought planning. *Applicable Exhibit A Task(s): Tasks 1-3*	
X	Engagement & Innovation - Activities and projects that support water education, outreach, and innovation efforts. Please fill out the Supplemental Application on the website. *Applicable Exhibit A Task(s): Tasks 1-3*	
	Agricultural - Projects that provide technical assistance and improve agricultural efficiency. *Applicable Exhibit A Task(s): Tasks 1-3*	
X	Environmental & Recreation - Projects that promote watershed health, environmental health, and recreation. *Applicable Exhibit A Task(s): Tasks 1-3*	
	Other	Explain:

Location of Water Project	
Please provide the general county and coordinates of the proposed project below in **decimal degrees**. The Applicant shall also provide, in Exhibit C, a site map if applicable.	
County/Counties	Statewide, across all mountain regions of Colorado. The Senator Beck research and dust-on-snow "sentry" site is located in Ouray County, but adjacent to San Juan, San Miquel, Hinsdale, and Dolores Counties
Latitude	37° 54' 24.89088N
Longitude	-107° 42' 40.75924W

Water Project Overview
Please provide a summary of the proposed water project (200 words or less). Include a description of the project and what the CWP Grant funding will be used for specifically (e.g., studies, permitting process, construction). Provide a description of the water supply source to be utilized or the water body affected by the project, where applicable. Include details such as acres under irrigation, types of crops irrigated, number of residential and commercial taps, length of ditch improvements, length of pipe installed, and area of habitat improvements, where applicable. If this project addresses multiple purposes or spans multiple basins, please explain.

The Applicant shall also provide, in Exhibit A, a detailed Statement of Work, Budget, Other Funding Sources/Amounts and Schedule.

The CODOS Project is an applied science effort on behalf of the Colorado water community. Senator Beck Basin Study Area (SBB) at Red Mountain Pass is the "sentry site" for dust-on-snow monitoring in the Colorado Mountains.

This Project spans multiple basins, ten additional passes are monitored throughout the season:
- Park Cone
- Spring Creek
- Wolf Creek
- Hoosier
- Grizzly Peak
- Berthoud Summit
- Willow Creek
- Rabbit Ears
- McClure
- Grand Mesa

In addition to dust presence, severity and location in the snowpack, collected data includes other variables (i.e. SWE) essential to water professionals, streamflow forecasting, and model calibration/verification. Timely CODOS Updates describe conditions, by major watershed, and predict the influence on snowmelt timing/rates.

SBB is located between 11,000'-13,500' (higher than any SNOTEL) and has three meteorological towers and a streamgage. Measurements include radiation (albedo) which allow assessment of the snowpack energy budget in forecasting near-term melt rates.

This Project addresses multiple purposes. The dust-on-snow, snowpack, and meteorological information collected is unique to our organization. *No other entity is collecting this kind of information let alone making it available to Colorado water stakeholders (environmental, storage, conservation, recreation), researchers, and the public*. CWP funding will be used to conduct field work, data collection and reporting.

Measurable Results

To catalog measurable results achieved with the CWP Grant funds, please provide any of the following values as applicable:

	New Storage Created (acre-feet)
	New Annual Water Supplies Developed or Conserved (acre-feet), Consumptive or Nonconsumptive
	Existing Storage Preserved or Enhanced (acre-feet)
	Length of Stream Restored or Protected (linear feet)
	Efficiency Savings (indicate acre-feet/year OR dollars/year)

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	Area of Restored or Preserved Habitat (acres)	
	Quantity of Water Shared through Alternative Transfer Mechanisms	
	Number of Coloradans Impacted by Incorporating Water-Saving Actions into Land Use Planning	
	Number of Coloradans Impacted by Engagement Activity	
X	Other	Explain: Much of the information is used for decision making for water management, recreation, and environmental purposes. Our data allows an analysis that improves snowpack accumulation/ablation understanding. We inform about climate change, monitoring for climate induced changes. It is difficult to give a measureable result. However one recent measure of success can be found in the successful management of reservoirs and streamflows in SW Colorado this past runoff season, this can be partly attributed to our Project.

Water Project Justification

Provide a description of how this water project supports the goals of Colorado's Water Plan, the most recent Statewide Water Supply Initiative, and the applicable Roundtable Basin Implementation Plan and Education Action Plan. The Applicant is required to reference specific needs, goals, themes, or Identified Projects and Processes (IPPs), including citations (e.g. document, chapters, sections, or page numbers).

The proposed water project shall be evaluated based upon how well the proposal conforms to Colorado's Water Plan Framework for State of Colorado Support for a Water Project (CWP, Section 9.4, pp. 9-43 to 9-44;)

The Colorado dust-on-Snow Project supports the goals of the:

Colorado Water Plan

As mentioned in **Chapter 4-Water Supply section of the Colorado Water Plan (page 4-14), under the header "Dust-on-Snow Events,"** dust-on-snow events introduce a level of uncertainty into managing water supplies. Dust-on-snow "can advance snowmelt timing, enhance snowmelt runoff intensity, and decrease snowmelt yields". This can lead to on average "peak runoff three weeks earlier than normal." "This shift is independent of climate change, which may also result in earlier snowmelt patterns." And if dust events continue as the *Colorado Dust-On-Snow Program has documented*, this will affect "Colorado's present and future water supply by decreasing flows by 5%, on average. On the Colorado River, these reductions would result in a decrease of 750,000 cfs, or twice the amount of water the City of Denver uses annually."

Goal A. Supply-Demand Gap (CWP, Chap. 10, Sec. 10.3, Pg. 10.9).

The CODOS Project is cost effective and efficient. Through monitoring and reporting snowpack and dust conditions and its consequences on snowmelt timing/rate and hence streamflows, allow water management to be better informed to allocate water resources with more predictability and assuredness, enhancing the ability of managers to keep reservoirs, and water user allocations, at optimum levels throughout snowmelt season and beyond, closing the supply-demand gap.

Goal B. Conservation (CWP, Chap. 10, Sec. 10.3, Pg. 10.9)

The CODOS Project through monitoring and reporting on snowpack and dust conditions and its influence on snowmelt timing/rate and streamflow promotes highly efficient water management. Insightful knowledge promotes better forecasting, hence management, promoting conservation of water. CODOS Project data and analysis are very helpful in extreme years (i.e. drought/flood) that assist where current forecasting models, based on long-term averages, may be at a disadvantage.

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Goal C. Land Use (CWP, Chap. 10, Sec. 10.3, Pg. 10.10)
CODOS' expertize on the subject of dust-on-snow allows us to speak to the causes and consequences dust-on-snow. We do extensive speaking engagements where we education managers and the public on how poor land use decisions (or inaction) in the Southern Colorado Plateau lead to dust events in Colorado. It is important to advocate for change in land use in the Southern Colorado Plateau in order to reduce dust severity/events in Colorado.

Goal D. Agriculture (CWP, Chap. 10, Sec. 10.3, Pg. 10.10)
The CODOS Project through monitoring and reporting on snowpack and dust conditions and its influence on snowmelt timing/rate and hence streamflow promotes agricultural conservation and efficiency. Improved water allocation allows a more "adaptive management" of resources based on current conditions and a confident forecast of future conditions.

Goal F. Watershed Health, Environment, and Recreation (CWP, Chap. 10, Sec. 10.3, Pg. 10.12)
Through monitoring and timely reporting on snowpack, dust conditions, and radiation (albedo) conditions allows much improved knowledge of streamflow conditions. This means water enthusiasts are better informed for safe and enjoyable water experience. This also means water managers can confidently release flows (i.e Mcphee) for downstream rafters and environmental and watershed health flows.

Goal H. Education, Outreach, and Innovation (CWP, Chap. 10, Sec. 10.3, Pg. 10.13)
CODOS actively engages in education and outreach. Every year we speak to k-12 students, teach university field classes (UC-Colorado Springs, U of Minnesota, Geneseo, Prescott College, etc), and hold a "Snow School for Water Professionals" class for folks active as a water professional. We also regularly speak at conferences and water organizations (Law of the Rio Grande, Colorado River District, San Miguel Watershed Coalition, Mesa State, Animas Watershed Forum, Colorado Outdoor Industry) as well as for water conservation districts. We are active on social media and do press interviews often.

Goal I. Additional Critical Goals and Actions (CWP, Chap. 10, Sec. 10.3, Pg. 10.14)
Climate Change: Monitoring for climate induced changes in our mountain systems is part of CSAS' mission statement. Climate change researchers around the world have recognized mountains as a sensitive bellwether of global change, where system responses quicker to present than in lower elevation urbanized or rural settings. Our Senator Beck Research Basin is a high elevation study site where we monitor (three highly instrumented meteorological stations) and document (5-year repeat plant species inventory) for climate induced changes. We also host a wide array of researchers investigating snowpack, ecology, and health of our high mountain basin.

SWSI 2010
Recommendation #1. Actively encourage projects to address multiple purposes, including municipal, industrial, environmental, recreational, agricultural, risk management, and compact compliance needs.
The CODOS Project is multi-purposed. We monitor snowpack conditions, dust-on-snow conditions, collect high elevation meteorological data, monitor plant species amount and migration, and host research professionals developing new snow measurement technologies and investigating snow accumulation/ablation processes. All of this information feeds into many uses; recreation, climate change, environment, storage/supply, water allocation, and risk management.

Recommendation #5. Support meeting Colorado's nonconsumptive water needs by working with Colorado's water stakeholders.
Please see response under Recommendation #1.

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Basin Implementation Plan

Colorado Basin Roundtable-Basin Implementation Plan: "Preparing for climate uncertainty, support environmental and recreation projects, efficient and effective water infrastructure."
Please see responses above as to how the CODOS Project assists with this objective of the Colorado Basin Roundtable. But also. In-stream flow regimes and plant/animal species protection are easier to achieve with improved predictive ability of runoff that CODOS provides.

Gunnison Basin Roundtable-Basin Implementation Plan: "Protect Existing Water Uses in the Gunnison Basin."
Senator Beck Research Basin feeds into the Gunnison watershed and we conduct field work at a site near Park Cone. The data and information we collect assists in being fully informed to the current state of the snowpack and to protect existing water resources.

Southwest Basin Roundtable-Basin Implementation Plan: "Maintain Agriculture Water Needs, Meet Recreational Water Needs, Meet Environmental Water Needs."
Please see responses above as to how the CODOS Project assists with the objectives of the Southwest Basin Roundtable. But also worth noting, our station data and snowpack data is particularly useful to the Animas, San Miguel, Uncompahgre, and Rio Grande watersheds. Data is collected above 11,000' and provide crucial information particularly when the highest SNOTEL in the region (at 11,000') melts out and stakeholders are "blind" as to what the remaining snowpack has in store.

The **proposed project addresses most goals outlined in individual Basin Implementation Plans,** and contributes to meeting these specific goals and IPP's, as an example:

- Addressing multiple purposes including municipal, industrial, environmental, recreation, agricultural, risk management, and compliance needs.
- Implement efficiency measures to maximize beneficial use and production.
- Implement IPP's that work towards meeting agricultural water supply shortages.
- Maintain the condition and natural function of streams, lakes, wetlands and riparian areas.
- Support hydropower operations
- Protect existing water uses, and water supply options for all existing and new uses and values.

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Related Studies

Please provide a list of any related studies, including if the water project is complementary to or assists in the implementation of other CWCB programs.

A significant number of research and technical studies have resulted from the CODOS Program. A comprehensive list can be found on the CSAS website, http://www.snowstudies.org/pubs1.html, and CODOS website http://www.codos.org/#lit. A brief list of dust-on-snow related studies is below:

Colorado Water Conservation Board: Colorado's Water Plan, Chapter 4 (https://www.colorado.gov/cowaterplan).

Painter, T. H,S. M. Skiles, J. S. Deems, W. T. Brandt, and J. Dozier (2017), Variation in rising limb of Colorado River snowmelt runoff hydrograph controlled by dust radiative forcing in snow, Geophysical Research Letters, 44. https://doi.org/10.1002/2017GL075826.

Zhuojun Zhang, Harland L. Goldstein, Richard L. Reynolds, Yongfeng Hu, Xiaoming Wang, and Mengqiang Zhu (2018), Phosphorus Speciation and Solubility in Aeolian Dust Deposited in the Interior American West, Environ. Sci. Technol., 2018, 52 (5), pp 2658–2667. doi: 10.1021/acs.est.7b04729

ChenglaiWu, Xiaohong Liu, Zhaohui Lin, Stefan R. Rahimi-Esfarjani, and Zheng Lu (2018), Impacts of absorbing aerosol deposition on snowpack and hydrologic cycle in the Rocky Mountain region based on variable-resolution CESM (VR-CESM) simulations, Atmospheric Chemisrty and Physics, 18, 511–533, 2018. https://doi.org/10.5194/acp-18-511-2018

Skiles, S.M. and Painter, T. (2017) 'Daily evolution in dust and black carbon content, snow grain size, and snow albedo during snowmelt, Rocky Mountains, Colorado', Journal of Glaciology, 63(237), pp. 118–132. doi: 10.1017/jog.2016.125.

Skiles, S.M., Painter, T. and Okin, G.S. (2017) 'A method to retrieve the spectral complex refractive index and single scattering optical properties of dust deposited in mountain snow', Journal of Glaciology, 63(237), pp. 133–147. doi: 10.1017/jog.2016.126.

Axson, J. L., H. Shen, A. L. Bondy, C. C. Landry, J. Welz, J. M. Creamean, A. P. Ault (2016), Transported Mineral Dust Deposition Case Study at a Hydrologically Sensitive Mountain Site: Size and Composition Shifts in Ambient Aerosol and Snowpack, Aerosol and Air Quality Res., 16: 555-567, doi:10.4209/aaqr.2015.05.0346

Landry, C. C., K. A. Buck, M. S. Raleigh, and M. P. Clark (2014), Mountain system monitoring at Senator Beck Basin, San Juan Mountains, Colorado: A new integrative data source to develop and evaluate models of snow and hydrologic processes, Water Resour. Res., 50, doi:10.1002/2013WR013711.

Bryant, A. B., T. H. Painter, J. S. Deems, and S. M. Bender (2013), Impact of dust radiative forcing in snow on accuracy of operational runoff prediction in the Upper Colorado River Basin, Geophys. Res. Lett., 40, doi:10.1002/grl.50773, 2013.

J. Brahney, A.P. Ballantyne, C. Sievers, J.C. Neff. Increasing Ca2+ deposition in the western US: the role of mineral aerosols. Aeolian Research (2013), http://dx.doi.org/10.1016/j.aeolia.2013.04.003

Clow, D.W.,M.W. Williams, P.F. Schuster. Increasing aeolian dust deposition to snowpacks in the Rocky Mountains inferred from snowpack, wet deposition, and aerosol chemistry. Aeolian Research (2016), TBD

Deems, J. S., T.H. Painter, J.J. Barsugli, J. Belnap, and B. Udall (2013), Combined impacts of current and future dust deposition and regional warming on Colorado River Basin snow dynamics and hydrology, Hydrol. EarthSyst. Sci., 17, 4401-4413, doi:10.5194/hess-17-4401-2013.

Painter, T. H., A. C. Bryant, and S. M. Skiles (2012), Radiative forcing by light absorbing impurities in snow from MODIS surface reflectance data, Geophys. Res. Lett., 39, L17502, doi:10.1029/2012GL052457.

Skiles, S. M., T. H. Painter, J. S. Deems, A. C. Bryant, and C. Landry (2012), Dust radiative forcing in snow of the Upper Colorado River Basin: Part II. Interannual variability in radiative forcing and snowmelt rates, Water Resour. Res., doi:10.1029/2012WR011986.

Painter, T. H., S. M. Skiles, J. S. Deems, A. C. Bryant, and C. Landry (2012), Dust radiative forcing in snow of the Upper Colorado River Basin: Part I. A 6 year record of energy balance, radiation, and dust concentrations, Water Resour. Res., doi:10.1029/2012WR011985.

Painter, T. H., J. Deems, J. Belnap, A. Hamlet, C. C. Landry, and B. Udall (2010), Response of Colorado River runoff to dust radiative forcing in snow, Proceedings of the National Academy of Sciences, published ahead of print September 20, 2010,doi:10.1073/pnas.0913139107.

Lawrence, C. R., T. H. Painter, C. C. Landry, and J. C. Neff (2010), Contemporary geochemical composition and flux of aeolian dust to the San Juan Mountains, Colorado, United States, Journal of Geophysical Research, 115, G03007, doi:10.1029/2009JG001077.

Steltzer, H., C. Landry, T. H. Painter, J. Anderson, and E. Ayres. 2009.Biological consequences of earlier snowmelt from desert dust deposition in alpine landscapes. Proceedings of the National Academy of Sciences. 106:11629-11634, doi_10.1073_pnas.0900758106.

Neff, J.C., A.P. Ballantyne, G.L. Farmer, N.M. Mahowald, J.L. Conroy, C.C. Landry, J.T. Overpeck, T.H. Painter,C.R. Lawrence and R.L. Reynolds. 2008. Increasing eolian dust deposition in the western United States linked to human activity, Nature Geoscience, Vol. 1, No. 3, pp. 189-195, March 2008, doi: 10.1038/ngeo136

Painter, T. H., A. P. Barrett, C. C. Landry, J. C. Neff, M. P. Cassidy, C. R. Lawrence, K. P. Thatcher, L. Farmer.(2007) Impact of disturbed desert soils on duration of mountain snow cover. Geophysical Research Letters. V34, 12, L12502, 10.1029/2007GL030208.

Previous CWCB Grants, Loans or Other Funding

List all previous or current CWCB grants (including WSRF) awarded to both the Applicant and Grantee. Include: 1) Applicant name; 2) Water activity name; 3) Approving RT(s); 4) CWCB board meeting date; 5) Contract number or purchase order; 6) Percentage of other CWCB funding for your overall project.

Applicant Name	Water Activity Name	Approving RT	CWCB Board Meeting Date	Contract Number
Center for Snow & Avalanche Studies	Colorado Dust-on-Snow Project	Rio Grande, Southwest, Gunnison, Colorado	N/A	CTGG1 2017-1239
Center for Snow & Avalanche Studies	Center for Snow & Avalanche Studies	N/A	N/A	POGG1 PDAA 201800000436
Center for Snow & Avalanche Studies	Center for Snow & Avalanche Studies	N/A	N/A	POGG1 PDAA 201700000467
Center for Snow & Avalanche Studies	Center for Snow & Avalanche Studies	N/A	N/A	POGG1 PDAA 201600000000 00000173

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Center for Snow & Avalanche Studies	Center for Snow & Avalanche Studies	N/A	N/A	POGG1 PDAA 20150000000000000144	
Center for Snow & Avalanche Studies	Center for Snow & Avalanche Studies	N/A	N/A	OE PDA 14000000021	
Center for Snow & Avalanche Studies	Center for Snow & Avalanche Studies	N/A	N/A	OE PDA 13000000008	
Center for Snow & Avalanche Studies	Center for Snow & Avalanche Studies	N/A	N/A	OE PDA 11000000107	
Center for Snow & Avalanche Studies	Center for Snow & Avalanche Studies	N/A	N/A	OE PDA 10000000058	

Taxpayer Bill of Rights

The Taxpayer Bill of Rights (TABOR) may limit the amount of grant money an entity can receive. Please describe any relevant TABOR issues that may affect your application.

No Tabor issues will affect this application

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Submittal Checklist	
X	I acknowledge the Grantee will be able to contract with CWCB using the Standard Contract.
Exhibit A	
X	Statement of Work(1)
X	Budget & Schedule(1)
	Engineer's statement of probable cost (projects over $100,000)
X	Letters of Matching and/or Pending 3rd Party Commitments(1)
Exhibit C	
X	Map (if applicable)(1)
X	Photos/Drawings/Reports
X	Letters of Support (Optional)
X	Certificate of Insurance (General, Auto, & Workers' Comp.) (2)
X	Certificate of Good Standing with Colorado Secretary of State(2)
X	W-9(2)
	Independent Contractor Form(2) (If applicant is individual, not company/organization)
Engagement & Innovation Grant Applicants ONLY	
X	Engagement & Innovation Supplemental Application(1)

(1) Required with application.
(2) Required for contracting. While optional at the time of this application, submission can expedite contracting upon CWCB Board approval.

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ENGAGEMENT & INNOVATION GRANT FUND SUPPLEMENTAL APPLICATION

Introduction & Purpose

Colorado's Water Plan calls for an outreach, education, public engagement, and innovation grant fund in Chapter 9.5.

The overall goal of the Engagement & Innovation Grant Fund is to enhance Colorado's water communication, outreach, education, and public engagement efforts; advance Colorado's water supply planning process; and support a statewide water innovation ecosystem.

The grant fund aims to engage the public to promote well-informed community discourse regarding balanced water solutions statewide. The grant fund aims to support water innovation in Colorado. The grant fund prioritizes measuring and evaluating the success of programs, projects, and initiatives. The grant fund prioritizes efforts designed using research, data, and best practices. The grant fund prioritizes a commitment to collaboration and community engagement. The grant fund will support local and statewide efforts.

The grant fund is divided into two tracks: engagement and innovation. The Engagement Track supports education, outreach, communication, and public participation efforts related to water. The Innovation Track supports efforts that advance the water innovation ecosystem in Colorado.

Application Questions

*The grant fund request is referred to as "project" in this application.

Overview (answer for both tracks)
In a few sentences, what is the overall goal of this project? How does it achieve the stated purpose of this grant fund (above)?
To collect, analyze, and distribute climate, weather, dust and snowpack information to stakeholders, decision makers, and the public at large. Foster education related to our mountains and snow.
Who is/are the target audience(s)? How will you reach them? How will you involve the community?
The water community and general public is target audience. We reach them through email updates, two websites (https://snowstudies.org/ and http://www.codos.org/#codos), social media, webinars, and public talks and meetings. Involvement can be part of taking a field class, and through citizen science, where folks send in pictures and observations of dust and snowpack conditions.
Describe how the project is collaborative or engages a diverse group of stakeholders. Who are the partners in the project? Do you have other funding partners or sources?
Our information is sought after by a wide variety of groups; ski enthusiasts, boaters, water community (water districts, reservoir operators, water managers), mountain enthusiasts, river forecasters, etc. All these groups are encouraged to share observations and give feedback that can be disseminated to the community via our websites and Updates. In winter/spring it can mean daily conversations with stakeholders. We have multiple funding partners in the Project, please see the list in Exhibit B. But they include 6 water conservation districts, Denver Water, Bureau of

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Overview (answer for both tracks)
Reclamation (Western and Lower Colorado office), GMUG Forest, City of Grand Junction, plus researchers and private donations.
Describe how you plan to measure and evaluate the success and impact of the project?
One measure of success is asking the "did our information improve operations management and decision making? Was our information accurate?" Impact is measured through direct feedback from stakeholders, end of season debriefings, and an online survey.
What research, evidence, and data support your project?
A rich history and numerous publications support our Project. Please see related studies section of this application, nearly all of which we participated. Please see journal publications and popular press articles here: http://www.codos.org/#lit and here https://snowstudies.org/popular-press/ and here https://snowstudies.org/publications-presentations/
Describe potential short- and long-term challenges with this project.
Long-term challenges are financial predictability and stability, maintaining adequate funding to achieve objectives. Short-term challenges are usually, weather conditions, scheduling conflicts, time constraints in reporting observations imposed by naturally changing weather/snowpack conditions.

Please fill out the applicable questions for either the Engagement Track or Innovation Track, unless your project contains elements in both tracks. If a question does not relate to your project, just leave it blank. Please answer each question that relates to your project. Please reference the relevant documents and use chapters and page numbers (Colorado's Water Plan, Basin Implementation Plan, PEPO Education Action Plan, etc.).

Engagement Track
Describe how the project achieves the education, outreach, and public engagement measurable objective set forth in Colorado's Water Plan to "significantly improve the level of public awareness and engagement regarding water issues statewide by 2020, as determined by water awareness surveys."
By continuing to offer snow field classes, talks to k-12, universities, and professionals. Public presentations and webinars. Maintain updated websites, active social media, and reaching out via conferences and media.
Describe how the project achieves the other measurable objectives and critical goals and actions laid out in Colorado's Water Plan around the supply and demand gap; conservation; land use; agriculture; storage; watershed health, environment, and recreation; funding; and additional.

The Project's data, observations, and analyses helps meet water needs through cost-effective water efficiency management (more data and better information lead to better allocation of resources), assists with risk assessments of extreme events (flood/drought), documents the impacts and prepare us for climate change. Project's information improve long-term and short-term adaptive decision making to improve recreation activities, watershed health, plant and animal species recovery.
Describe how the project achieves the education, outreach, and public engagement goals set forth in the applicable Basin Implementation Plan(s).
Please also see responses above. By continuing to offer snow field classes, talks to k-12, universities, and professionals. Public presentations and webinars. Maintain updated websites, active social media, and reaching out via conferences. Disseminating current state-of-the-science information about our snowpack, mountain ecosystem health and climate change.
Describe how the project achieves the basin roundtable's PEPO Education Action Plans.
Please also see above. Reaching out to coordinate efforts across state, federal, and roundtable agencies. The CSAS Director also regularly sits on undergrad and graduate student's committees, and often assists them in doing science experiments at SBB.

Innovation Track
Describe how the project enhances water innovation efforts and supports a water innovation ecosystem in Colorado.
Our non-profit's very foundation is centered on serving the Colorado water community and general public. We host researchers and collect data for state-of-the-science research in SBB. We conduct applied research through the CODOS Project, meaning we collect data and information that informs and improves system processes understanding and adaptive management NOW, not some point in the future. We do not "sit" on data/information in order to publish a journal article sometime down the road. We make information and its implications available to the Colorado community immediately. Also too, our data/observations feed into understanding longer-term trends and processes. Our efforts feed into the communities efforts to change, create, support other innovation efforts.
Describe how the project engages/leverages Colorado's innovation community to help solve our state's water challenges.
Through an exchange of ideas and discoveries. Educate the various and diverse audiences in Colorado.
Describe how the project helps advance or develop a solution to a water need identified through TAP-IN and other water innovation challenges. What is the problem/need/challenge?
The problem is not having data to identify needs and gauge progress. We collect, interpret and provide that information.
Describe how this project impacts current or emerging trends; technologies; clusters, sectors, or groups in water innovation.

Last Updated: July 2019

Innovation Track
Climate change is a problem in the here and now, and dust events in Colorado have worsened since the 1990's. We keep track of these current and emerging trends. We host researchers developing new technologies, whether it be a private company developing a data collecting drone, or NASA's SNOWEX campaign (NASA's effort to develop a snow sensing satellite is being done in Senator Beck Basin).

Last Updated: July 2019

Colorado Water Conservation Board
Water Plan Grant - Exhibit A

Statement Of Work	
Date:	**July 26, 2019**
Name of Grantee:	**Center for Snow and Avalanche Studies**
Name of Water Project:	**Colorado Dust-on-Snow Project**
Funding Source:	**CWP Grant: Water Storage/Conservation/Environment/Recreation/Engagement & Innovation**

Water Project Overview:

Introduction and Background:

In the Western United States (U.S.) 70– 80% of annual stream discharge originates from snowmelt. Colorado is a headwaters state, most major rivers originate in the high Rocky Mountains and collectively account for 70% of Colorado's surface water. Mountain environments are recognized as a sensitive bellwether of global and regional change. In addition, studies have shown (see reference list) that dust events, because of the reduction of snow surface albedo (reflectance), can advance snowmelt timing, enhance snowmelt runoff intensity, and decrease snowmelt yields. Dust-on-snow events result in peak runoff three weeks earlier than normal on average. This shift is independent of climate change. Dust deposition has increased more than 200% in Colorado since the 1990's with no signs of abating.

The Center for Snow and avalanche Studies (CSAS) was established to enhance the interdisciplinary investigation of the alpine environment and snow accumulation/ablation processes. CSAS has four main functions:

- Conduct long-term climate and snowpack monitoring at our high alpine Senator Beck Basin Study Area (SBB)
- Host interdisciplinary research at SBB
- Host snow field classes (primary, secondary, undergrad/grad, professionals) and foster education
- Operate the statewide Colorado Dust-on-Snow Program (CODOS)

Dust-on-snow is a problem presenting addition complexities and uncertainties into managing water supplies. The CODOS program is the only organization monitoring dust-on-snow in the state of Colorado in a comprehensive, applied manner and delivers timely and actionable dust-on-snow updates to water managers, forecasters, stakeholders, recreationalists, and public. Dust-on-snow events are rigorously monitored and sampled at SBB throughout the winter, building a long-term record of dust loading with USGS collaboration. Ten other sample locations throughout Colorado are visited at least three times during winter/spring until the snowcover is gone (see map in Exhibit C). Snowpack (SWE, depth, density, etc.) and dust-on-snow observations from these field visits, and from SBB, are presented in frequent CODOS update products. These iterative products describe current dust-in-snow conditions by major watershed, and predict the likely influence of dust-on-snow on near-term snowmelt timing and rates and resulting streamflow. Analyses includes association of dust, snowpack, and weather conditions to hydrograph patterns observed since 2006 at 19 headwater stream gauges monitored in most major mountain watersheds. As the season unfolds, plausible and probable patterns in spring dust-enhanced

snowmelt behaviors are identified by watershed. CODOS has already developed transformative research and applied scientific techniques (and refining tools and methodologies is ongoing) aimed at understanding and predicting snowmelt from a mountain snowpack that is impacted by air-borne pollutants. Building on and incorporating these tools are essential to meeting Colorado's current and future water needs.

In addition to dust-on-snow and snowpack data collection, the meteorological data collected at SBB, located between 11,000' – 13,500' at elevations above any SNOTEL station, is highly comprehensive. Variables collected include solar radiation and albedo (reflectance) which is the dominant control on snowmelt. There are only three meteorological stations in Colorado that collect this information, two of them are in SBB. These data (in addition to monitoring for climate induced changes in our Colorado Mountains) allow assessment of the energy budget of the snowpack in forecasting near-term melt rates (exacerbated by dust-on-snow), often giving reservoir operators and managers a ~2 day "heads up" of changes in streamflow.

Because of the dust-on-snow, snowpack, and meteorological data we collect at SBB, a wide range of interdisciplinary researchers seek to do work in the Basin. Research includes plant ecology, development of snow measurement instrumentation, understanding snow accumulation/ablation processes primarily as it relates to dust, snowpack chemistry, and the advancement of snow modeling. We currently host the Cold Regions Research & Environment Laboratory doing snowpack investigations on the microstructure of snow influenced by dust. Another notable research endeavor in SBB is NASA's SnowEx Project, which took place in 2016 and will again in 2020, and its goal is the technological development of a global snow sensing satellite. We have also assisted with the development of the Jet Propulsion Laboratory's Airborne Snow Observatory and have hosted ASO since its inception.

Airborne and satellite data can only inform researchers, water managers, and forecasters (i.e. Colorado Basin River Forecast Center) if dust is present on top of the snowpack at the specific moment the data is collected (also subject to weather conditions), often at a high financial cost. The best way to understand dust-on-snow severity and extent is by direct field observations. CODOS data provides knowledge as to the 1) presence of dust within the snowpack 2) when dust may emerge at the surface, and 3) when dust layers merge together further decreasing albedo. This data is used by forecasters and modelers for satellite/airborne data validation/verification.

The CODOS Project provides a statewide benefit by providing water managers, forecasters, researchers, and stakeholders information as to the timing/rate of snowmelt that directly leads to improved management and efficient allocation of water supplies in Colorado, both consumptive and non-consumptive, thereby effectively increasing water availability to downstream users and improving the ability to meet all local water supply gaps identified by Roundtables and by the Statewide Water Supply Initiative

In summary, the CODOS Project provides and/or supports:

- Preservation of historical flows and sustainability of Colorado's water resources.
- Optimal, cost-effective and efficient water management.
- Addressing multiple purposes and compliance needs.
- Adaptive management to optimize multiple benefits.
- Water maintenance and allocation for recreational benefits (i.e. releases for boating, fishing)
- Improved flow regimes for environmental purposes; in-stream flows, riparian and watershed health, threatened and endangered plants and wildlife.

- Monitoring for climate change and subsequent effects on the mountain snowpack and ecosystem
- Improved risk assessment for drought mitigation planning and improved flood forecasting
- Education and community outreach

The **proposed project addresses most goals outlined in individual Basin Implementation Plans,** and contributes to meeting these specific goals and IPP's, as an example:

- Addressing multiple purposes including municipal, industrial, environmental, recreation, agricultural, risk management, and compliance needs.
- Implement efficiency measures to maximize beneficial use and production.
- Implement IPP's that work towards meeting agricultural water supply shortages
- Maintain the condition and natural function of streams, lakes, wetlands and riparian areas.
- Support hydropower operations
- Protect existing water uses, and water supply options for all existing and new uses and values.

Project Objectives:

The objective is to continue to serve the Colorado water community and citizens through the Colorado Dust-on-Snow Project by:

- Conduct statewide dust-on-snow field campaigns to track the severity and extent of dust events throughout the snow accumulation and ablation period
- Analyze data and provide timely and applicable updates to forecasters, water community and public
- Maintain and calibrate sensors on the Project's three meteorological stations and stream gauge
- Dust-on-snow and meteorological data management, QAQC, and reporting
- Maintain project webpages with data files, graphics, and relevant information
- Continue to improve data, visualization, and interpretation platforms on Project websites for easy public dissemination of information
- Provide educational outreach throughout Colorado

Last Updated: July 2019

Tasks
Task 1 – Statewide Dust-on-Snow Field Work
Description of Task:
Collect dust-on-snow information at SBB and at least 10 other locations throughout Colorado during the winter and spring, including: Park Cone, Spring Creek Pass, Wolf Creek Pass, Hoosier Pass, Grizzly Peak, Berthoud Summit, Willow Creek Pass, Rabbit Ears Pass, McClure Pass, and Grand Mesa. Also, collect dust-on-snow samples for USGS analysis.
Method/Procedure:
Timely statewide visits, via motorized vehicle, to CODOS sites to collect snowpack and dust information. These profiles of the snowpack allow the documentation of the severity and spatial extent of dust events. A field assistant will accompany Director on trip, and, when appropriate will visit some sites solo to optimize human resources. Field trips will occur at least 3 times a year.
Deliverable:
Field data documentation including snow profile forms, pictures of dust-on-snow profiles and surrounding landscapes. Collection of snow samples and delivery to USGS project partners for mass loading and chemical analysis.

Last Updated: July 2019

Tasks
Task 2 – Dust-on-Snow Updates, Reporting and Outreach
Description of Task:
Collation of field observations and timely creation of dust-on-snow updates and alerts to stakeholders. Season summary and progress reports.
Method/Procedure:
Field data formatted and summarized, data includes CODOS snow profiles, USGS streamflow data, USGS dust sample analysis, SNOTEL data, SBB data, and NWS weather forecasts. Dust-on-snow analysis and report writing. Creation of presentations for educational outreach.
Deliverable:
These timely, actionable, iterative updates and alerts describe current dust-in-snow conditions, by major watershed, and predict the likely influence of dust-on-snow on near-term snowmelt timing and rates. Analyses includes association of dust-on-snow, snowpack, and weather conditions to hydrograph patterns observed since 2006 at 19 headwater stream gauges monitored in most major watersheds. Project reports to CWCB and other funders. Consultations and presentations to stakeholders, funders, general public, university and K-12 students.

Last Updated: July 2019

Tasks
Task 3 – Station Maintenance, Calibration, and Data Management and Access
Description of Task:
Meteorological station sensor maintenance and calibration. Meteorological data collection, management, QAQC, and reporting. Maintain and improve Project websites, data access, visualization, interaction, interpretation, and dissemination of station data, dust-on-snow and related information.
Method/Procedure:
Maintain instrumentation on rotating calibration schedule. Maintain communication, data collection, storage and archive servers. Data QA/QC. Maintain dust-on-snow data files. Project staff or appropriate third party, creates/maintains platforms, tools and webpage content.
Deliverable:
Three highly instrumented meteorological stations and a stream gauge kept fully operational and calibrated. Access, via the CSAS and CODOS webpages, to serially complete near-real time and archived meteorological and dust-on-snow data files. Ability to download near-real time data files to be used in forecasting and hydrologic modeling, the availability of near-real time dust-on-snow and meteorological data graphics.

Last Updated: July 2019

Budget and Schedule

This Statement of Work shall be accompanied by a combined Budget and Schedule that reflects the Tasks identified in the Statement of Work and shall be submitted to CWCB in excel format.

Reporting Requirements

Progress Reports: The applicant shall provide the CWCB a progress report every 6 months, beginning from the date of issuance of a purchase order, or the execution of a contract. The progress report shall describe the status of the tasks identified in the statement of work, including a description of any major issues that have occurred and any corrective action taken to address these issues.

Final Report: At completion of the project, the applicant shall provide the CWCB a Final Report on the applicant's letterhead that:

- Summarizes the project and how the project was completed.
- Describes any obstacles encountered, and how these obstacles were overcome.
- Confirms that all matching commitments have been fulfilled.
- Includes photographs, summaries of meetings and engineering reports/designs.

The CWCB will pay out the last 10% of the budget when the Final Report is completed to the satisfaction of CWCB staff. Once the Final Report has been accepted, and final payment has been issued, the purchase order or grant will be closed without any further payment.

Payment

Payment will be made based on actual expenditures and must include invoices for all work completed. The request for payment must include a description of the work accomplished by task, an estimate of the percent completion for individual tasks and the entire Project in relation to the percentage of budget spent, identification of any major issues, and proposed or implemented corrective actions.

Costs incurred prior to the effective date of this contract are not reimbursable. The last 10% of the entire grant will be paid out when the final deliverable has been received. All products, data and information developed as a result of this contract must be provided to CWCB in hard copy and electronic format as part of the project documentation.

Performance Measures

Performance measures for this contract shall include the following:
(a) Performance standards and evaluation: Grantee will produce detailed deliverables for each task as specified. Grantee shall maintain receipts for all project expenses and documentation of the minimum in-kind contributions (if applicable) per the budget in Exhibit B. Per Water Plan Grant Guidelines, the CWCB will pay out the last 10% of the budget when the Final Report is completed to the satisfaction of CWCB staff. Once the Final Report has been accepted, and final payment has been issued, the purchase order or grant will be closed without any further payment.
(b) Accountability: Per Water Plan Grant Guidelines full documentation of project progress must be submitted with each invoice for reimbursement. Grantee must confirm that all grant conditions have been complied with on each invoice. In addition, per Water Plan Grant Guidelines, Progress Reports must be submitted at least once every 6 months. A Final Report must be submitted and approved before final project payment.

Last Updated: July 2019

Performance Measures
(c) Monitoring Requirements: Grantee is responsible for ongoing monitoring of project progress per Exhibit A. Progress shall be detailed in each invoice and in each Progress Report, as detailed above. Additional inspections or field consultations will be arranged as may be necessary. (d) Noncompliance Resolution: Payment will be withheld if grantee is not current on all grant conditions. Flagrant disregard for grant conditions will result in a stop work order and cancellation of the Grant Agreement.

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Colorado Water Conservation Board

Water Plan Grant - Exhibit B
Budget and Schedule

Prepared Date: July 28, 2019

Name of Applicant: Center for Snow and Avalanche Studies

Name of Water Project: Colorado Dust-on-Snow Project

Project Start Date: January 1, 2020

Project End Date: December 31, 2024

Task No.	Task Description	Task Start Date	Task End Date	Grant Funding Request	Match Funding	Total
1	Statewide Dust-on-Snow Field Work	1/1/2020	12/31/2024	60,250	189,950	$250,200
2	Dust-on-Snow Reporting, Reporting and Outreach	1/1/2020	12/31/2024	34,025	107,750	$141,775
3	Station maintenance, calibration, data management, website data access	1/1/2020	12/31/2024	30,725	97,300	$128,025
						$0
						$0
			Total	$125,000	$395,000	$520,000

Letters of Matching and/or Pending Party Commitments

Please note: Some Letters of Matching Commitment also serve (I feel) as Letters of Support, you may find the same Letter in Exhibit A under Letters of Support

United States Department of the Interior

U. S. GEOLOGICAL SURVEY
Box 25046, MS 980
Denver Federal Center
Denver, Colorado 80225-0046
Geosciences and Environmental Change Science Center

July 30, 2019

To whom it may concern,

The U.S. Geological Survey has maintained an 8-year collaboration with the Center for Snow and Avalanche Studies (CSAS) and their Dust-on-Snow research by providing in-kind lab analyses of dust-on-snow samples. Analyses includes determining dust mass loading, dust particle size, and mineral compositions of dust deposited at all 11 CODOS sample locations throughout Colorado. The U.S. Geological Survey intends to continue our collaboration with CSAS into the foreseeable future barring unexpected budgetary constraints. I strongly encourage your support for the important data collection and research being conducted by CSAS so that this valuable and unique program can be sustained.

Respectfully,

Harland Goldstein

Upper Gunnison River Water Conservancy District

210 West Spencer Avenue, Suite B • Gunnison, Colorado 81230
(970) 641-6065 • www.ugrwcd.org

July 31, 2019

Colorado Water Conservation Board
1313 Sherman Street, Room 718
Denver, CO 80203

RE: Letter of Matching Funding

To Whom It May Concern:

On behalf of Upper Gunnison River Water Conservancy District (UGRWCD) I encourage you to support the data collection and research being conducted by the Center for Snow and Avalanche Studies (CSAS) located in Silverton, Colorado.

The UGRWCD has supported the Center's Dust-on-Snow research in nearly every year since 2009 at the $7,500 level and has full intentions of continuing support at this amount in the foreseeable future.

The information distributed by the Colorado Dust-on-Snow Program and CSAS has been a useful tool in monitoring and documenting dust and snow events that can be directly correlated to runoff patterns throughout the region and state. The UGRWCD believes that the information and updates provided by CSAS are a valuable resource for predicting the effects of these, and for forecasting spring runoff. The collection of this base data will make this information even more valuable for future modeling efforts.

The Dust-on-Snow Program relies heavily on a broad base of support from numerous funders and stakeholders, and the UGRWCD greatly appreciates the past participation from the Colorado Water Conservation Board. We encourage your Board to give this request a favorable recommendation so that this valuable program can be sustained.

Sincerely,

Frank J. Kugel
General Manager

United States Department of the Interior

BUREAU OF RECLAMATION
Lower Colorado Regional Office
P. O. Box 61470
Boulder City, NV 89006-1470

IN REPLY REFER TO:
LC-10103
1.3.10

VIA ELECTRONIC MAIL ONLY

Center for Snow and Avalanche Studies
Mr. Jeff Derry
P.O. Box 190
Silverton, CO 81433

Subject: Agreement No. R17AP00074 – Colorado Dust-on-Snow Program

Dear Mr. Derry,

The subject Agreement was awarded on July 10, 2017 for $59,056.00. The total obligations to date on the Agreement are $35,000.00 and the remaining performance period is 24 months.

If you have questions regarding this letter, please contact me at 702-293-8550 or Leslie Dieguez Grants Management Specialist, at 702- 293- 8369.

Sincerely,

Diana Blake
Grants Officer

Gmail **Chris Landry <snowstudies@gmail.com>**

CSAS: Letter of Matching Commitment

1 message

Anderson, Beth A -FS <beth.a.anderson@usda.gov> Mon, Jul 29, 2019 at 8:36 AM
To: "jderry@snowstudies.org" <jderry@snowstudies.org>
Cc: "Fehlmann, Merna -FS" <merna.fehlmann@usda.gov>

Hi Jeff,

On behalf of Grand Mesa, Uncompahgre, and Gunnison (GMUG) National Forest, we encourage the Colorado Water Conservation Board to support the data collection and research being conducted by the Center for Snow and Avalanche Studies (CSAS) located in Silverton, Colorado. GMUG has supported Center for Snow and Avalanche Studies for over five years at the $8,000/year level. GMUG has full intentions of continuing our support at the $8,000 level into the foreseeable future.

Thank you,

Beth Anderson

Beth Anderson
Watershed Program Manager

Forest Service

Grand Mesa, Uncompahgre &

Gunnison National Forest

p: 970-874-6656
c: 970-275-7620
Beth.a.anderson@usda.gov

2250 South Main Street
Delta, CO 81416
www.fs.fed.us

Caring for the land and serving people

Colorado River District
Protecting Western Colorado Water Since 1937

Colorado Water Conservation Board
1313 Sherman Street, Room 718
Denver, CO 80203

RE: Colorado Water Plan Request and Letter of Support for CSAS

July 31, 2019

To Whom It May Concern:

On behalf of Colorado River District (CRD) I am writing to urge you to support the Colorado Water Plan funding request to support the data collection and research being conducted by the Center for Snow and Avalanche Studies (CSAS) located in Silverton, Colorado.

Addressing this funding issue clearly fits the mission of the Colorado River District: "***to lead in the protection, conservation, use, and development of the water resources of the Colorado River basin for the welfare of the District***." For this reason, the CRD has a long history supporting CSAS and the associated Colorado Dust-on-Snow (CODOS) research starting in 2007. Since then the CRD has increased this support level to $25,000/year and we intend to continue this level of support into the foreseeable future, subject to availability and annual appropriation.

The CODOS information collected and provided by the CSAS is a powerful tool to assist in the monitoring, assessment and evaluation of changes related to climate and related snowmelt runoff patterns and forecasting throughout the state and Upper Colorado River basin region. The CSAS is a unique entity and their sophisticated monitoring program in Senator Beck sub basin is an essential resource that is found nowhere else. The CSAS programs provide and archive data sets that are critical for future modeling efforts, as well.

In summary, the CSAS programs relies heavily on a broad base of support from numerous funders and stakeholders, and as such, we encourage the CWCB to not only continue historical support of CSAS but to expand this support by issuing a favorable recommendation for the Colorado Water Plan grant funding request so that this valuable program can be sustained.

Sincerely,

Dave "DK" Kanzer, P.E.

201 Centennial Street / PO Box 1120 • Glenwood Springs, CO 81602
(970) 945-8522 • (970) 945-8799 Fax
www.ColoradoRiverDistrict.org

Deputy Chief Engineer

July 30, 2019

Colorado Water Conservation Board of Directors
1313 Sherman Street
Denver, Colorado 80203

TRI-COUNTY WATER
CONSERVANCY DISTRICT

Dear Board of Directors:

The Center for Snow and Avalanche Studies (CSAS) is applying for Water Plan Grant. CSAS's efforts to study the effects of dust on our snowpack and the resulting yearly runoff are critical to our mission at Tri-County Water. The study plots are located within our drainage basin above Ridgway Reservoir and the CSAS has been instrumental in helping us manage our water supplies by providing real time information to help us to predict the volume of runoff to be expected and more importantly the timing. They provide daily updates and analysis that greatly improve management of our water supplies.

Tri-County started supporting CSAS's Dust-on-Snow research in 2007 at the $1,000/year level. In 2010 we increased our support to $2,500/year and have contributed that amount every year since. Tri-County Water has every intention of continuing our support at the $2,500 level into the foreseeable future.

Since CSAS provides such a unique and valuable service to the water managers of Colorado, Tri-County Water ardently supports the CSAS's application to the CWCB for a Water Plan Grant and encourages the Board to give it due consideration.

Sincerely,

Mike Berry
General Manager

647 NORTH 7TH STREET · MONTROSE, COLORADO 81401
(970) 249-3369 · TRICOUNTYWATER.ORG

DENVER WATER

1600 West 12th Ave
Denver, CO 80204-3412
303.628.6000
denverwater.org

July 30, 2019

Colorado Water Conservation Board

1313 Sherman Street, Room 721
Denver, CO 80203

Re: Center for Snow and Avalanche Studies

Dear Board Members,

On behalf of Denver Water, I encourage you to continue supporting the research being conducted by the Center for Snow and Avalanche Studies located in Silverton, Colorado. Denver Water has been supporting the Center's "Dust on Snow" research since 2007, and in 2013 we began supporting the more general mission of the Center. Since 2013 Denver Water has contributed $6000 toward the Dust on Snow program and an additional $5000 for general support. Denver Water intends to continue to support the Center at these funding levels into the future.

Denver Water supports the research conducted by the Center for Snow and Avalanche studies because we consider it worthwhile. Already the research has provided an answer to this important question: *"Does dust on snow cause a reduction in the seasonal volume of snowmelt or is it only the timing of the melt affected?"* The dust reports we receive during the winter and spring help us to predict how quickly the snow is likely to melt, which helps us manage our water supply facilities. With adequate support from water suppliers and organizations such as the CWCB, I expect that the Center will continue disseminating useful research results, including the effects of climate change on snow hydrology.

If you have any questions, please contact me at laurna.kaatz@denverwater.org.

Sincerely,

Laurna Kaatz
Climate Program Director
Denver Water

THE SOUTHWESTERN WATER CONSERVATION DISTRICT
Developing and Conserving the Waters in the
SAN JUAN AND DOLORES RIVERS AND THEIR TRIBUTARIES
West Building – 841 East Second Avenue
DURANGO, COLORADO 81301
(970) 247-1302

July 29, 2019

Colorado Water Conservation Board
1313 Sherman Street, Room 718
Denver, CO 80203

RE: Letter of Support - Water Plan Implementation Grant Application - Center for Snow & Avalanche Studies

To Whom It May Concern:

On behalf of the Southwestern Water Conservation District (SWCD), I encourage you to support the data collection and research being conducted by the Center for Snow and Avalanche Studies (CSAS) located in Silverton, Colorado.

SWCD started supporting CSAS's Dust-on-Snow research in 2007 at the $5,000/year level and has contributed that amount every year since. The information distributed by the Colorado Dust-on-Snow Program and CSAS has been a useful tool in monitoring and documenting dust and snow events that can be directly correlated to runoff patterns throughout the region and state. SWCD believes that the information and updates provided by CSAS are a valuable resource for predicting the effects of these, and for forecasting spring runoff. The collection of this base data will make this information even more valuable for future modeling efforts.

The Dust-on-Snow Program relies heavily on a broad base of support from numerous funders and stakeholders, and SWCD greatly appreciates the past participation from the Colorado Water Conservation Board. We encourage your Board to give this request a favorable recommendation so that this valuable program can be sustained.

Thank you in advance for your consideration of their request.

Warm Regards,

Robert Wolff
Board President
Southwestern Water Conservation District

Rio Grande Water Conservation District
8805 Independence Way • Alamosa, Colorado 81101
Phone: (719) 589-6301 • Fax: (719) 992-2026
Protecting & Conserving San Luis Valley Water

July 29, 2019
Colorado Water Conservation Board
1313 Sherman Street, Room 718
Denver, CO 80203

RE: Letter of Matching Funding

To Whom It May Concern:

On behalf of the Rio Grande Water Conservation District (RGWCD) I encourage you to support the data collection and research being conducted by the Center for Snow and Avalanche Studies (CSAS) located in Silverton, Colorado.

The RGWCD started supporting CSAS's Dust-on-Snow research in 2008 at the $3,000/year level. Beginning in 2010 RGWCD increased our support to $5,000/year and has contributed that amount every year since. RGWCD has full intentions of continuing our support at the $5,000 level into the foreseeable future.

The information distributed by the Colorado Dust-on-Snow Program and CSAS has been a useful tool in monitoring and documenting dust and snow events that can be directly correlated to runoff patterns throughout the region and state. The RGWCD believes that the information and updates provided by CSAS are a valuable resource for predicting the effects of these, and for forecasting spring runoff. The collection of this base data will make this information even more valuable for future modeling efforts.

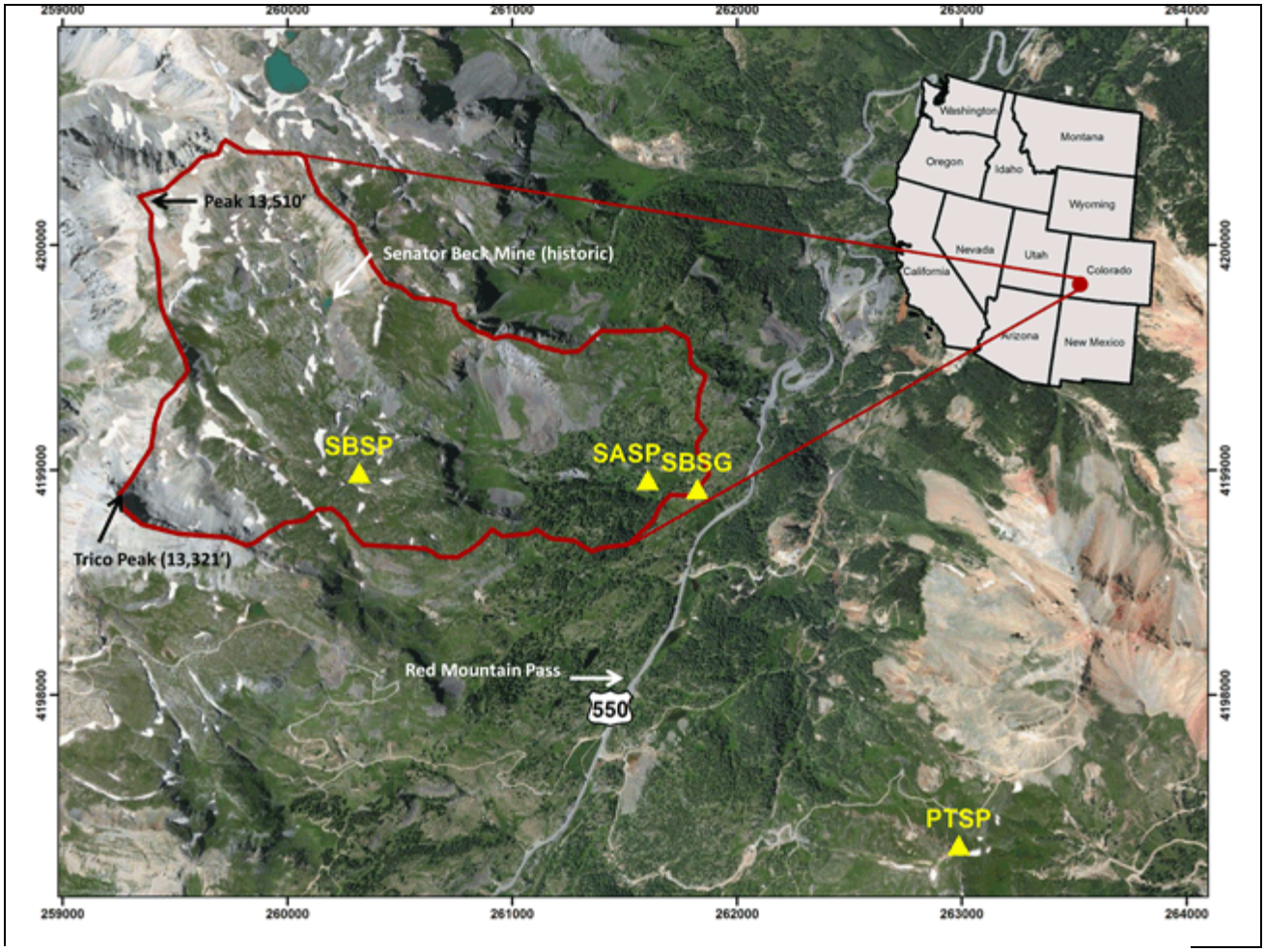
The Dust-on-Snow Program relies heavily on a broad base of support from numerous funders and stakeholders, and the RGWCD greatly appreciates the past participation from the Colorado Water Conservation Board. We encourage your Board to give this request a favorable recommendation so that this valuable program can be sustained.

Sincerely,

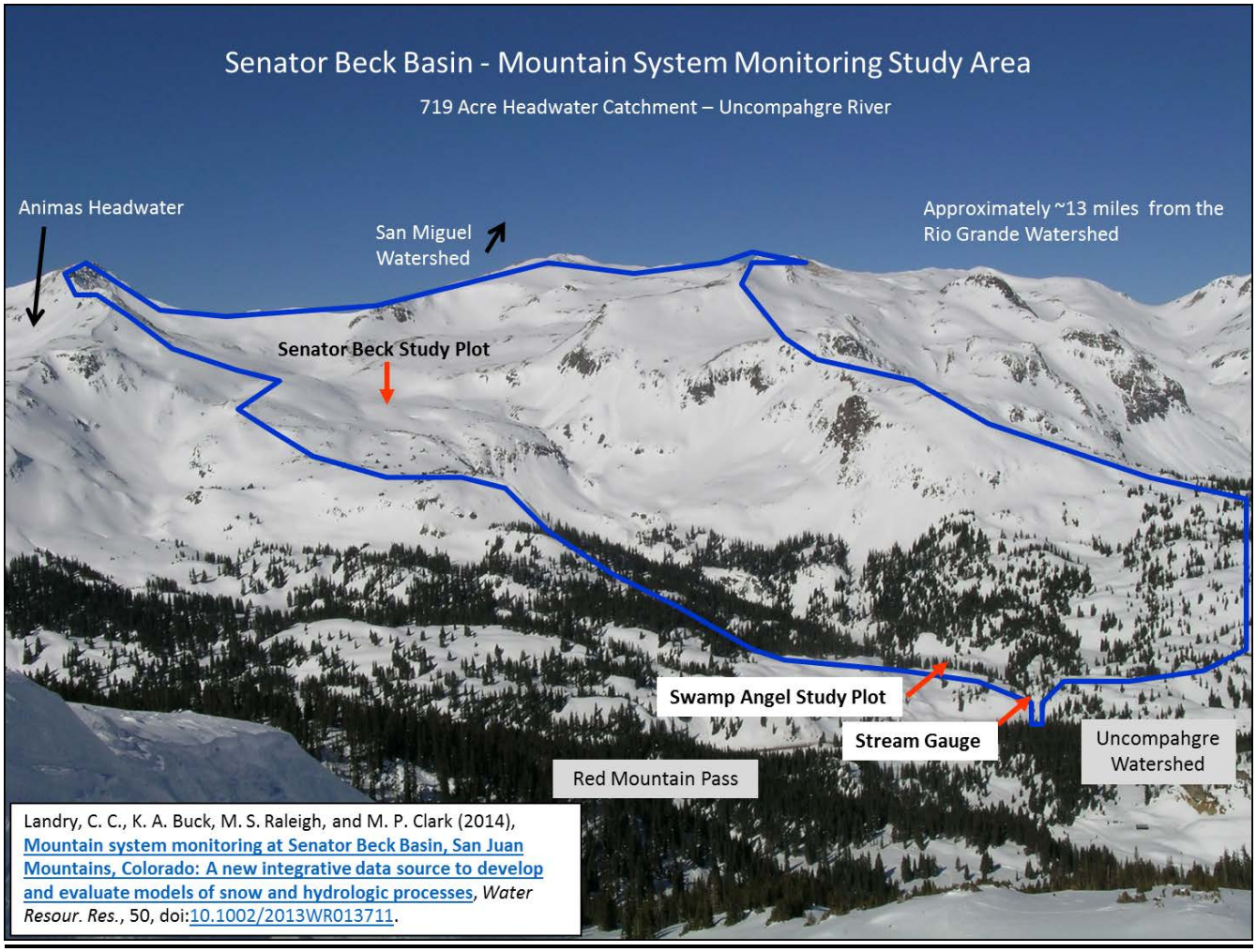
Cleave Simpson
General Manager-Rio Grande Water Conservation District

Exhibit C

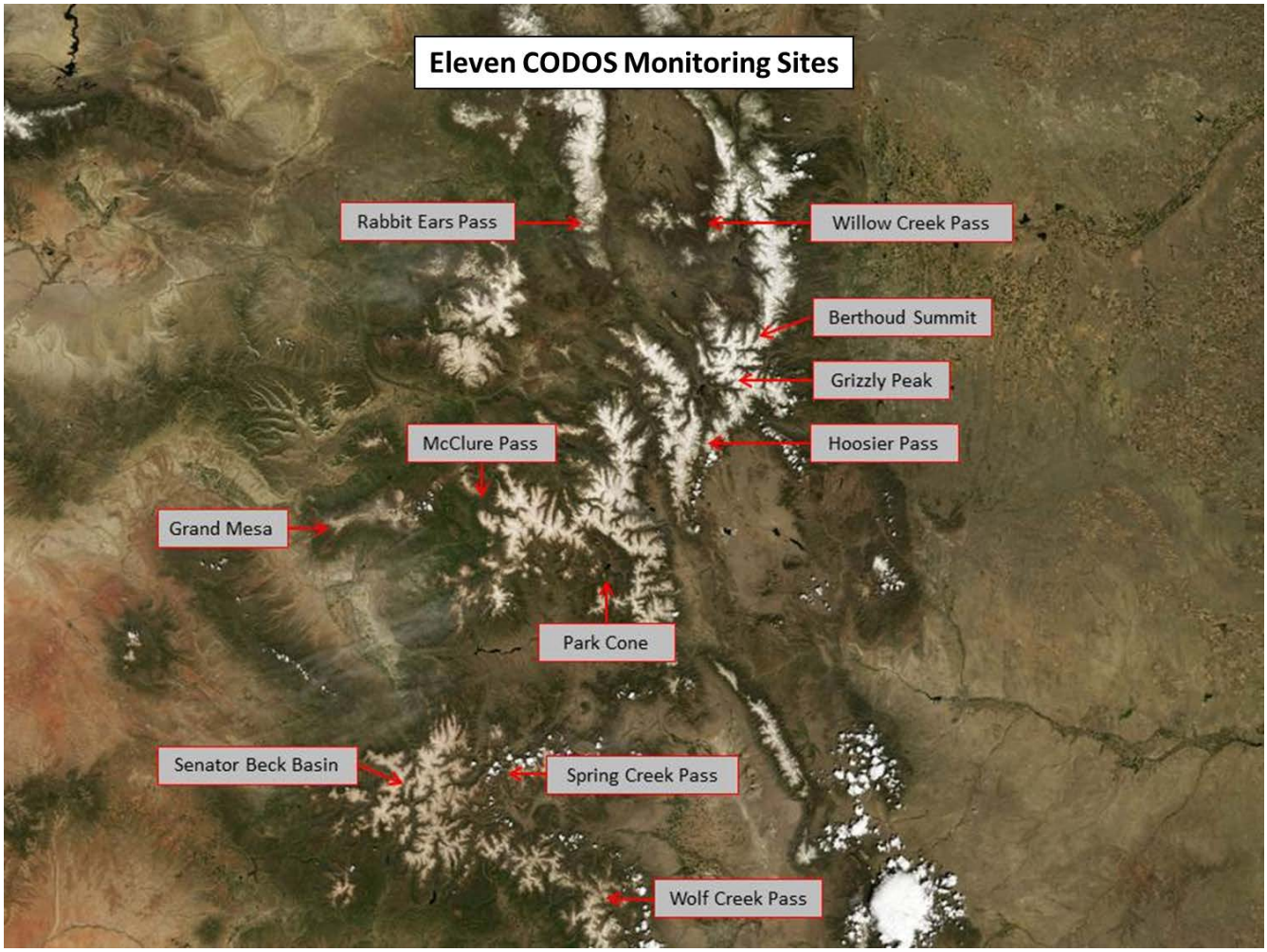
Project Map



Senator Beck Basin Study Area is located at 37°54'24.8"N x 107°43'34.6"W in the Ouray Ranger District of the Uncompahgre National Forest in the Western San Juan Mountains of Southwestern Colorado. A Special Use Permit was granted to the Center for Snow and Avalanche Studies in October 2003. Under that permit, CSAS received permission to develop and use two study plots and develop a stream gauging station within the 719 acre (290 ha) Senator Beck Basin.

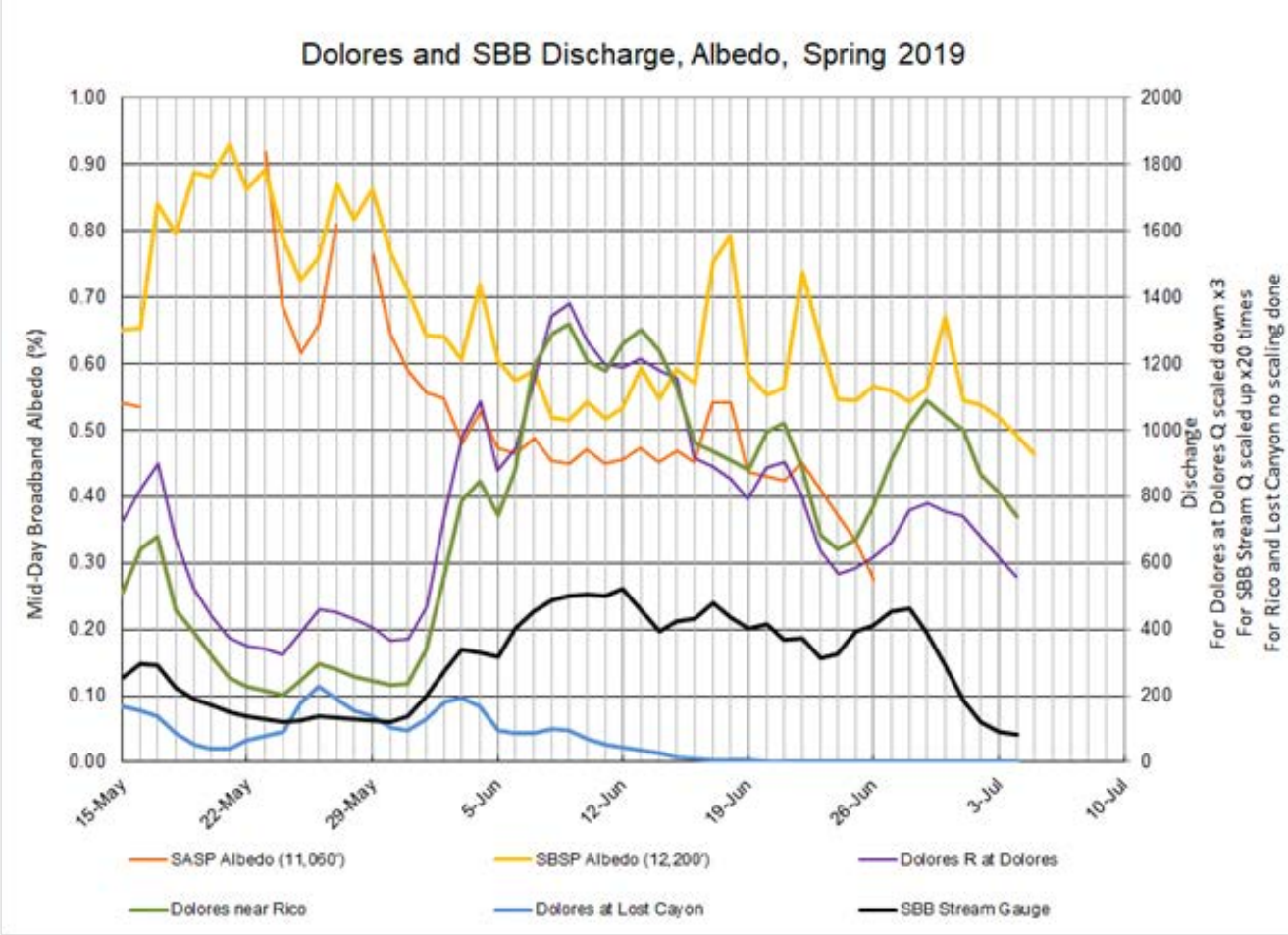


Senator Beck Basin is a high elevation headwater catchment located in the Uncompahgre Watershed. The Uncompahgre River is a major tributary to the Gunnison River, itself a major tributary to the Colorado River. SBB also immediately adjoins headwater catchments of the Animas River, a major tributary of the San Juan River, and headwaters of the San Miguel River, a major tributary to the Dolores River, all of which are also tributaries to the Colorado River. SBB is 13 miles to the west of the Rio Grande watershed.

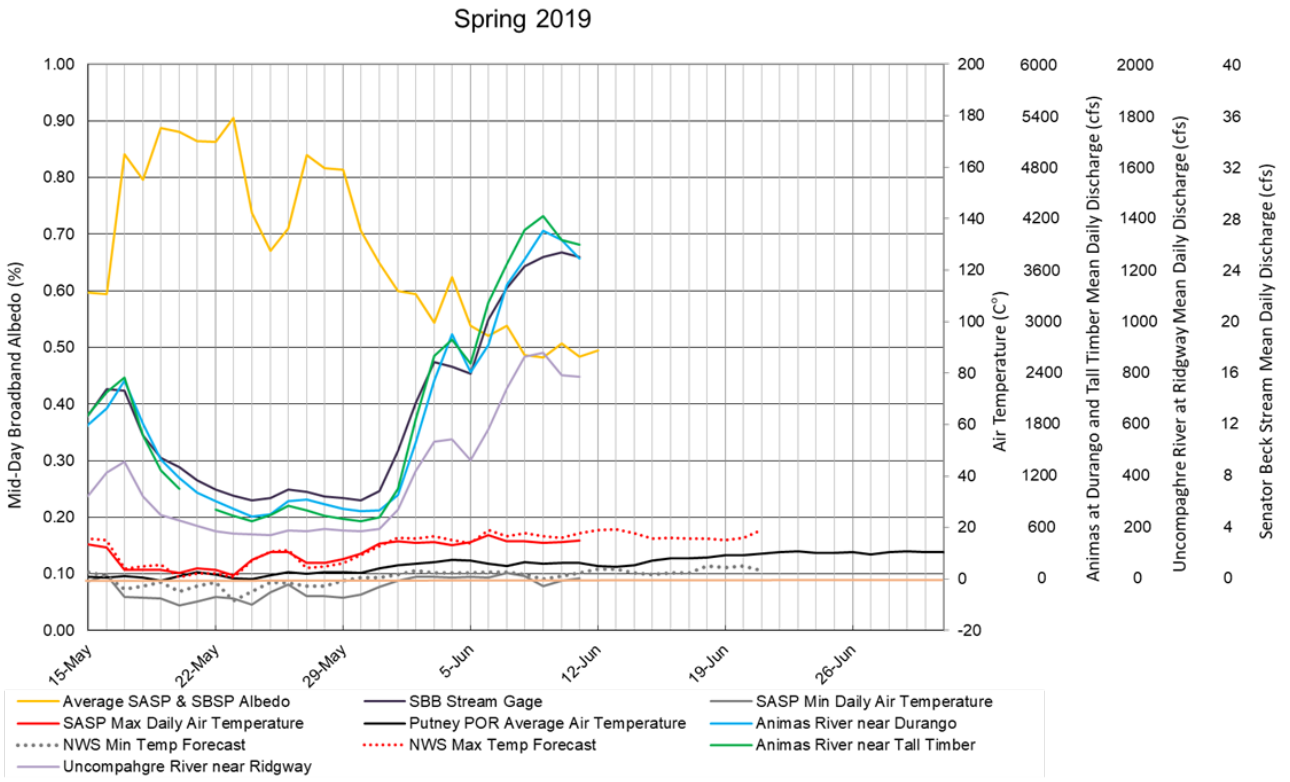


Map of the CODOS Project sample locations throughout Colorado. All sites are located at the summit of mountain passes near SNOTEL stations to compliment both datasets. Note the difference of dust-on-snow severity in Southwest Colorado vs Northeast Colorado in this MODIS image.

Data Plots



Example of data plots provided to water managers on a daily basis during snow ablation. Albedo measurements typically give managers a 1-2 day "heads up" of changes in streamflow.



Example of data plots provided to water managers on a daily basis during snow ablation. Albedo measurements typically give managers a 1-2 day "heads up" of changes in streamflow. This plot also takes into account the NWS forecast for minimum and maximum daily air temperatures.

Letters of Support

United States Department of the Interior
BUREAU OF RECLAMATION
Western Colorado Area Office
Durango Field Division
185 Suttle Street, Suite 2
Durango, CO 81303-7911

IN REPLY REFER TO:

WCD-SBehery
2.4.1.04

August 1, 2019

Mr. Chairman
Colorado Water Conservation Board
1313 Sherman St.
Room 718
Denver, Colorado 80203

Subject: Letter of Support for Water Plan Grant funding for Center for Snow and Avalanche Studies

Dear Mr. Chairman, Colorado Water Conservation Board Members and Staff:

As the Hydrologist for the Western Colorado Area Office for Reclamation, it is my pleasure to write this letter of support on behalf of the Center for Snow and Avalanche Studies (CSAS) for a Water Plan Grant.

Reclamation and CSAS have worked together for many years, and most recently have stepped up collaboration in 2019 for the very exciting above-average snowpack and runoff season. Having critical information regarding snowpack conditions is crucial to management and filling operations, especially at the highest mountain elevations where CSAS sites are located. No other entity provides high elevation (>12,000 ft) snowpack, radiation, and dust data along with consistent communication and analysis.

In 2019, data and analysis provided by Jeff on a daily (and sometimes more often) basis were crucial in making decisions on major operations at both Navajo and McPhee dams. Dust, solar radiation, flow, and temperature data at CSAS's high elevation sites aided realtime operations in the Animas, San Juan, and Dolores basins, as they gave a 1-3 day heads-up on what was going to be coming down the river.

At Navajo Dam, data and analysis provided by Jeff helped forecast the peak date on the Animas River with a 10-day lead time, which is the trigger for Navajo's annual ESA-mandated spring peak release. The perfectly timed release, coupled with the above average snowpack, resulted in satisfying the peak 10,000 cfs downstream flow target for the first time in 10 years.

At McPhee Reservoir, the realtime high elevation data helped Reclamation manage the peaks and rampdown of the recreational release, ensuring that boater flows and ecological flow targets were

maximized while protecting project water. High elevation snow remained when SNOTEL stations began "going blind," and the high elevation data helped managers to continue structuring releases to meet ecological and recreation goals when otherwise they would have been purely at the mercy of the high elevation snowmelt and inflows without a look ahead. Jeff's consistent observations and data were extremely valuable during this time to forecast release patterns and the expected remaining duration of the higher inflows for communication to the public to aid in their planning and expected boating days below McPhee Dam on the Dolores River. It also helped to meet the challenge of balancing the reservoir at full capacity at the critical time necessary to meet flow regime goals below McPhee Dam ramping down from boatable flows to the base flow.

At our four other San Juan River Basin reservoirs, the high elevation data was used when performing the delicate balancing act of inflows-vs-releases in a year with a very high volume of water and rain-on-snow events. This was essential to ensure the reservoirs filled while releases remained under safe channel capacity. Once the other SNOTEL stations melted out to zero, forecasters have little information on what is coming next. Having a streamgage at Swamp Angel gave us essential information on the persistent high elevation snow and melt, and whether flow reductions we were seeing downstream was likely due to cloud cover, albedo resets from precipitation, or other factors, and at what point we could start reasonably expecting the recession to begin.

Anyone interested in becoming familiar with the work performed at CSAS should attend the annual Snow School. Learning what kind of data is available, how it is collected and where, and the implications of the findings at the sites was an eye-opening experience that has led to a great collaborative relationship benefiting Reclamation's mission.

I can highly recommend CSAS for a Water Plan Grant and believe the data and effort provided by Jeff and his staff are well worth the investment.

Sincerely,

Susan Novak Behery, P.E.
Hydraulic Engineer

July 30, 2019

Colorado Water Conservation Board of Directors
1313 Sherman Street
Denver, Colorado 80203

TRI-COUNTY WATER
CONSERVANCY DISTRICT

Dear Board of Directors:

The Center for Snow and Avalanche Studies (CSAS) is applying for Water Plan Grant. CSAS's efforts to study the effects of dust on our snowpack and the resulting yearly runoff are critical to our mission at Tri-County Water. The study plots are located within our drainage basin above Ridgway Reservoir and the CSAS has been instrumental in helping us manage our water supplies by providing real time information to help us to predict the volume of runoff to be expected and more importantly the timing. They provide daily updates and analysis that greatly improve management of our water supplies.

Tri-County started supporting CSAS's Dust-on-Snow research in 2007 at the $1,000/year level. In 2010 we increased our support to $2,500/year and have contributed that amount every year since. Tri-County Water has every intention of continuing our support at the $2,500 level into the foreseeable future.

Since CSAS provides such a unique and valuable service to the water managers of Colorado, Tri-County Water ardently supports the CSAS's application to the CWCB for a Water Plan Grant and encourages the Board to give it due consideration.

Sincerely,

Mike Berry
General Manager

647 NORTH 7TH STREET · MONTROSE, COLORADO 81401
(970) 249-3369 · TRICOUNTYWATER.ORG

Rio Grande Water Conservation District
8805 Independence Way • Alamosa, Colorado 81101
Phone: (719) 589-6301 • Fax: (719) 992-2026
Protecting & Conserving San Luis Valley Water

July 29, 2019
Colorado Water Conservation Board
1313 Sherman Street, Room 718
Denver, CO 80203

RE: Letter of Matching Funding

To Whom It May Concern:

On behalf of the Rio Grande Water Conservation District (RGWCD) I encourage you to support the data collection and research being conducted by the Center for Snow and Avalanche Studies (CSAS) located in Silverton, Colorado.

The RGWCD started supporting CSAS's Dust-on-Snow research in 2008 at the $3,000/year level. Beginning in 2010 RGWCD increased our support to $5,000/year and has contributed that amount every year since. RGWCD has full intentions of continuing our support at the $5,000 level into the foreseeable future.

The information distributed by the Colorado Dust-on-Snow Program and CSAS has been a useful tool in monitoring and documenting dust and snow events that can be directly correlated to runoff patterns throughout the region and state. The RGWCD believes that the information and updates provided by CSAS are a valuable resource for predicting the effects of these, and for forecasting spring runoff. The collection of this base data will make this information even more valuable for future modeling efforts.

The Dust-on-Snow Program relies heavily on a broad base of support from numerous funders and stakeholders, and the RGWCD greatly appreciates the past participation from the Colorado Water Conservation Board. We encourage your Board to give this request a favorable recommendation so that this valuable program can be sustained.

Sincerely,

Cleave Simpson
General Manager-Rio Grande Water Conservation District

DENVER WATER

1600 West 12th Ave
Denver, CO 80204-3412
303.628.6000
denverwater.org

July 30, 2019

Colorado Water Conservation Board

1313 Sherman Street, Room 721
Denver, CO 80203

Re: Center for Snow and Avalanche Studies

Dear Board Members,

On behalf of Denver Water, I encourage you to continue supporting the research being conducted by the Center for Snow and Avalanche Studies located in Silverton, Colorado. Denver Water has been supporting the Center's "Dust on Snow" research since 2007, and in 2013 we began supporting the more general mission of the Center. Since 2013 Denver Water has contributed $6000 toward the Dust on Snow program and an additional $5000 for general support. Denver Water intends to continue to support the Center at these funding levels into the future.

Denver Water supports the research conducted by the Center for Snow and Avalanche studies because we consider it worthwhile. Already the research has provided an answer to this important question: *"Does dust on snow cause a reduction in the seasonal volume of snowmelt or is it only the timing of the melt affected?"* The dust reports we receive during the winter and spring help us to predict how quickly the snow is likely to melt, which helps us manage our water supply facilities. With adequate support from water suppliers and organizations such as the CWCB, I expect that the Center will continue disseminating useful research results, including the effects of climate change on snow hydrology.

If you have any questions, please contact me at laurna.kaatz@denverwater.org.

Sincerely,

Laurna Kaatz
Climate Program Director
Denver Water

Upper Gunnison River Water Conservancy District

210 West Spencer Avenue, Suite B • Gunnison, Colorado 81230
(970) 641-6065 • www.ugrwcd.org

July 31, 2019

Colorado Water Conservation Board
1313 Sherman Street, Room 718
Denver, CO 80203

RE: Letter of Matching Funding

To Whom It May Concern:

On behalf of Upper Gunnison River Water Conservancy District (UGRWCD) I encourage you to support the data collection and research being conducted by the Center for Snow and Avalanche Studies (CSAS) located in Silverton, Colorado.

The UGRWCD has supported the Center's Dust-on-Snow research in nearly every year since 2009 at the $7,500 level and has full intentions of continuing support at this amount in the foreseeable future.

The information distributed by the Colorado Dust-on-Snow Program and CSAS has been a useful tool in monitoring and documenting dust and snow events that can be directly correlated to runoff patterns throughout the region and state. The UGRWCD believes that the information and updates provided by CSAS are a valuable resource for predicting the effects of these, and for forecasting spring runoff. The collection of this base data will make this information even more valuable for future modeling efforts.

The Dust-on-Snow Program relies heavily on a broad base of support from numerous funders and stakeholders, and the UGRWCD greatly appreciates the past participation from the Colorado Water Conservation Board. We encourage your Board to give this request a favorable recommendation so that this valuable program can be sustained.

Sincerely,

Frank J. Kugel
General Manager

Colorado River District
Protecting Western Colorado Water Since 1937

Colorado Water Conservation Board
1313 Sherman Street, Room 718
Denver, CO 80203

RE: Colorado Water Plan Request and Letter of Support for CSAS

July 31, 2019

To Whom It May Concern:

On behalf of Colorado River District (CRD) I am writing to urge you to support the Colorado Water Plan funding request to support the data collection and research being conducted by the Center for Snow and Avalanche Studies (CSAS) located in Silverton, Colorado.

Addressing this funding issue clearly fits the mission of the Colorado River District: "***to lead in the protection, conservation, use, and development of the water resources of the Colorado River basin for the welfare of the District***." For this reason, the CRD has a long history supporting CSAS and the associated Colorado Dust-on-Snow (CODOS) research starting in 2007. Since then the CRD has increased this support level to $25,000/year and we intend to continue this level of support into the foreseeable future, subject to availability and annual appropriation.

The CODOS information collected and provided by the CSAS is a powerful tool to assist in the monitoring, assessment and evaluation of changes related to climate and related snowmelt runoff patterns and forecasting throughout the state and Upper Colorado River basin region. The CSAS is a unique entity and their sophisticated monitoring program in Senator Beck sub basin is an essential resource that is found nowhere else. The CSAS programs provide and archive data sets that are critical for future modeling efforts, as well.

In summary, the CSAS programs relies heavily on a broad base of support from numerous funders and stakeholders, and as such, we encourage the CWCB to not only continue historical support of CSAS but to expand this support by issuing a favorable recommendation for the Colorado Water Plan grant funding request so that this valuable program can be sustained.

Sincerely,

Dave "DK" Kanzer, P.E.

201 Centennial Street / PO Box 1120 • Glenwood Springs, CO 81602
(970) 945-8522 • (970) 945-8799 Fax
www.ColoradoRiverDistrict.org

Deputy Chief Engineer

THE SOUTHWESTERN WATER CONSERVATION DISTRICT
Developing and Conserving the Waters in the
SAN JUAN AND DOLORES RIVERS AND THEIR TRIBUTARIES
West Building – 841 East Second Avenue
DURANGO, COLORADO 81301
(970) 247-1302

July 29, 2019

Colorado Water Conservation Board
1313 Sherman Street, Room 718
Denver, CO 80203

RE: Letter of Support - Water Plan Implementation Grant Application - Center for Snow & Avalanche Studies

To Whom It May Concern:

On behalf of the Southwestern Water Conservation District (SWCD), I encourage you to support the data collection and research being conducted by the Center for Snow and Avalanche Studies (CSAS) located in Silverton, Colorado.

SWCD started supporting CSAS's Dust-on-Snow research in 2007 at the $5,000/year level and has contributed that amount every year since. The information distributed by the Colorado Dust-on-Snow Program and CSAS has been a useful tool in monitoring and documenting dust and snow events that can be directly correlated to runoff patterns throughout the region and state. SWCD believes that the information and updates provided by CSAS are a valuable resource for predicting the effects of these, and for forecasting spring runoff. The collection of this base data will make this information even more valuable for future modeling efforts.

The Dust-on-Snow Program relies heavily on a broad base of support from numerous funders and stakeholders, and SWCD greatly appreciates the past participation from the Colorado Water Conservation Board. We encourage your Board to give this request a favorable recommendation so that this valuable program can be sustained.

Thank you in advance for your consideration of their request.

Warm Regards,

Robert Wolff
Board President
Southwestern Water Conservation District

United States Department of the Interior

U. S. GEOLOGICAL SURVEY
Box 25046, MS 980
Denver Federal Center
Denver, Colorado 80225-0046
Geosciences and Environmental Change Science Center

July 30, 2019

To whom it may concern,

The U.S. Geological Survey has maintained an 8-year collaboration with the Center for Snow and Avalanche Studies (CSAS) and their Dust-on-Snow research by providing in-kind lab analyses of dust-on-snow samples. Analyses includes determining dust mass loading, dust particle size, and mineral compositions of dust deposited at all 11 CODOS sample locations throughout Colorado. The U.S. Geological Survey intends to continue our collaboration with CSAS into the foreseeable future barring unexpected budgetary constraints. I strongly encourage your support for the important data collection and research being conducted by CSAS so that this valuable and unique program can be sustained.

Respectfully,

Harland Goldstein

Colorado State University
Knowledge to Go Places

Natural Resource Ecology Laboratory
1499 Campus Delivery
Fort Collins, Colorado 80523-1499 U.S.A.
FAX (970) 491-1965

16 April 2009

To Whom It May Concern:

Dramatic changes are occurring in mountain regions worldwide as the climate warms, and yet mountain areas worldwide are poorly instrumented and studied. In spite of serving as vitally important source areas for water, there are few time series of quantitative measurements at high elevations that can be used to measure nature and rates of environmental change. This is true even in the American West where mountain snowpacks supply water for up to 30 million people downstream. Research at high altitudes is physically demanding and often dangerous, and there are few academic centers in mountainous areas to provide a source of investigators. And yet here we have the Center for Snow and Avalanche Studies in Silverton, Colorado, that has undertaken to develop a long-term research and monitoring program for the San Juan Mountains in the Senator Beck Basin. Their work has already provided invaluable information on how land use change in desert regions to the west contribute dust to snowpacks and alter snowmelt dynamics. There is no similar study area within hundreds of kilometers.

The Center for Snow and Avalanche Studies, combined with the Silverton-based Mountain Studies Institute, is trying to fill a gaping hole in the understanding of San Juan Mountains climate, hydrology, biogeochemistry, and ecology in a place where little past research has occurred. These mountains host headwaters of the Colorado and Rio Grande Rivers and are at the junction of major ecological and weather zones of the western US. Considering the value of high elevation records, I strongly encourage support to continue the meteorological and hydrologic monitoring at Senator Beck. I hope also that researchers, including myself and my students, will be able to take advantage of these records in years to come.

Sincerely,

Jill S. Baron, Senior Research Scientist, Colorado State University, and
Research Ecologist, US Geological Survey

MARK W. WILLIAMS
Institute for Arctic and Alpine Research
University of Colorado at Boulder, CB 450
Boulder, CO 80309

303.492.8830 (tel)
303.492.6388 (fax)
markw@snobear.colorado.edu

Chris Landry
Center for Snow and Avalanche Studies
PO Box 190
Silverton, CO 81433

To: potential collaborators

Dear Chris,

It is my pleasure to write a letter of support for the monitoring activities conducted at the high-elevation Senator Beck basin by the Center for Snow and Avalanche Studies. High-elevation ecosystems are the most threatened ecosystems in theUnited States. Your monitoring activities are essential for early detection of environmental problems.

I am the principal investigator of the Niwot Ridge (NWT) Long-Term Ecological Research Project (LTER), funded by the National Science Foundation. The NWT LTER program is the only high-elevation site in the LTER network and the only multidisciplinary, long-term alpine and subalpine study site on the continent. My experience as the PI of the NWT LTER has shown that meteorological, hydrological, cryospheric, and ecological conditions change strongly over relatively short distances in mountain environments. Thus, high-elevation areas serve as early-warning systems where the environmental impacts of climate change, including changes in atmospheric chemistry, can be studied directly.

High-elevation ecosystems at mid-latitudes are characterized by a six to nine month period of continuous snow cover, with freezing temperatures and snow possible throughout the growing season. The harsh environmental conditions characteristic of these environments result in organisms that are on the edge of environmental tolerances. Consequently, these organisms and the biogeochemical processes mediated by them are sensitive to small environmental changes in climate and other parameters. Moreover, the presence of a seasonal snowpack in alpine environments amplifies climate signals.

The San Juan Mountains face special threats as a result of possible changes in global climate and also from regional pollution caused by existing and proposed coal-fired power plants. Monitoring of snow conditions is essentially to quantify if, when, and how much climate warming may affect the amount of snowfall and the timing and magnitude of snowmelt runoff. My research experience has shown that it is likely that regional pollution from present human activities, particularly coal-fired power plants, will affect stream and lake water chemistry and the aquatic organisms in those water bodies. Many more power plants are proposed for the four corners area. It is essential that there be long-term monitoring of water chemistry in areas such as the Senator Beck basin to determine if and when those emissions cause environmental harm.

Please feel free to contact me for further information.

Mark Williams
PI, Niwot Ridge LTER project
Former editor, Arctic, Antarctic, and Alpine Research
Former chair, Cryospheric Sciences Focus Group, American Geophysical Union