Bureau of Reclamation
WaterSMART: Water and Energy Efficiency Grants for FY 2018

Upper Republican NRD Remote Water Metering and Conservation Project

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Upper Republican Natural Resources District
Imperial, Nebraska
Perkins, Chase and Dundy Counties

Executive Summary

The Upper Republican NRD (URNRD) Remote Water Metering and Conservation Project is intended to reduce groundwater irrigation applications to increase long term groundwater and surface water availability in a region of Nebraska where significant conflict between water users exist. The URNRD is the most upstream portion of the Republican River Basin in Nebraska which was the subject of a Basin Study, released by the Bureau of Reclamation in March 2016, that included the States of Nebraska, Kansas and Colorado as partners. The study indicated that declining groundwater levels and stream flows have created intense competition for limited water supplies, and litigation. The proposed project can help reduce decline rates by providing irrigators and the URNRD timely water use information that will improve water management decisions by both irrigators and the URNRD. Project funds will be used to install equipment that will allow for near real-time acquisition of water-use information from 1,018 irrigation wells, which is approximately one-third of all irrigation wells and flow meters in the URNRD. This information will be coupled with real time evapotranspiration rates of crops and provided to irrigators so they can more easily eliminate unnecessary irrigation applications by matching water use with actual crop-water needs. An existing radio-frequency network established by an electric utility to operate its automated electric-meter reading program will be used in the project area to provide the automated water-meter readings to the URNRD and irrigators. All irrigation wells within the URNRD and project area have flowmeters; the project primarily entails equipping them with digital registers and radio modules so that the usage information can be transmitted via the radio network.

Background Data

The primary water supply in the URNRD is the High Plains Aquifer, which has a variable saturated thickness in the district ranging from 50 feet to 400 feet. The total, available water supply within the URNRD is approximately 61 million acre feet; roughly 10 million acre feet of that supply exists in the project area that includes the western half of Chase County and a small part of Perkins County, which borders Chase County to the north.

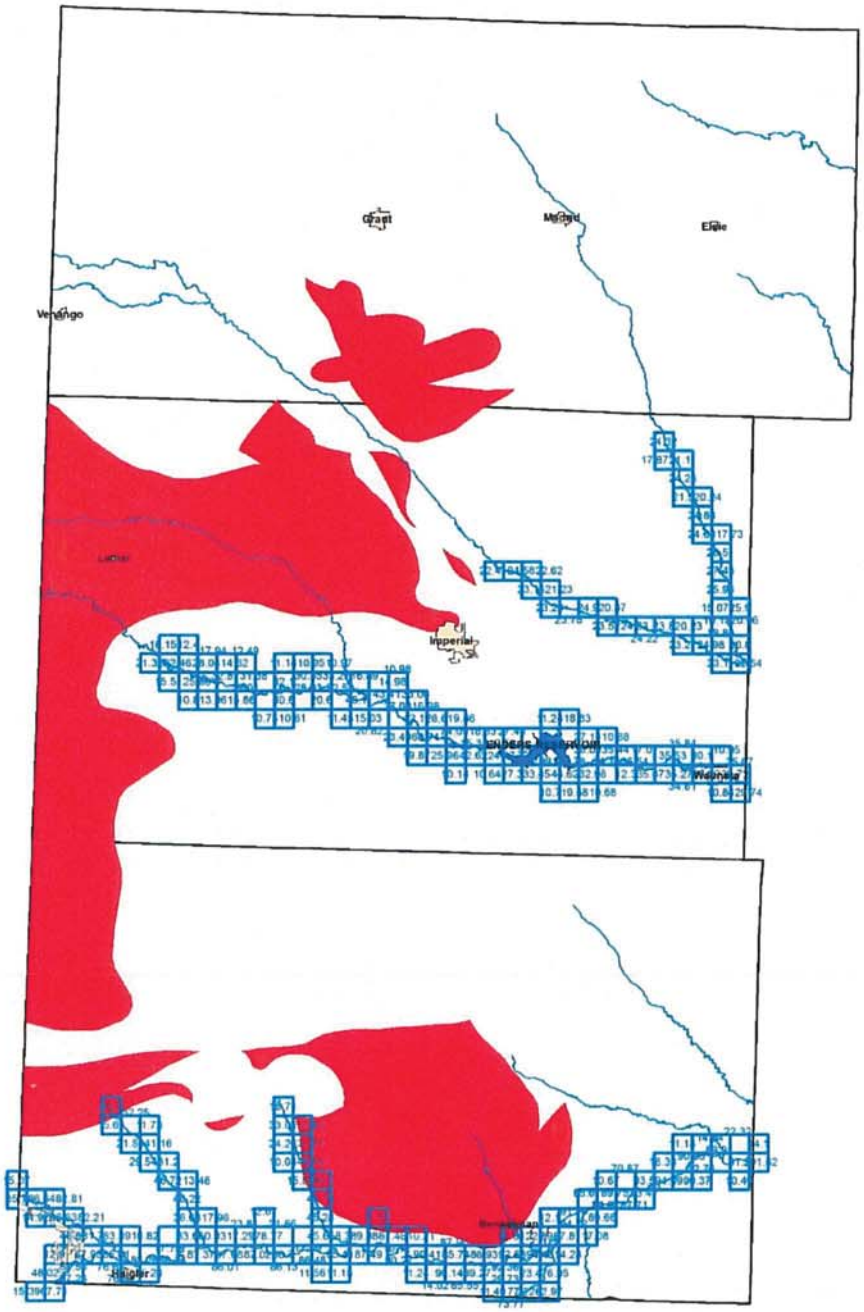
Approximately 98 percent – 99 percent of all water used in the URNRD and the project area is for crop irrigation and the average, long-term annual aquifer withdrawals for irrigation is approximately 430,000 acre feet in the district. Within the 132,340 irrigated-acre project area, average annual use is 12" per acre annually, or 132,340 acre feet. On average, approximately 70% of the irrigated cropland in the URNRD and project area is planted to corn, with the remainder in beans, alfalfa, potatoes and small grains.

The Ogallala geologic formation underlies all but the extreme southern and northwestern parts of the URNRD. It ranges in thickness from a feathered edge to more than 400 feet. The Ogallala Formation consists of beds of silt, sand, gravel, caliche, and clay, with considerable variability in the character of the formation within short vertical or horizontal distances. Some of the sand and gravel deposits are weakly cemented by calcium carbonate into rocks ranging from friable sandstone to relatively hard, ledge-forming mortar beds. Except in a few areas, most notably western Perkins and Chase Counties, the Ogallala Formation is overlain by unconsolidated Quaternary deposits. The aquifer is unconfined. In general, the direction of ground-water flow is west to east except in the vicinity of the Republican River. Average ground-water-flow velocities range from less than 50 feet to more than 200 feet per year.

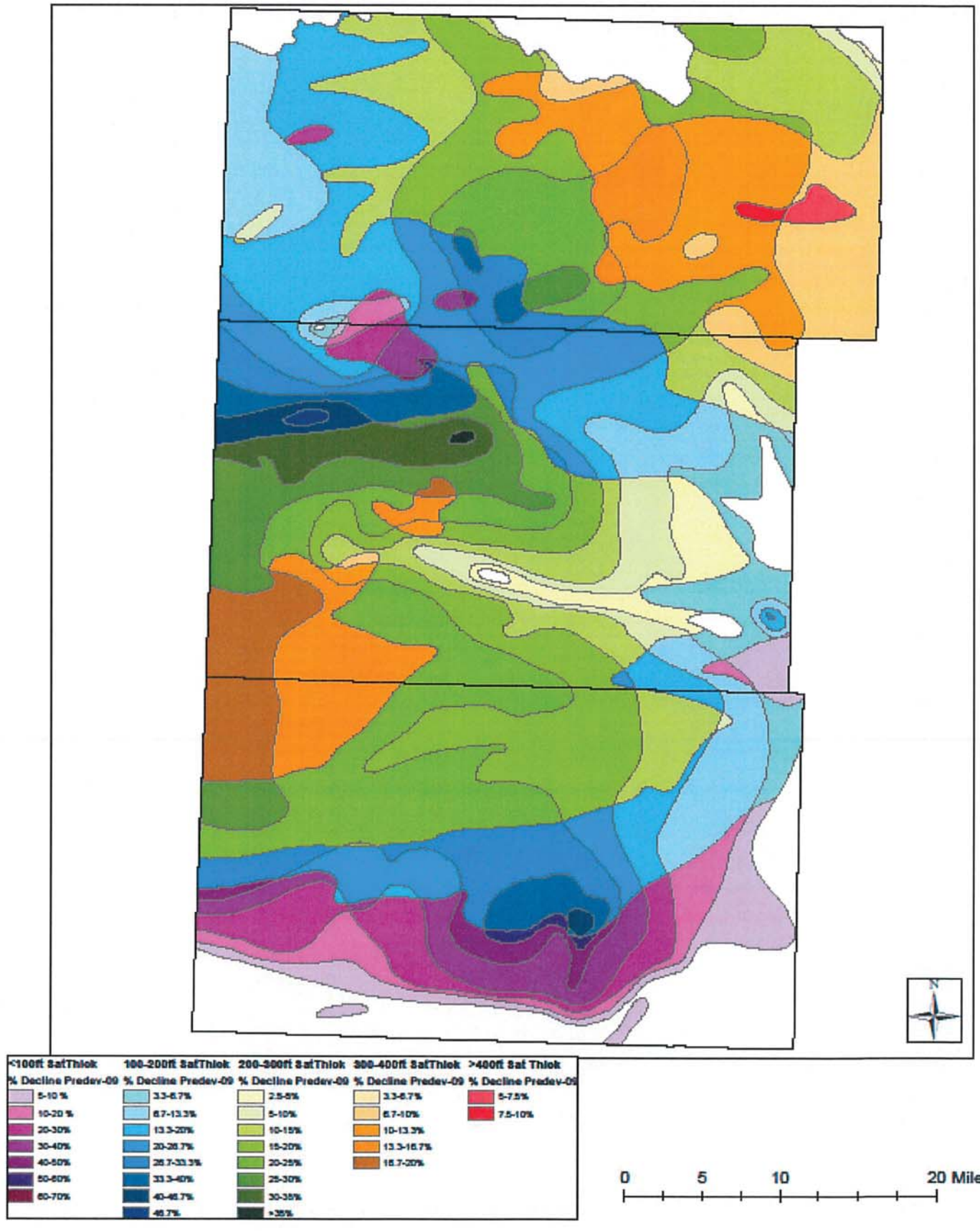
Declines in water levels throughout the URNRD from the period before widespread groundwater irrigation development began in the 1960's until now have averaged approximately 24 feet, with the most significant declines being 60-70 feet. The largest area of declines this severe is the project area subject to this grant application, in western Chase County. Approximately half of the project area has experienced groundwater declines of 50 feet to 70 feet since before largescale groundwater irrigation began in the late 1960's and early 1970's and average annual declines in the water table exceed the district average of .75 feet annually. A primary reason for the significant water-availability issues in the project area is the density of irrigated land. In many areas within the project area, approximately three-quarters of the land mass is irrigated. This compares to the district-wide average of approximately one-quarter of the land mass being irrigated.

The URNRD and other NRDs in Nebraska were created via state statute in 1972 and didn't have the ability to regulate irrigation development or water use until 1979, after most development had occurred. Because of groundwater declines witnessed in the URNRD throughout the 1970's, the URNRD led the effort to convince state lawmakers to give NRDs the authority to regulate groundwater use. Shortly after the authority was granted, the URNRD required all irrigation wells to be metered and began restricting groundwater use using an allocation system believed to be the first restrictions on groundwater agricultural use in the U.S. However, the URNRD could not undo irrigation development that occurred before it had the ability to impose regulations and while regulations used since then have slowed declines, they still persist, notably in the project area.

The map on the following page shows areas of the URNRD (in red) where at least 25% of the saturated thickness of the underlying aquifer has been depleted. The western half of the county in the middle, Chase County, comprises most all the project area. The map on p. 5 shows declines in the URNRD relative to saturated thickness. Chase County is the middle county.


Imperial

URNRD Declines Relative To Saturated Thickness



The saturated thickness of the aquifer in the project area varies significantly, from approximately 100 feet to 400 feet. There is still enough available water that if actions such as the proposed project are taken, sufficient water can be made available for irrigation for the foreseeable future. It is the URNRD's goal to eventually stop all groundwater declines throughout the district by incrementally decreasing water use. As indicated before, the challenge to do so is particularly strong in the project area because of the high density of irrigated lands. As regulations imposed by the URNRD become tighter over time to meet our goal of stopping groundwater declines, it may be especially important that irrigators within the project area have tools such as real-time water usage info to be able to operate successfully. The URNRD has steadily reduced the allocation over time and the current allocation is about 40% less than it was when allocations were first implemented.

Correlative rights govern the use of groundwater in the URNRD and throughout Nebraska. Correlative rights allow landowners to extract groundwater from an underlying aquifer for beneficial purposes, subject to management by the public, i.e. NRDs such as the URNRD. All irrigation wells must be registered in Nebraska and landowners must first obtain a permit to drill a well. The correlative rights doctrine has been adopted into state statute with some modifications. State law provides that every landowner shall be entitled to reasonable and beneficial use of the groundwater underlying his or her land subject to the provisions of the Nebraska Ground Water Management and Protection Act and the correlative rights of other landowners when the groundwater supply is insufficient for all users. In enacting this basic doctrine, the Nebraska Legislature made broad findings about the need to manage and regulate groundwater use for the long-term benefit of the public and the state's economy.

The URNRD is a political subdivision of the State of Nebraska, along with 22 other NRDs. They are local government entities with broad responsibilities and significant authorities to protect natural resources including water. Major Nebraska river basins form NRD boundaries, enabling districts to respond best to local needs. Elected boards of directors govern districts. Much of the funding comes from local property taxes. Some Districts, including the URNRD, also have the ability to levy a tax on the practice of irrigation.

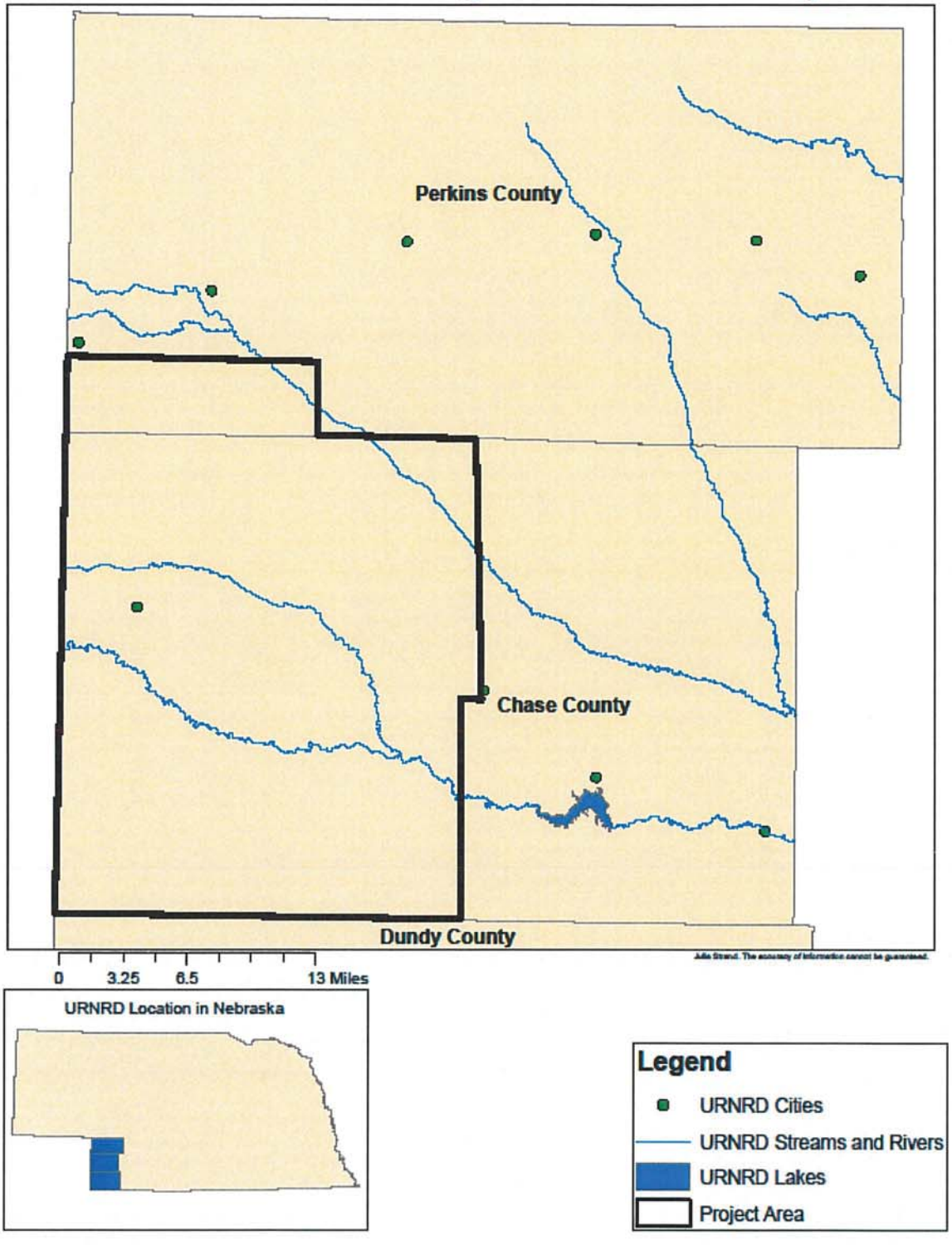
The URNRD has had two assistance agreements with the Bureau of Reclamation. In September 2012, the URNRD and BOR entered into an agreement, which ended Sept. 30, 2014 pursuant to the contract, to reduce water use through the use of soil moisture probes. The project successfully launched a popular and effective cost-share program that continues to exist and to date has led to the installation of more than 500 soil moisture probes with telemetry throughout the URNRD.

The second agreement with BOR is still in effect, until Sept. 30, 2018, and began in September 2016. The URNRD Drought Mitigation and Groundwater Management Project combines real-

time water level measurement data from groundwater-level sensors that have been deployed with modeling tools and real-time water usage to develop regulations and irrigator tools to ensure water is available during drought periods.

Additionally, the URNRD has a goal of reducing groundwater pumping by 20 percent from 1998-2002 baseline pumping volumes in years of average precipitation. With the Nebraska Department of Natural Resources, the URNRD will annually evaluate trends in long term groundwater depletions over typically wet and dry cycles, approximately 12 years, and jointly assess if additional management actions are needed to accomplish the objective.
The URNRD employs three technicians who, among other duties, twice annually measure static groundwater levels at approximately 400 wells across the district. Additionally, they annually read mechanical flow meters that exist on all irrigation wells to determine water usage on individual fields for the year. This information is largely used to ensure irrigators are complying with URNRD water use restrictions.

URNRD Remote Water Metering and Conservation Project Area



Technical Project Description

Since 1979, the URNRD has required flowmeters on all irrigation wells in the district. Currently, there are approximately 3,300 irrigation wells. With rare exceptions, all of the meters are mechanical: Water flow turns a prop-style impeller inserted into irrigation pipe and flow is totalized on a mechanical, odometer-style register mounted on top of the irrigation pipe. The impellers are made of high-impact plastic and each is individually calibrated to accommodate the use of any register. Stainless steel bearings are used to support the impeller shaft. The register is driven by a flexible steel cable encased with a vinyl liner. Below is a picture of the type of flow meter used in the URNRD.

The URNRD employees three technicians who qualified to repair the flow meters and approximately one-third of the meters in the district are inspected annually, on a rotating basis. Every year in the mid to late fall, once farmers are done irrigating, the technicians read the meters and record the year's water use from each well. Their use for the year is calculated and farmers are informed what it was and how much remaining allocation they have during a given, 5-year allocation period. The process is adequate for regulatory purposes to determine usage in relation to the allocation they are allowed to use, but deficient as an irrigation management tool.

Highline Electric Cooperative, based in Holyoke, Colo., provides electricity for a large, predominantly rural area of eastern Colorado and the western half of Chase County and a small part of Perkins County within the URNRD. The cooperative has 1,018 irrigation services in the URNRD, most of them in western Chase County, and has recently developed a radio frequency network that is the backbone of its new automated meter reading system. A significant portion of the system is in place and the system is expected to be completed this year.

The proposed project primarily entails equipping the 1,018 flow meters used by the URNRD with digital registers and radio modules that will allow water usage to be communicated via the radio system to the URNRD and irrigators who own and use the irrigation wells. The digital registers that will replace the mechanical registers now on all but a handful of flowmeters will display the flow rate and volumetric total. Below and left is the type of mechanical register now used; below and right is an illustration of the digital register that will replace the mechanical registers on the meters.

The McCrometer Propeller flowmeter comes with a standard instantaneous flowrate indicator and straight-reading totalizer. An optional FlowCom register is also available. *Typical face plates.*

The digital register has an output that is able to interface with the radio network used by Highline Electric once it is connected to a radio transceiver. The transceiver that will be used will receive inputs from the digital registers and interact with base stations in the utility's service area. The module has a powerful two-watt transmitter and will be able to obtain hourly meter readings. The modules are battery powered, waterproof, and able to operate within temperature ranges of -22 F to 185 F that are well outside of temperatures they will be exposed to once deployed. The modules will be mounted on 6 foot to 8 foot tall masts to ensure better communications during the growing season when corn, the predominant crop in the area, can be several feet tall. Below is a picture of the type of module that will be used.

This project proposal does not request any BOR funds for installation costs; installation will be done by URNRD employees after receiving training on how to do so.

A network interface will be purchased by the URNRD and customized to receive and communicate water usage information so it meets our regulatory purposes and is readily available to irrigators. The interface will continually gather and process the data transmitted via the network and will include diagnostic tools to help manage and monitor the network. The URNRD will conduct an extensive educational program to make irrigators aware of the data availability and how to use it. This is not an onerous task: There are an estimated 130 irrigators within the project area. Much of the education will occur via one-on-one meetings between URNRD staff and irrigators in the project area.

The interface will be customized to allow irrigators, via a log-in system, to access their water usage information. Total use for each day will be available, as well as the aggregate total that includes all days during the calendar year. In addition to their usage, daily evapotranspiration rates that indicate what actual crop water needs were during the days that they irrigated will be available on the interface. This is a key part of the project, as irrigators will know whether they applied more water than was necessary based on actual crop water needs during variable time periods and can adjust their irrigation scheduling accordingly. It is also our desire to include projected, future ET during the next 3-4 days on the interface that will be based on weather forecasts. This ET estimate of course will be less accurate because it will be based on forecasted conditions that haven't occurred and may change, but will be a useful tool to irrigators as irrigators make watering decisions if the forecast comes to fruition.

The URNRD is in the process of installing weather stations throughout the district that will measure temperature, relative humidity, wind speed and direction, solar radiation, barometric pressure and precipitation. Some of these measurements will be used to estimate the ET that will be provided to irrigators via the interface to indicate whether they are over-watering. The weather stations will estimate the ET of native grass, and the ratio of that over reference crops such as irrigated corn will produce ET estimates available to irrigators. Crop co-efficients, or properties of plants used to make the estimates, are often based on crops grown a distance from the areas in which they are used to calculate estimated ET. This can produce inadequate estimates. We will be able to produce highly refined crop coefficients for the weather stations applicable to the project area from the use of at least one research-grade sensor that will calculate actual, instead of estimated, ET of crops. We are now working with the University of Nebraska-Lincoln to collect and use data from the use of what is known as an eddy covariance tower to collect ET data during this and future growing seasons. A picture of one of the towers, which cost approximately $55,000 and will not be paid for from this proposed grant, is below.

Evaluation Criterion A – Quantifiable Water Savings

Water-use reductions experienced in the URNRD due to use of irrigation-management tools similar to those proposed for the project are the primary basis of estimates for this project. Studies of water use reductions observed from the use of irrigation scheduling made possible, and/or improved by the proposed project, are consistent with water-use reductions experienced within the URNRD through use of the irrigation management tools. The District has learned in recent years through its involvement in incentive programs that any technology that increases irrigators' engagement with and understanding of crops' water demands relative to how much water they are applying increases the desire to reduce water use.

We estimate that annual water use within the project area will be reduced by approximately 8,271 acre feet annually. That savings represents a 6.2% reduction in the current annual, average irrigation water use of 132,340-acre feet within the project area (an average of 12" per irrigated acre). We anticipate the project will result in average annual water use in the project area, then, of 124,069-acre feet instead of 132,340-acre feet. As explained in more detail below, the estimate is based on a conservative estimate of the percentage of producers who will use the data to improve irrigation scheduling.

As mentioned earlier, the URNRD, with aid from a BOR WaterSMART grant, in 2012 initiated a cost-share program to encourage the use of soil-moisture sensors with telemetry units that remotely relay soil-moisture information and irrigation recommendations directly to farmers. Since 2012, the cost-share program has been extremely popular and led to the installation of probes on approximately 65,000 irrigated acres within the URNRD. The probes are mostly of the capacitance type that measure soil-moisture content to depths of approximately 3 feet – 4 feet and software that considers soil types, water needs of the particular crop that is planted, and other factors are the basis of recommendations on whether irrigations are needed. Studies have

indicated that use of the probes in production-agriculture environments like the project area can reduce water usage by an average of 1 inch – 4 inches annually.

Since inception, the URNRD has kept in contact with users of the probes to determine issues related to their use, including their estimates of water-use reductions, if any. Rather consistently, irrigators who say they closely monitor soil-moisture info relayed by the instruments and follow the associated irrigation recommendations report using approximately 2 inches less water per acre than they would have absent use of the probes. Using our historic water-use records available on every irrigated field in the URNRD, we have assessed these reports to determine their validity. Based on this review, they appear valid: Average water use of irrigators before they began using probes compared to average water use after they began using probes was approximately 1.5 inches per acre more. We believe this is less than the 2 inches reported by those who use the probes because some irrigators implemented the probes but did not follow the irrigation recommendations they provided. This reaction from some is to be expected after they begin using new technology.

Improved irrigation scheduling from matching actual irrigation usage with ET estimates as proposed under the project is expected to lead to similar water-use reductions as irrigation recommendations from the use of soil moisture probes. Both are indicators of crop water needs and manual ET gauges used in the URNRD along with moisture probes have shown there is a close correspondence between the two. It should be noted that the proposed project would reduce water use at a lower cost than the use of soil moisture sensors on the same number of acres: The one-year cost of using soil moisture sensors on all 132,340 acres would be approximately twice the cost of implementing the proposed project, and future annual costs of the proposed project would be approximately 5% of the total cost of annual subscription fees associated with use of probes.

For the purpose of estimating water savings under the project, we have assumed that in the short term, half the irrigators in the project area that has 132,340 irrigated acres will utilize the data available from the project to reduce water usage by an average of 1.5 inches per acre. That estimate, applied to half of the 132,340 acres, results in the estimated annual savings of 8,271-acre feet (132,340/2 x 1.5"/12). We believe this is a conservative estimate and that there will be deeper reductions in the future as irrigators trust the technology and application of the data more. As mentioned earlier, URNRD staff will meet with irrigators in the project area to expedite this process as much as possible.

Irrigators within the URNRD have an incentive to reduce their water use via the project that is relatively unique. Unlike most regions of the country, the amount of groundwater irrigators can use is regulated within the URNRD, so they must conserve water or risk violating the URNRD's rules and regulations. Doing so can cause significant losses in allocation – e.g. for every inch of

overuse irrigators lose 2 inches of allocation during the next allocation period – and impact land values. Positive allocation balances from responsible water use are heavily used by area realtors as an advertising tool when selling land; less available allocation means less water to use in the future, depressing prices.

Irrigators have incentive to reduce pumping without sacrificing yields to reduce pumping costs. For instance, at current power rates, reducing pumping by just 1.5 inches over the course of an irrigation season can reduce costs of irrigating a quarter section of land by approximately $1,000. Additionally, irrigators are expected to use the real-time information to know what their water use is in relation to their allocation which is expected to encourage more conservative water use. Our annual records of water use on all irrigated land beginning in 1979 will make calculations of water savings caused by the project relatively straightforward.

Similar to the estimates described earlier of water savings resulting from use of soil moisture probes, we will be able to compare average water use over variable time periods before the project is implemented to average water use after the project is implemented. These estimates can be done on a field-by-field or irrigator-by-irrigator basis. Monthly precipitation records during the pre-and-post project periods will allow for lateral comparisons, i.e. comparisons of average usage pre-and-post project during time periods with similar precipitation, which impacts irrigation decisions, during the growing season.

Water measurement tools and methods to be utilized under the project are proven, including the Water Balance or Checkbook Method that is a well-known tool for irrigation scheduling. The premise of the tool is to balance water being extracted from the soil (via evaporation and plant transpiration) with water being added to the soil (via irrigation and rainfall). Typically, automated weather stations are used to measure specific environmental conditions and then specific formulas are used calculate reference ET and/or estimate effective rainfall. In addition, crop specific coefficients as described earlier will be applied to ET values to fine tune water use. When used consistently with reliable field data, the water balance index can show growers how closely their irrigation practices are meeting the current plant water use demand.

The general use of irrigation scheduling, which we propose will be made easier and more effective by crop water demand information available under the proposed project, was shown to reduce water applications by 11 percent in Nebraska (Kranz et al., 1992). This level of reduction is similar to, and slightly below, the approximately 12.5% reduction in water use by those who use soil moisture probes and follow their recommendations that was the basis of the water-reduction estimate for this project. If approximately half the irrigators in the project area use the data, total savings is the 6.2% described earlier.

Separate studies have shown (Vines et al., 2013) that providing people feedback on their utility usage such as what will occur under the project, e.g. when and how much they are using, can reduce consumption by 5 percent to 20 percent.

Finally, the information will let District staff know whether over-watering is occurring using the same comparisons of water use and ET. The District will be able to respond to the information by creating programs and possibly rules modifications to reduce water use to levels that the data suggests is reasonable to slow groundwater declines without causing sudden economic harm. Water modeling conducted outside of this grant project will combine groundwater level and water usage information so that analysis of water availability under different usage scenarios can be analyzed. For example, the model inputs may include groundwater level changes that occur under current usage rates as observed using the automated flow meters proposed under the project. Levels of irrigation water applications less than current usages, but that analysis of ET data determines is still adequate to meet crop water needs, may also be inserted into the model. Management of water supplies within the URNRD has the potential to improve significantly under the proposed project and will allow a more focused approach to water management.

This project will demonstrate how farmers can improve upon or maintain current yields while using less water. This will be achieved by the implementation of near real-time monitoring of irrigation water applied and the correlation with locally measured ET data as described in this proposal. Past studies have shown water savings ranging from 1% - 50% using similar technology (Buchleiter, 1996) (Kranz, 1992) (Varble, 2011).

Evaluation Criterion B – Water Supply Reliability

The proposed project is consistent with the District's goals and objectives relative to groundwater and achieving long-term water-supply reliability: "Develop management programs to extend groundwater reservoir life to the greatest extent practicable, allowing for the beneficial use of water in an effective and efficient manner to satisfy the District's socio-economic needs and obligations while minimizing the risk that water resources will be insufficient for future generations to meet their socioeconomic needs. Develop, promulgate and enforce rules and regulations that provide for appropriate protection of the aquifer so as to slow and eventually stop water table declines in order that beneficially usable quantities of water remain in the aquifer; incentives to use water efficiently; conservation of groundwater; and maintaining or enhancing groundwater quality." (*URNRD Master Plan, 2010-2020*)

In addition to preserving groundwater, it is important to note the project will help increase the reliability of surface water supplies. The average impact groundwater pumping in the project area has on stream flow is 36% over a 50-year period (36% of groundwater pumped during that time period would have resulted in stream flow if not pumped). The heart of the project area

includes the Frenchman River, a primary tributary of the Republican River, which provides water to many downstream surface water users served by federal projects. Applied to the annual, estimated water-use reduction of 8,271-acre feet described in the last evaluation criterion section, the 36% stream flow depletion factor has a resulting, annual benefit to stream flow of 2,978-acre feet over a 50-year period.

Such benefits and efforts to produce them are expected to help ease friction between the water management and water supply entities within Nebraska's portion of the Republican Basin. Much of the friction has been initiated by concerns over how to maintain compliance with the Republican River Compact. Over the past 15 years, the potential regulatory actions and financial costs of maintaining compliance created, understandably, hard feelings between entities as they considered who was at fault for creating these new obligations and challenges. Among the entities often at odds were the NRDs in the Republican Basin – URNRD, the Middle Republican NRD and the Lower Republican NRD. The attached letters from the Middle and Lower Republican NRDs show their support for the project, and by extension the ability of such projects to improve collaboration and support between entities in the Republican Basin.

The BOR in the application materials asks whether future water conservation projects by other water users are enhanced by the project. This is a primary intent of the project – after implementing this project we intend to have similar telemetry capabilities throughout the URNRD. From a cost standpoint, working with the electric utilities such as this project proposes is much cheaper – roughly one-half to one-third the cost – than creating our own communication network. As this project develops, we will work with the two other electric utilities in the URNRD to implement similar projects. In areas of the URNRD where sharing a communication network with an electric utility is not feasible, we will develop a standalone network that fills in the gaps.

With regard to reliability more specifically, slowing groundwater declines can only be achieved by reducing water use and is an outcome of management policies and best management practices based on information provided by the proposed project.

As mentioned in the section providing background data, declines in water levels throughout the URNRD have averaged approximately 24 feet, with the most significant declines being 60-70 feet. The largest area of declines this severe is the project area, with approximately half of the project area having groundwater declines of 50 feet to 70 feet. According to the U.S. Department of Homeland Security Office of Cyber and Infrastructure Analysis, declining water tables and less crop production caused by them long term pose a threat to critical infrastructure, such as higher food and fuel prices. Counties of highest concern overlying the High Plains Aquifer are those that modeling described in the Homeland Security report showed as having 25 or fewer years of groundwater use available. No such counties in Nebraska were shown to be facing that

imminent of a problem, but of the seven counties in Nebraska where the life of the aquifer usable for irrigation was shown to be 50-100 years, one is where most of the project area is located, Chase County.

The fact that approximately 100 feet – 400 feet of saturated aquifer thickness remains throughout much of the project area provides sufficient time to reduce water usage to levels necessary to stabilize the aquifer over the long term so a water supply is available for the foreseeable future. Water saved as the result of the project will extend the life of the aquifer in the area and be available for future use, whatever those uses may be. Given the current economy and land uses, the expectation is that the water would most likely be used to irrigate crops in the future at rates that don't cause groundwater level declines. Real-time water usage information as a tool to manage irrigation water use, we expect, will exist as long as irrigated agriculture does. Because water usage information such as that provided by the project is so inherent to crop production and water management usage information, we believe the project or some iteration of it long term will be used and beneficial as long as irrigated crops are produced in the project area. For descriptive purposes only, we'll select 50 years as a project life, though we expect it or some iteration of it will be available longer. Over a 50-year period, with annual water use reductions of 8,271-acre feet, a total of 413,550 acre feet will have been saved.

Communities that will benefit from the project are solely rural and located in one of the more rural parts of Nebraska. The total population of the three counties that comprise the URNRD is approximately 9,000 and approximately 4,000 people live in Chase County, where the project is mostly located. The project is located within the most rural part of Chase County, as the project area doesn't include the two largest towns in Chase County, Imperial and Wauneta. The rural nature of the area creates a largely regional economy because residents often must drive relatively long distances outside of their local area to access services. Irrigated farming is the primary driver of the economy, providing the majority of jobs and business sales.

Sustainable water use can only be achieved when we replace water management techniques rooted in habits and notions with those based on science and data as proposed in the project. Technology has been and will continue to be developed that provides opportunities for water use to be more sustainable and we must take advantage of opportunities such as those described in this proposal to make progress. The current system of manually measuring water use once annually is akin to an investor deciding how to invest his money (resources) based on market activities that occurred months ago. The proposed project will give farmers who currently have an incentive to reduce water use because of the District's pumping limitations the current information they need to do so – namely how much water they are using relative to their allocation and, importantly, how much water ET data suggests they actually need to apply.

Evaluation Criterion C – Implementing Hydropower

The project does not have a hydropower component.

Evaluation Criterion D – Complementing On-Farm Irrigation Improvements

Irrigators in the project area and throughout the URNRD may apply for assistance for on-farm efficiency improvements through the Environmental Quality Incentives Program (EQIP) administered by the Natural Resources Conservation Service (NRCS). There are many on-farm efficiency improvements that can be implemented with EQIP in the project area. They include the following: Efficiency improvements to irrigation systems, namely conversion of gravity or flood-based irrigation systems to sprinklers or sub-surface drip; and converting high-pressure sprinkler systems to low-pressure systems with drop nozzles.

EQIP also supports improvements in irrigation efficiency with financial assistance for irrigation water management. This includes financial assistance to install soil moisture sensors and technical assistance to help irrigators use advanced methods to determine the amount of irrigation water to apply.

Irrigators in the project area may also use EQIP to support other management practices that improve on-farm efficiency in irrigation water use but also address other important resource concerns. Producers can use EQIP to transition to no-till planting, support precision nutrient management, improve pest management techniques, and apply cover crops that support improved soil health. By using EQIP, producers can address all the relevant resource concerns on their operation and greatly improve on-farm efficiency.

Farmers in the URNRD have applied and continue to apply for financial and technical assistance from NRCS to improve on-farm efficiency. From 2014 through 2017, 18 EQIP contracts have been obligated for more than $340,000 worth of conservation practices that improve on-farm efficiency in the URNRD. In addition to those EQIP funds, an additional 6 contracts, obligating $98,000 in funds supporting on-farm efficiency, have been approved using the Regional Conservation Partnership Program (RCPP) Republican Basin Conservation Partnership. The RCPP, Republican Basin Conservation Partnership leverages matching funds from three Republican River Natural Resources Districts including the URNRD with federal funds to make more EQIP dollars available. These funds are targeted directly at treating inefficient water use on farms in the URNRD.

By collaborating, the URNRD and NRCS plan to implement on-farm improvements that will increase water use efficiency by 5-10% with improved irrigation water management. By treating 5,000 acres of irrigated land including in the project area with practices that improve water use

efficiency, we could expect to see approximately 416-acre feet of water savings annually. (5000 acres x 1 inch of water saving per acre = 5000-acre inches H2O.) (5000 acre inches / 12 inches per foot = 416 acres feet H2O).

Evaluation Criterion E – Department of the Interior Priorities

The proposed project supports the following Department of Interior priorities:

1. Utilizes science to identify best practices to manage land and water resources and adapt to changes in the environment.

The project supports this priority by giving irrigators tools to make water-use decisions that are based on science instead of information unrelated to actual crop-water needs that can lead to over-watering. Crop water needs accessible to farmers in the form of near real-time crop ET in their area coupled with near real-time water usage will allow them to irrigate using only volumes of water that are necessary.

2. Fosters relationships with conservation organizations advocating for balanced stewardship and use of public lands.

Reduced groundwater pumping for irrigation resulting from the project will strengthen bonds with other Natural Resources Districts in the Republican Basin. As evidenced by letters of support from two other NRDs, they see benefits reduced pumping has on stream flow in their regions, both of them downstream from the URNRD. Additionally, reduced pumping to the extent it benefits stream flow aids fish and wildlife managed by the Nebraska Game and Parks Commission and surface water supplies managed by the state Department of Natural Resources.

3. Improves relationships with persons and entities bordering our lands.

Water users outside of the URNRD have expressed interest in reduced water use to help stabilize their supplies, to the extent that use of the supply within the URNRD impacts supplies outside of the URNRD, namely downstream of the URNRD. These individuals and entities include surface water users, other Natural Resources Districts, and the State of Kansas.

4. Supports initiatives to modernize U.S. infrastructure

The U.S. Department of Homeland Security Office of Cyber and Infrastructure Analysis, as mentioned earlier, issued a report in August 2015 explaining the risk that continued depletion of the High Plains Aquifer has for U.S. infrastructure, namely the production and price of food and fuel. By reducing groundwater usage, the project will help sustain aquifer life and prolong the

ability to use the aquifer to produce food and fuel (ethanol via corn production), helping lessen the threat that aquifer depletion has to these to infrastructure components.

Evaluation Criterion F – Implementation and Results

The URNRD has long term and master plans that address short, mid-term and long range goals associated with water use and availability within the URNRD. The overarching goal within the plans is to slow and eventually stop groundwater declines. Specifically, the URNRD has formally adopted goal of "developing, promulgating and enforcing rules and regulations that provide for appropriate protection of the aquifer so as to slow and eventually stop water table declines in order that beneficially usable quantities of water remain in the aquifer; incentives to use water efficiently; conservation of groundwater; and maintaining or enhancing groundwater quality." (URNRD Master Plan, 2010-2020).

The URNRD's Integrated Management Plan, first approved in 2005, revised and approved in 2008, again in 2010, and revised and approved again in January 2016 in cooperation with the State of Nebraska, has goals and objectives with a purpose of "sustaining a balance between water uses and water supplies so that the economic viability, social and environmental health, safety and welfare of the river basin…can be achieved and maintained for both the near and long term."

The URNRD also has a Groundwater Management Plan, the main goal of which is to stop or slow groundwater declines.

The URNRD has pursued sustainable water use since the 1970's when it became, in 1979, the first entity in Nebraska and possibly the country to limit agricultural water use by establishing an allocation on the use of groundwater. Since that time, allocations have been reduced by approximately 40%. The regulations have slowed groundwater declines compared to what was predicted to occur absent regulations. Average groundwater declines are approximately 60% less than what USGS predicted they would be if regulations weren't established (Lappala, 1978) and the most significant groundwater declines are approximately half what USGS estimated would occur without regulations.

In addition to allocations, regulations limiting proximity of irrigation wells to one another were approved in 1979 and again in 1992. In 1997, the District approved and implemented the first well-drilling moratorium in Nebraska. Larger declines in areas that abut the District in Kansas and Colorado which do not have regulations or whose regulations are less stringent also illustrate the beneficial impact of these actions within the District. Average annual declines in areas of Kansas with a similar climate have been more than double those observed in the District.

Most recently, in 2013, the District made some of its most significant rules changes in its history when it restricted the use of unused allocation, or "carry-forward", and created new penalties for water users who use more than their water allotments. All agricultural water use has been metered since the late 1970's and approximately 400 wells are measured in the spring and fall. Metering, well measurements and allocations have created an extensive database from which the URNRD can base decisions to further its long term goal of slowing groundwater declines in the district. The proposed project represents the next step in water management for the URNRD and could serve as a model for other NRDs throughout Nebraska.

The primary URNRD goal which the project will help achieve, mentioned in the response to the first part of this question, is to slow and eventually stop groundwater declines. The project will help achieve this goal by giving irrigators and the district tools to eliminate unnecessary water use so that irrigation applications more closely match actual crop needs (URNRD Master Plan 2010-2020).
The project will also help achieve the following objectives contained in the URNRD's Long Range Implementation Plan:

- Develop, promulgate and enforce rules and regulations that provide for appropriate protection of the aquifer, incentives to use water efficiently, conservation of ground water, and maintenance and enhancement of groundwater quality: The project supports these objectives by providing the district data that could be used to tighten rules to reduce water use that would therefore protect the aquifer.
- Conduct monitoring and other data collection activities and research necessary for interpretation of changes in groundwater levels and actual and potential pollution of the aquifer: The project directly addresses this objective because the project is dependent on data collection that increases our understanding of the relationship between pumping and groundwater levels. We will be able to see in real time how groundwater levels react to many actual, different groundwater pumping scenarios.
- Cooperate with other agencies to plan and conduct data collection activities related to ground and surface water quantity and quality: The data collected as part of the project will be able to be shared with other experts in the fields of water quantity and quality such as the University of Nebraska-Lincoln.
- Reduce the potential for non-point contamination of ground and surface water through education, research, management practices, incentives and rules that protect the water but also minimize adverse effects on the economy of the area: Less water use and subsequently less leaching of nitrates into the groundwater supply via the project will help achieve this objective.

Additionally, one of the URNRD's primary objectives related to groundwater quantity is contained in the district's Groundwater Management Plan "to reduce the amount of groundwater being withdrawn." The proposed project will help achieve this objective. The district's IMP also has a goal of balancing uses and supplies which the project will help achieve by reducing water consumption.

Measuring the performance of the proposed project will be greatly aided by the URNRD's 38-year history of documenting annual water use on every irrigation well within the URNRD. This information will provide a valuable baseline that water usage following implantation of the project can be measured against. Precipitation data from previous years will allow us to measure water usage following project implementation with water usage from previous years where similar levels of precipitation occurred. The near real-time water application data will also allow us to compare water usage between irrigated crop fields in areas of the district with similar precipitation during the course of a growing season.

Evaluation Criterion G – Nexus to Reclamation Project Activities

The proposed project is in the same basin – the Republican Basin – as some Reclamation projects:
Enders Reservoir, which has historically served Frenchman Valley Irrigation District.
Swanson Reservoir, serving Frenchman-Cambridge Irrigation District
Hugh Butler Lake, serving Frenchman-Cambridge Irrigation District
Harry Strunk Lake, serving Frenchman-Cambridge Irrigation District
Harlan County Lake, serving Nebraska Bostwick and Kansas Bostwick Irrigation Districts

The project area itself, primarily in western Chase County, contains the upstream portion of the Frenchman River which supplies Enders Reservoir. The Frenchman River is a major tributary of the Republican River and downstream of the confluence of the Frenchman and Republican multiple canals part of Reclamation projects exist. Canals include: Meeker, Bartley, Cambridge, Naponee, Franklin and Superior within Nebraska and along the Republican River.

The URNRD does not receive Reclamation water and is not on Reclamation lands. To the extent that reduced groundwater under the project will increase stream base flow, it will contribute water to Reclamation projects.

Reduced groundwater pumping under the project will create additional baseflow to the Frenchman River of approximately 2,978-acre feet annually.

Project Budget

Funding Plan

The non-federal cost share required for the project has been obtained in expectation of pursuing this grant and thus is already available to the URNRD. There are no third-party funding sources; non-federal funding will be provided solely by the URNRD. The URNRD currently has and will have over the two-year duration of the project a cash balance sufficient to pay for the non-federal portion of the project. Funding sources that have secured necessary funds include a tax of $10 per irrigated acre in the URNRD that generates approximately $4.35 million annually that will be used to help fund the URNRD's portion of the cost-share agreement. The URNRD also levies a property tax on all property in the district that generates approximately $2.14 million annually.

The URNRD does not seek to include any in-kind costs incurred before the project start date. The project does not currently include any funding partners, thus no letters of commitment are attached, and no other federal funding relevant to the project has been received or requested. There are no pending funding requests that have not been approved.

The funding commitment from the URNRD is $468,844, the funds are currently available and will be at the time of grant award if one is awarded, there are no time constraints on availability of the funds, and there are no contingencies associated with the funding commitment.
The URNRD's contribution to the cost-share requirement will be monetary. Funds expended by the URNRD will be used to purchase the telemetry equipment, digital flow meter registers, conversion kits for the flow meters, and miscellaneous equipment for installation. Grant funds from BOR would be used for the same expenses.

There are no donations; no in-kind costs will be incurred before the project start date that URNRD would seek to include as project costs. There are no pending funding requests that would negatively affect the project if not approved.

Table 1 – Summary of Non-Federal and Federal Funding Sources

Funding Sources	Funding Amount
Non-Federal Entities	
1. Upper Republican NRD	$468,844
Other Federal Entities	
1. None	$0
Other Federal Subtotal	$0
Requested Reclamation Funding	$300,000
Total Study Funding	$768,844

Budget Proposal

Table 2

Budget Item Description	Computation $/unit	Computation Quantity	Quantity Type (hours/days)	Total Cost
Equipment				
Irrigation Flow Meter Digital Register w/ Telemetry Output	$402.25	1,018	One-time installation	$409,999
Bearing Assembly to Retrofit Existing Meters w/ Digital Registers	$190	1,018	One-time installation	$193,420
Radio Modules and Misc. Equipment to Receive Water Flow Outputs from Digital Register and Communicate to Radio Network	$162	1,018	One-time installation	$164,916
Subtotal				$768,335
Environmental Compliance Costs				$509
Salaries and Wages: No federal funds to be used for salaries/wages. Cost absorbed by URNRD				
Fringe Benefits: No fringe benefits provided via project				
Construction: Installation of telemetry equipment done by URNRD staff as part of regular job duties				
Travel: No federal funds to be used for travel for installation of equipment				
Total Direct Project Costs Subject to Federal Reimbursement				**$768,844**

Budget Narrative

As indicated in Table 2, the only costs for which the URNRD is seeking reimbursement are the costs of the equipment associated with the project, thus the total project costs subject to reimbursement only includes equipment costs. No salaries and wages, installation costs, or travel costs are included. The URNRD currently has staff that can install the equipment with very little training. We view installation of the equipment as a cost that should be absorbed solely by the URNRD because the work is associated with staff's current, regular job duties of maintaining flow meters in the district.

Following are key personnel for the project:

- Nate Jenkins, assistant URNRD manager, will act as program manager
- Dwain Curtis, URNRD technician, will assist in oversight of the project and aid in installation
- Cooper Bollman, URNRD technician, will install much of the equipment
- Mike Nesbitt, URNRD technician, will assist with installation
- John Lemon, URNRD technician, will assist with installation

As indicated in the above table, reimbursement for neither fringe benefits nor travel will be sought so they are not included as project costs.

The equipment costs listed in Table 2 are the result of quotes the URNRD has received for the required equipment and will not be installed under a construction contract, therefore no contractual costs are included.

The environmental and regulatory compliance costs of $509 listed in the budget table are minimal because the project primarily entails replacing existing equipment, flow meters, that are currently in compliance with environmental regulations. The radio network has already been installed by the electric utility therefore no radio communication infrastructure, e.g. radio towers, will have to be installed as part of the project. If environmental and regulatory costs exceed the budgeted amount, the URNRD, as may already be required, will pay additional and necessary amounts.

There are not other expenses currently considered part of the proposed project and no indirect costs are included, as indicated earlier, because we will not seek reimbursement for indirect costs.

We are wishful that this budget narrative provides all necessary information; it's brevity is due to the straightforward nature of the project – purchasing equipment needed for near real-time water usage information that will be coupled with ET data collected and disseminated to farmers to reduce water usage. The collection and communication of the ET data is currently underway and therefore is not part of the project costs associated with this grant application.

The total project costs, then, are $768,844. The URNRD will be responsible for 61% of the costs; BOR for 39%.

Environmental and Cultural Resources Compliance

- Will the project impact the existing environment? No, no earth-disturbing work affecting water, animals or water will be done.
- Are there any species listed as Federal threatened or endangered, or designated critical habitat in the project area? The Red Knot is a federally listed threatened species within Dundy County and the Whooping Crane is a federally listed endangered species within Perkins and Chase Counties. Would they be affected by any activities associated with the project? No
- Are there any wetlands or other surface waters inside the project area that potentially fall under CWA jurisdiction as Waters of the United States? Yes, but none will be impacted as no project equipment will be installed on such lands.
- When was the water delivery system constructed? The water delivery system consists of privately owned groundwater wells constructed from the 1950's through the mid 1990's.

- Will the proposed project result in any modification of or effects to features of an irrigation system? Existing flowmeters on irrigation wells will be modified with transmitters and telemetry equipment for remote monitoring of water use. Irrigation systems will not be modified, just the meter for improved water management. Are any buildings, structures, or features in the irrigation district listed or eligible for listing on the National Register of Historic Places? No
- Are there any known archeological sites in the proposed project area? No
- Will the proposed project have a disproportionally high and adverse effect on low income or minority populations? No, the project may help them by sustaining the economy of the region.
- 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

Required Permits or Approvals

The only permit or approval required by the URNRD would possibly be an FCC license, at minimal cost, to obtain a radio frequency.

Letters of Support

Please see the enclosed letters of support from:

- Nebraska Department of Natural Resources (Attachment 1)
- Middle Republican Natural Resources District (Attachment 2)
- Lower Republican Natural Resources District (Attachment 3)

Official Resolution

Due to the timing of the URNRD Board of Directors' meetings, the required official resolution is not enclosed but is expected to be mailed to BOR on May 10.

RESOLUTION OF THE UPPER REPUBLICAN NATURAL RESOURCES DISTRICT

Resolution No. UR-2018-05

WHEREAS, the Board of Directors agrees that Jasper Fanning, General Manager of the Upper Republican Natural Resources District, and Nate Jenkins, Assistant Manager, have legal authority to enter into an agreement with the U.S. Bureau of Reclamation to execute provisions of the WaterSMART Drought Resiliency Project Grant program; and

WHEREAS, Management of the Upper Republican Natural Resources District has reviewed and supports the application for WaterSMART Grant funds; and

WHEREAS, the Upper Republican Natural Resources District is a political subdivision of the State of Nebraska and as such has taxing authorities and current budgetary capabilities sufficient to provide the amount of funding specified in the WaterSMART Grant application funding plan; and

WHEREAS, the Upper Republican Natural Resources District agrees to work with the U.S. Bureau of Reclamation to meet established deadlines for entering into a cooperative agreement.

NOW, THEREFORE, be it resolved, that the Upper Republican Natural Resources District Board of Directors authorizes Management of the District to meet legal and financial obligations required under the U.S. Bureau of Reclamation's WaterSMART Drought Resiliency Project Grant Program.

Terry L. Martin — May 8, 2018

Terry Martin, Chairman — Date Approved

Attachment 2

NEBRASKA

Good Life. Great Water.

DEPT. OF NATURAL RESOURCES

Pete Ricketts, Governor

May 8, 2018

Nate Jenkins, Asst. Manager
Upper Republican Natural Resources District
PO Box 1140
Imperial, NE 69033

Dear Nate:

Please consider this letter a formal expression of support for your remote water metering and conservation project designed to reduce water usage and improve your data collection and processing capabilities.

With regard to the latter, more timely water usage information from a substantial part of your district that you have indicated would be available to the Department of Natural Resources (Department) via the project may aid our development of projected balances and resulting obligations relative to the Republican River Compact. Specifically, should your project help instigate the use of remote metering technology throughout Nebraska's portion of the Republican Basin, we would receive basin-wide water usage information much earlier than we do now and therefore could provide an earlier projection of whether, and to what extent, management actions such as stream augmentation or reductions in groundwater pumping would have to be taken to maintain Compact compliance. This advanced planning may also aid surface water users throughout the Basin.

We are also supportive of the project's potential to reduce groundwater pumping by improving farmers' irrigation scheduling. It makes sense that informed irrigation decisions to apply only amounts necessary as indicated by evapotranspiration rates and soil moisture content include exact, near real-time information about how much water is being applied.

Efforts to reduce water usage and improve planning and decision-making with regard to Compact obligations also have the potential to help reduce conflict among water users in the Republican Basin, which we wholeheartedly support.

Sincerely,

Gordon W. Fassett

Gordon W. Fassett, Director
Nebraska Department of Natural Resources

Gordon W. "Jeff" Fassett, P.E., Director
Department of Natural Resources
301 Centennial Mall South
P.O. Box 94676
Lincoln, Nebraska 68509
OFFICE 402-471-2363
FAX 402-471-2900
dnr.nebraska.gov

Attachment 2

Middle Republican Natural Resources District

220 Center Ave
Curtis, NE 69025
office@mrnrd.org
(308) 367 – 4281
www.mrnrd.org

May 4, 2018

Nate Jenkins, Asst. Manager
Upper Republican Natural Resources District
PO Box 1140
Imperial, NE 69033

Dear Nate:

As the neighboring, downstream Natural Resources District to yours managing to what to some extent is a shared water supply, the Middle Republican Natural Resources District (MRNRD) is pleased to support your BOR Grant proposal to use real-time water usage information to reduce water usage.

Our NRD, which includes close to 300,000 irrigated acres, is pursuing similar projects because near real-time water usage information is needed if farmers are to match their irrigation applications to actual crop-water needs as indicated by evapotranspiration rates and soil moisture content. As you know, the technology is available now to tell farmers when they should, and should not, irrigate, but they often lack the information real-time water usage provides: Whether the amounts they are applying when they do irrigate exceed what ET rates and soil moisture content indicates is necessary.

Our understanding is that your project will potentially reduce water usage in the Upper Republican NRD and have a positive impact on groundwater pumping and stream flow. The MRNRD hopes that your project as well as similar projects are implemented, providing a blueprint for real-time water management throughout the Republican Basin, increasing the reliability of water supplies and reducing conflict among users.

Sincerely,

Jack Russell
General Manager
Middle Republican Natural Resources District

Attachment 3

LOWER REPUBLICAN NATURAL RESOURCES DISTRICT

May 4, 2018

Nate Jenkins, Assistant Manager
Upper Republican Natural Resources District
PO Box 1140
Imperial, NE 69033

Dear Nate:

The Lower Republican Natural Resources District supports your proposed project to reduce water usage by approximately 8,270 acre feet annually. This level of reduction would be substantial and has the potential to aid surface water users in the Republican Basin by reducing groundwater pumping impacts on the Republican River. According to the information provided, this reduction has the potential to minimize impacts to Republican River stream flow by almost 3,000 acre feet annually over a 50-year period.

We are interested in the development of your project because it could assist our district in pursuing similar projects in the future using real-time water usage information to improve farmers' irrigation scheduling. In addition to being a tool for farmers, such information could help regulators such as ourselves gain a better understanding of how water usage throughout the growing season corresponds with the irrigation needs of crops as indicated by evapotranspiration rates. This is valuable educational information as we discuss with farmers different ways to conserve water and could help us as we craft new rules regarding water use in the future.

We think your project also has the ability to help lessen conflict among water users to the extent that it is able to help stabilize water supplies in your district and downstream regions such as ours.

Sincerely,

Todd R. Siel

Todd Siel
General Manager
Lower Republican Natural Resources District