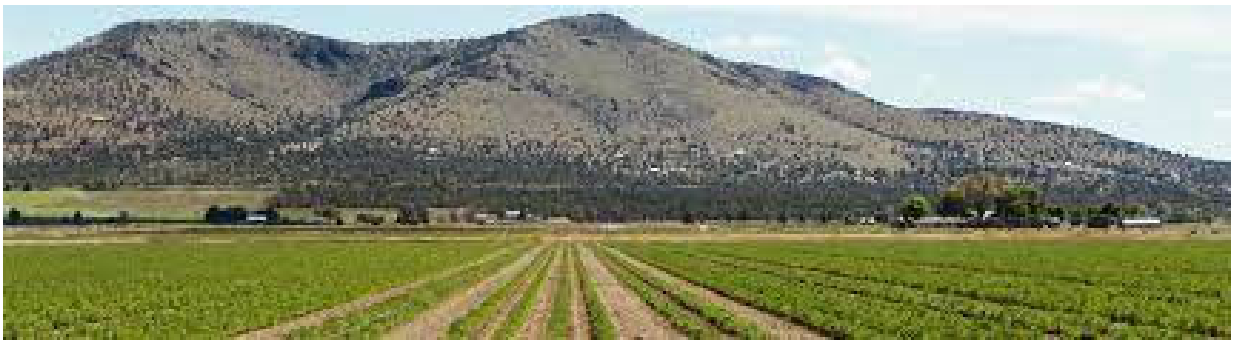

Deschutes Basin Cloud Seeding Feasibility Investigation

Application for U.S. Bureau of Reclamation WaterSMART Applied Science Grant

Applicant: North Unit Irrigation District

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1 Executive Summary

This application submitted on October 17, 2023, is to investigate cloud seeding as an important water management tool for water management in the Deschutes Basin and for North Unit Irrigation District (NUID or District). NUID is a junior water right holder in the Deschutes Basin near Madras, Oregon in Jefferson County. The District serves nearly 60,000 acres of diverse irrigated agricultural lands however the area suffers from perennial water supply shortages and extreme and exceptional drought that threaten the industry, community, and economy. In 2022, 60 percent of NUID sat fallow due to irrigation water supply shortages. NUID proposes to investigate the feasibility of cloud seeding as a means to balance climate variability and water management in the region. This study would be done using high-resolution numerical weather model which is running the latest subfreezing cloud physics package. The model can be run over multiple winters (Nov-April for 5-10 years). The model would produce 3-D clouds (including subfreezing water drops), temperature, and wind data for every hour. This model output can then be used to count up the number of seedable hours and the seedable cloud altitudes over all the mountain areas near NUID. This project will be initiated in April 2024 and complete in April 2025.

2 Technical Project Description

This project will fund a cloud seeding study to determine feasibility of using cloud seeding to augment snowpack in Oregon's Deschutes Basin that covers several counties including Jefferson, Deschutes, Crook, and Klamath Counties.

Cloud seeding is a form of weather modification that increases the efficiency of a cloud by enhancing its natural ability to produce precipitation with the goal of increasing snowpack. Cloud seeding is a physical process in which a seeding agent is released into an existing cloud formation with supercooled liquid water (SLW.) The water molecules freeze upon contact with the seeding surface and continue to grow as the particle collides with other water molecules in the cloud that then results in snow. This enhances the cloud's efficiency. In pilot studies in Idaho and elsewhere, typically cloud seeding results in 10-15% more of the condensed water vapor hitting the ground with a less than 1% increase of total water content seeded into the cloud.

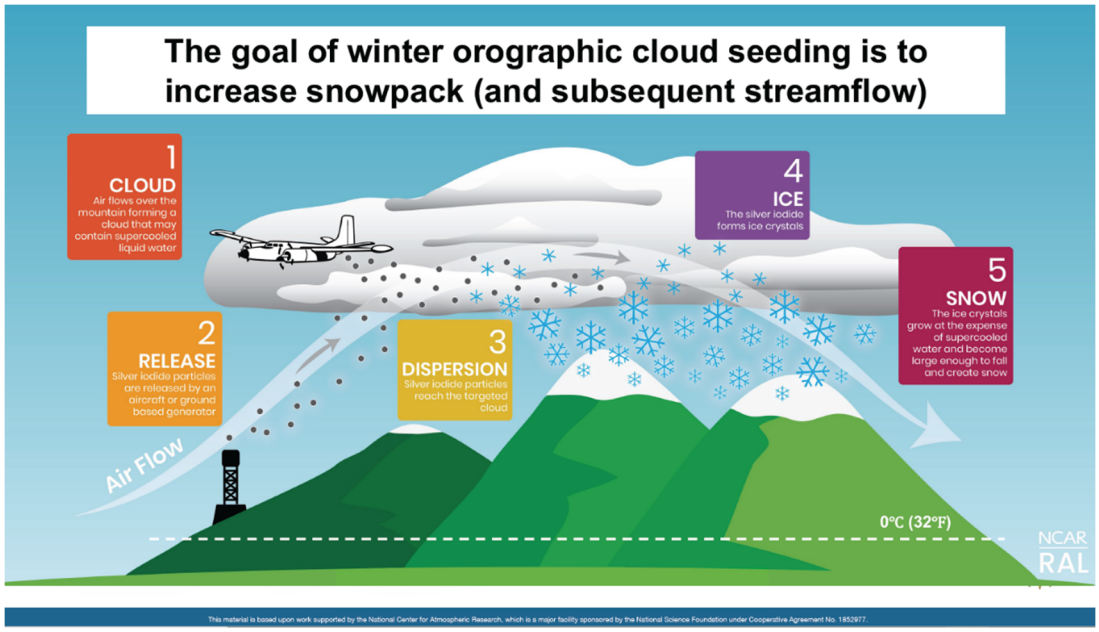


Figure 2-1 Cloud seeding process (Source: NCAR)

Nearly half of the states west of the Rockies have some sort of cloud seeding program or are studying feasibility of cloud seeding in their basins. As of 2023, there are not any active cloud seeding studies occurring in the state of Oregon. Cloud seeding has been used to augment water supplies for about four decades in Idaho where it's been able to boost snowpack levels by an estimate 10-15%. This project would fund a study in Oregon to model the potential for cloud seeding in the Deschutes Basin.

NUID would seek a qualified contractor to perform a modeling study that will identify the potential for cloud seeding in the Deschutes Basin. A high-resolution weather model will be run over multiple winters to produce 3D clouds, temperature, and wind data for each hour. That model output will then be used to count the number of seedable hours and seedable cloud altitudes over the mountainous areas in the basin. The goal of this project is to identify if cloud seeding is feasible for the Deschutes Basin. This information can also be used to determine further feasibility throughout the entire state of Oregon. This information can then be used to engage local, state, and federal government partners to initiate a seeding pilot program in the basin.

2.1.1 Applicant Category

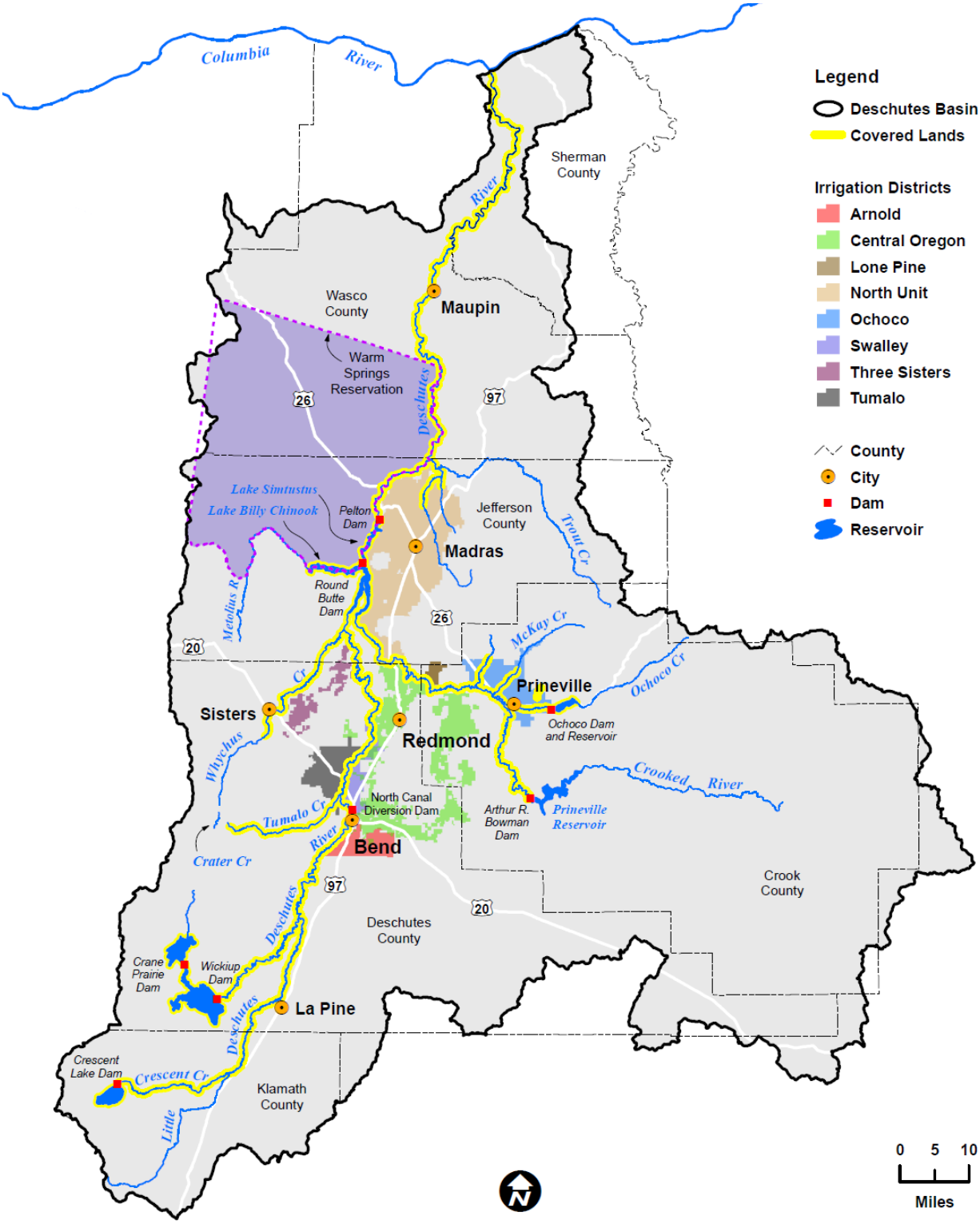
North Unit Irrigation District is a Category An applicant.

2.1.2 Project Location

The study area for this proposal is the Deschutes Basin. The Deschutes River Basin covers approximately 10,500 square miles of land in central Oregon. Bounded by the Cascades Mountains on the west, the Ochoco Mountains on the east, and the Columbia River to the north, the Deschutes River Basin includes six major tributaries above Lake Billy Chinook. The basin is 170 miles long in a north-south direction and 125 miles wide at its longest east-west extension. The mainstem Deschutes collects snowmelt runoff from tributary streams originating in the Cascades as well as from tributaries flowing from the Ochoco Mountains, in particular the Crooked River, and from the Columbia Plateau. Groundwater also significantly contributes to the mainstem Deschutes and some tributary flow – springs originating from the basin's

unique geology historically kept streamflows almost steady throughout the year. The Deschutes Basin narrows to only a few miles at its mouth where it discharges into the Columbia River.

The below map is of the entire basin with NUID's service area outlined.



2.2 Data Management Practices

This project uses inputs from National Weather Service (NWS) from weather stations throughout the basin including SNOTEL and local NWS Hydro-meteorological network similar to the Desert Research Institute (DRI) model. The DRI Cloud Seeding program maintains its own web page with the bulk of the input data publicly available. DRI's website has current operations and operating criteria for all cloud seeding sites publicly available. Additionally, NUID commits to disseminating this data to its basin partners including local, state, and federal government including fellow irrigation districts.

3 Evaluation Criteria

3.1 E.1.1. Water Management Challenge

This project gathers information to address two primary water management challenges: (1) providing snowfall augmentation to combat persistent drought; and (2) increasing irrigation reliability for NUID patrons.

Persistent drought has plagued Jefferson County and NUID for most of the past decade with multiple years of consecutive drought. Again in 2023, Governor Tina Kotek issued emergency drought declarations for Jefferson, Deschutes, and Crook Counties. A recent vulnerability assessment of southern and central Oregon shows the effects of climate change on hydrology will be highly significant with decreased snowpack and earlier snowmelt shifting the timing and magnitude of streamflow, with significantly lower summer flows (Halofsky, Peterson, Ho, 2019.) Additionally, climate models show a change in fall and winter inflows to the reservoirs. Ultimately, this could result in higher rain precipitation and thus higher streamflows in the fall and winter in addition to lower flows in the late summer.

Annual climatic variation impacts the degree to which reservoirs are able to fill and store water for irrigation use, and the District imposes a water allotment that limits the amount of water patrons receive based on the water available. When this scenario occurs, patrons may not be able to irrigate their fields to the extent necessary to support their crops. Often, patrons are forced to fallow more acres than they otherwise would choose to, as well as to deficit irrigate, which results in a decrease in crop production and revenue. Although many patrons have already invested in updating on-farm infrastructure to improve application efficiency of the water that they receive, in 2020 many patrons were forced to fallow 20 to 25 percent of their fields and in some cases, up to 40 percent (Kohn 2020a, b, c; Havstad and Casad 2020).

Wickiup Reservoir, located on the east slope of the cascade mountain range is NUID's main source of irrigation water supply. In the last 5 years, Wickiup has failed to fill and saw record low reservoir levels to begin irrigation seasons. Subsequently, NUID patrons have suffered through multiple years of reduced irrigation water allocations in addition to abnormally high spring and summer temperatures. Further, recent completion of the Deschutes Basin Habitat Conservation Plan requires that winter flows, released from Wickiup Reservoir, increase over the next eight years to provide ecological and biological benefits for the Oregon Spotted Frog, listed as threatened under the Endangered Species Act. These winter releases will further impact NUID irrigation water supplies as the junior water right holder on the Deschutes River system.

In 2020-2023, NUID estimates nearly 70 percent of fields went fallow because of persistent drought. This study would allow the District and region to understand the feasibility of cloud seeding as a method to help alleviate perennial water shortages through augmentation of snowfall.

3.2 E.1.2. Project Benefits

This project would provide a foundation to pursue cloud seeding on a watershed and state level as a means to provide snow augmentation and that can contribute to improved irrigation supply reliability and drought resiliency.

Many western states have successful cloud seeding programs. For example, the Idaho Collaborative Cloud Seeding Program estimates an additional annual runoff of 1.24 million acre-feet in the Upper Snake Basin as a result of its cloud seeding program. Oregon does not have any active cloud seeding projects as of 2023. In 2023, the State Legislature considered a bill to consider the investigation into cloud seeding in Oregon. While that bill stalled in committee, several water managers and agricultural partners testified in favor of the legislation and mentioned the importance of this potential strategy to their respective entities.

The results from this study could be used by more than eight irrigation districts in the Deschutes Basin alone. These results can also be transmitted to regional environmental groups for in-stream flow augmentation potential, cities and municipalities relying on surface and groundwater supplies, utilities that have hydroelectric operations within the Deschutes Basin, and basin recreational interests.

If successful, cloud seeding can be used as a drought resiliency measure for the basin. Providing more snowfall in winter has the potential to support the natural hydrograph, support flows for state and federally listed and native species, supporting riparian habitat, provide security for local food sources, increase collaboration amongst water managers in the basin, and preserve the agriculture industry in the basin.

3.3 E.1.3. Project Implementation

NUID would seek a qualified contractor to perform a modeling study that will identify the potential for cloud seeding in the Deschutes Basin. A high-resolution weather model will be run over multiple winters to produce 3D clouds, temperature, and wind data for each hour. That model output will then be used to count the number of seedable hours and seedable cloud altitudes over the mountainous areas in the basin. The goal of this project is to identify if cloud seeding is feasible for the Deschutes Basin. This information can also be used to determine further feasibility throughout the entire state of Oregon. This information can then be used to engage local, state, and federal government partners to initiate a seeding pilot program in the basin. The following sections give an overview of major tasks, milestones, and schedule.

Task One: **Development of Cloud Seeding Model**

A qualified contractor will develop a high-resolution weather model that can produce three dimensional results on an hourly timestep. The model will output clouds, temperature, and wind data. Inputs of the model will include regional weather data from the NWS and other publicly available sources. The contractor will produce multiple winters of simulations that will be used for task two.

Schedule: Start April 2024 / End October 2024

Milestones: 30% model delivered by June 2024; 90% model delivered by September 2024

Task Two: **Evaluation of Model Results for Feasibility of Cloud Seeding**

A qualified contractor will take the modeling results and determine the seedability of storms by analyzing temperature, vertical and horizontal wind components, and atmospheric stability. In essence, the storms

simulated need to show they are cold enough that seeding materials can reach an activation temperature and wind direction needs to ensure materials can be dispersed. Results will be documented in a report reviewed by regional experts.

Schedule: Start October 2024 / End April 2025

Milestones: 30% draft documentation by January 2025; 60% draft by February 2025; 90% draft by March 2025; final report delivered by April 2025.

Task Three: **Report review process**

NUID will contract with regional and national experts to review the results and associated documentation. Reviewers will receive initial results when available and review the 60% draft report in February 2025. Reviewers will be compensated for their time.

Schedule: Start October 2024 / End April 2025

Milestones: Reviewer comments on initial results due November 2024; comments on 60% review due early March 2025; and comments on 90% review due early April 2025.

3.4 E.1.4. Dissemination of Results

This project uses inputs from National Weather Service (NWS) from weather stations throughout the basin including SNOTEL and local NWS Hydro-meteorological network similar to the Desert Research Institute (DRI) model. The DRI Cloud Seeding program maintains its own web page with the bulk of the input data publicly available. DRI's website has current operations and operating criteria for all cloud seeding sites publicly available. Additionally, NUID commits to disseminating this data to its basin partners including local, state, and federal government including fellow irrigation districts.

NUID anticipates this study will be used to further investigations and implementation of cloud seeding in Oregon. This information will be shared with the Oregon Water Resources Department and Oregon Legislature to further efforts to fund investigations and implementations of cloud seeding.

3.5 E.1.5. Presidential and Department of Interior Priorities

This project directly addresses presidential and DOI priorities on climate change and serving disadvantaged or underserved communities.

3.5.1 Addresses Climate Change and Increases Resiliency

This study will inform an important drought resiliency tool for NUID and the state of Oregon. A 2019 vulnerability assessment of southern and Central Oregon shows the effects of climate change on hydrology will be highly significant with decreased snowpack and earlier snowmelt shifting the timing and magnitude of streamflow with significantly lower summer flows (Halofsky et. Al 2019). Additionally, climate models from the Inter-governmental Panel on Climate Change (IPCC) show a change in fall and winter flows to the reservoir. This could result in higher flows in the fall and winter in addition to lower flows in the late summer. Additionally, the most recent IPCC report, they found that escalating climate change impacts causing hotter droughts and progressive loss of seasonal water storage in snow and ice will tend to reduce summer season flows in much of western North America.

Cloud seeding could provide an important tool to augment snowpack levels to improve water supply reliability in the critical summer months.

3.5.2 Serves Disadvantaged Communities (Impacts due to Climate Change)

Jefferson County, NUID service area, is identified as a disadvantaged community because of the expected agriculture loss rate, expected building loss rate, projected flood risk, projected wildfire risk, and low income.

Lands served by the District are primarily large-acreage farms (260 to 2000 acres) dedicated to high-value crops such as vegetable seeds, grass seeds, peppermint, garlic seed, alfalfa, and radish (Headwaters Economics 2017). The value of crop commodities sold in Jefferson County is greater than the value of crop commodities sold in the surrounding counties combined, and the crops grown in NUID are important contributors to the national and international crop markets—hybrid carrot seed grown from NUID-irrigated lands produce 55 percent of the nation's and 40 percent of the world's supply (Headwaters Economics 2017; NUID 2021). However, the District's junior water rights, in concert with a changing climate and recent changes to Deschutes and Crooked River water management, have left agricultural production in the District vulnerable to water shortages. Annual climatic variation impacts the degree to which reservoirs are able to fill and store water for irrigation use, and the District imposes a water allotment that limits the amount of water patrons receive based on the water available. When this scenario occurs, patrons may not be able to irrigate their fields to the extent necessary to support their crops. Often, patrons are forced to fallow more acres than they otherwise would choose to, as well as to deficit irrigate, which results in a decrease in crop production and revenue. Although many patrons have already invested in updating on-farm infrastructure to improve application efficiency of the water that they receive, in 2020 many patrons were forced to fallow 20 to 25 percent of their fields and in some cases, up to 40 percent (Kohn 2020a, b, c; Havstad and Casad 2020). Cloud seeding has the potential to provide more resiliency and sustainability to water supply in Jefferson County. The first step of using this tool is studying the feasibility.

4 Project Budget

OVERALL PROJECT BUDGET Line Items	**Cash Match Funds**	**Water SMART Grant Funds**	**Total Cost**
Task One: Development of Cloud Seeding Model		70,000	70,000
Task Two: Evaluation of Model Results and Documentation	70,000		70,000
Task Three: Report Review Process	6,000	6,000	12,000
TOTAL:	**76,000**	**76,000**	**152,000**

4.1 Table One Summary of Non-Federal and Federal Funding Sources

Funding Sources	**Amount**
Non-Federal Entities	
1. Oregon Water Resources Department Water Project Feasibility Grant	$76,000

Non-Federal Subtotal:	$76,000
REQUESTED RECLAMATION FUNDING	**$76,000**

5 Environmental and Cultural Resource Considerations

- 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.
    - This project does not include any construction activities. There will not be any impact to surrounding environment as a result of project work.
- 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?
    - This project study area includes ESA-listed species including the Oregon spotted frog, bull trout, and Middle Columbia River steelhead. However, these species will not be affected by any activities associated with the proposed project.
- 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.
    - The basin includes wetlands that are considered Waters of the United States. There is no impact of any wetlands as a result of project work.
- When was the water delivery system constructed?
    - Construction of the U.S. Bureau of Reclamation Deschutes Project, including the NUID, began in the late 1930's and concluded in the mid-1940's.
- 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.
    - Yes. There will not be any impacts to historic/cultural features as a result of project work.
- Are there any known archeological sites in the proposed project area?
    - No.
- 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.

5.1 National Environmental Policy Act

This project does not require any additional environmental or statutory compliance including any additional activities to comply with the National Environmental Policy Act.

5.2 National Historic Preservation Act

This project does not require any additional environmental or statutory compliance including any additional activities to comply with the National Historic Preservation Act.

5.3 Endangered Species Act

This project does not require any additional environmental or statutory compliance including any additional activities to comply with the Endangered Species Act.

5.4 Required Permits or Approvals

There are no required permits or approvals for the project work.

6 Overlap or Duplication of Effort Statement

North Unit Irrigation District is not aware of, nor anticipates, any overlap between the proposed project and any other active or anticipated proposal or project in terms of activities, costs, or commitment of key personnel.

7 Conflict of Interest Disclosure Statement

North Unit Irrigation District does not have any actual or potential conflict of interest at the time of submission of this application.

8 Restrictions on Lobbying

No funds under this grant or cooperative agreement will be used for lobbying activities.

9 Uniform Audit Reporting Statement

NUID has not expended more than $750,000 in the past fiscal year.