LOWER LOUP
NATURAL RESOURCES DISTRICT

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llnrd.org

July 23, 2021

Mr. Thomas Riley

Director, Nebraska Department of Natural Resources

via Electronic Submission

Re: Lower Loup NRD Application for Water Sustainability Fund Grant

The Lower Loup Natural Resources District (LLNRD) submits the included application to the Water Sustainability Fund for the collection of hydrogeologic information through Airborne Electromagnetic Mapping (AEM). The Board of Directors of the Lower Loup NRD recognizes the importance of detailed hydrogeologic information to the conservation and protection of the water resources. This type of information is necessary for the Board to make the science-based management decisions utilizing the best available data. The LLNRD Board has approved this application to the Water sustainability Fund and committed to providing the necessary matching funds to the grant.

The LLNRD hopes that the Natural Resources Commission shares the Board of Directors recognition of the importance of detailed hydrogeologic information to conservation and protection of the water resources of the state. The LLNRD has and will continue to work with the partner agencies, including other Natural Resource Districts, the University of Nebraska Conservation and Survey Division, NDNR and other state, city, and county agencies to protect our groundwater resources for the continued beneficial use of the citizens of Nebraska. Should the Department or the Natural Resource Commission require any additional information or clarification regarding this application, please contact me directly and I will ensure that your request is met. Thank you for your consideration of this grant application.

Sincerely,

Russell Callan
General Manager

NEBRASKA NATURAL RESOURCES COMMISSION

Water Sustainability Fund

Application for Funding

Section A.

ADMINISTRATIVE

PROJECT NAME: Lower Loup NRD Aquifer Framework Mapping Nance County

SPONSOR'S *PRIMARY CONTACT INFORMATION* **(Not Consultant's)**

Sponsor Business Name: Lower Loup Natural Resources District

Sponsor Contact's Name: Russell Callan

Sponsor Contact's Address: 2620 Airport Drive, Ord, NE 68862

Sponsor Contact's Phone: (308) 728-3221

Sponsor Contact's Email: rcallan@llnrd.org

1. **Funding** amount requested from the Water Sustainability Fund:

   Grant amount requested. $ 250,000

   - If requesting less than 60% cost share, what %? N/A

   If a loan is requested amount requested. $ N/A

   - How many years repayment period? N/A
   - Supply a complete year-by-year repayment schedule. N/A

2. **Neb. Rev. Stat. § 2-1507 (2)**

   Are you applying for a **combined sewer overflow project**? YES☐ NO☒

   If yes:

- Do you have a Long Term Control Plan that is currently approved by the Nebraska Department of Environmental Quality? YES☐ NO☐ N/A
- Attach a copy to your application. N/A
- What is the population served by your project? N/A
- Provide a demonstration of need. N/A
- **Do not complete the remainder of the application.**

3. **Permits Required/Obtained** Attach a copy of each that has been obtained. For those needed, but not yet obtained (box **"NO"** checked), 1.) State when you will apply for the permit, 2.) When you anticipate receiving the permit, and 3.) Your estimated cost to obtain the permit.

(N/A = Not applicable/not asking for cost share to obtain)
(Yes = See attached)
(No = Might need, don't have & are asking for 60% cost share to obtain)

G&P - T&E consultation (required)	N/A☒	Obtained: YES☐	NO☐
DNR Surface Water Right	N/A☒	Obtained: YES☐	NO☐
USACE (e.g., 404/other Permit)	N/A☒	Obtained: YES☐	NO☐
FEMA (CLOMR)	N/A☒	Obtained: YES☐	NO☐
Local Zoning/Construction	N/A☒	Obtained: YES☐	NO☐
Cultural Resources Evaluation	N/A☒	Obtained: YES☐	NO☐
Other (provide explanation below)	N/A☒	Obtained: YES☐	NO☐

N/A

4. **Partnerships**

List each Partner / Co-sponsor, attach documentation of agreement:

Please see next paragraph for discussion on cooperators.

Identify the roles and responsibilities of each Partner / Co-sponsor involved in the proposed project regardless of whether each is an additional funding source.

The project is being done in cooperation with several local and state agencies with coordinated data collection to improve efficiency and gain economy of scale, with the goal of centralizing statewide AEM data through the Nebraska GeoCloud. The GeoCloud will provide technical support to the Lower Loup Natural Resources District (LLNRD), including incorporation of the completed data products into the existing datasets that comprise the overall framework of hydrogeology. Additionally, any test holes necessary for interpretation of the AEM data will be completed by CSD and incorporated into the statewide test hole database. After the completion of the data collection, interpretation, and framework update, the information about the aquifer characteristics and extents will be provided to the NDNR for incorporation into the existing models as the "best available" information in the FAB Report (NDNR, 2021).

5. **Other Sources of Funding**

Identify the costs of the entire project, what costs each other source of funding will be applied to, and whether each of these other sources of funding is confirmed. If not, please identify those entities and list the date when confirmation is expected. Explain how you will implement the project if these sources are not obtained.

The sources of funding for the project are the required local match from the LLNRD of 40% ($167,000) and the WSF application request of 60% ($250,000). No other sources of funding are proposed for this project. While there are no other sources of funds proposed for this project, the LLNRD, other NRDs, and NDNR have spent considerable time, effort, and money to develop this technology and implement it in many areas of the state. The project partners are committed to utilizing AEM to continue to develop a hydrogeologic framework and block areas necessary for the protection and conservation of the groundwater resources.

6. **Overview**

In 1,000 words *or less*, provide a brief description of your project including the nature/purpose of the project and its objectives. Do not exceed one page!

In recent years landowner conflicts over water availability have arisen in the Lower Loup Natural Resources District in Nance County. For example, two landowners in the area reported dramatic irrigation well pumping interference during the 2019 and 2020 growing seasons. The wells are located over 2,000 feet in distance. The older, east well was constructed in 1975 and the new, west well was constructed in 2018, operating for the first time in the summer of 2019. During an LLNRD-monitored pumping experiment, a drawdown of 11.3 feet was recorded on the older, east well when the new, west well was set at the default 550 gallons per minute (GPM) pump rate for 25 hours. The east well was not set to pump during the experimental period in order to test best-case scenario drawdown. A second recording was done during the same experiment over a 7-hour period, which produced a 4.9 feet drop in water level in the

east well. When both wells are pumping at their default rates, 550 GPM for the west well and 440 GPM for the east well, more significant drawdown occurs, as reported by the landowners in both 2019 and 2020. Based on The Groundwater Atlas of Nebraska a large portion of Nance County reports very low estimates for both saturated thickness and transmissivity of the unconfined portions of the High Plains aquifer. Furthermore, analysis of the geologic boring logs from existing area wells shows that aquifer-bearing soil materials, like sands and gravels, are minimally represented. As a result, in Fall 2019 the District prohibited new development of certified irrigated acres in an estimated area defined as a "well interference zone". A more scientific-based approach is needed for accurately drawing this new regulatory boundary of well interference.

This project seeks funding to collect Airborne Electromagnetics (AEM) data covering an approximate 300 square mile area in Nance County. This AEM data will provide a thorough understanding of the hydrogeology in this critical area with the goal of providing sustainable groundwater management practices, thus preventing water supply issues and potentially reducing landowner conflicts. An example of a management action as a result of this AEM data collection project is limiting or prohibiting new well development within a newly delineated well interference zone. Other examples of District action include improved well spacing requirements, well flow meter requirements, and the possibility of setting groundwater use allocations on existing wells within the new zone. This project is not only expected to reduce landowner conflicts from groundwater irrigation use, but is also expected to help prevent future drinking water supply issues from domestic and municipal wells in the area, especially during periods of water shortage such as drought. The AEM data will also be used to implement improved groundwater management for water quality purposes, as multiple wells in the area consistently report elevated nitrate concentrations. Finally, the AEM data will be added to the Nebraska GeoCloud system for public consumption.

7. **Project Tasks and Timeline**

Identify what activities will be conducted to complete the project, and the anticipated completion date.
For multiyear projects please list (using the following example):

Tasks	Year 1$	Year 2$	Year 3$	Remaining	Total $ Amt.
Permits	$18,000				$18,000
Engineering		$96,000			$96,000
Construction		$87,000	$96,000		$183,000
Close-out				$8,000	$8,000
				TOTAL	$305,000

- What activities (Tasks) are to be completed.
- An estimate of each Tasks expenditures/cost per year.
- Activities in years 4 through project completion under a single column.

This project will map a flight block (or area) across the Project Area in Nance County, covering approximately 518 miles of AEM survey (see Supplemental

Information Attachment (SIA), Figure 1) to develop a three-dimensional view of the aquifer in the vicinities of the City of Fullerton, the City of Genoa, and the Loup River. The project will consist of the planning of flight lines within the block area, collection of AEM data along the flight lines, processing of the raw AEM data, interpretation of the processed data, and reporting of the overall results. The AEM survey results will be incorporated into a Geographic Information System (GIS) spatial database for use by LLNRD. The resistivity data from the processed results will be tied to local geologic interpretations from traditional subsurface mapping. The AEM data will also be incorporated into the Nebraska GeoCloud, a state-wide, cloud-based AEM data library for public use.

This area is a high priority area targeted for AEM by the LLNRD where ongoing groundwater quantity problems are occurring, and potential use conflicts may occur that traditional methods of investigation have not resolved. Mapping results produced for these areas through this project will provide three-dimensional subsurface views of the aquifer materials and estimates of the extents and volumes of the ground water resources available (see SIA, Figure 7). The Reconnaissance flight lines conducted for this survey will be spaced approximately 2 miles apart, perpendicular to the estimated trend of the aquifer units. Additionally, “tie lines” will be spaced approximately 3 miles apart (oriented 90 degrees relative to the reconnaissance flight lines). However, the trend in the lines may shift due to the examination of the borehole only derived aquifer model throughout the area. In-fill Block flight lines will be flown at a spacing of approximately one quarter of a mile to provide detailed information over areas of aquifer zones identified in the reconnaissance flights. Similar approaches to Reconnaissance and detailed Block flights previously produced successful results in eastern Nebraska within the Papio-Missouri River Natural Resources District (P-MRNRD) (AGF, 2021) as well as the Lower Platte South Natural Resources District (LPSNRD) (AGF, 2019).

CSD geologists will evaluate the AEM survey results with CSD cross-section and ancillary data to make interpretations of the regional geologic setting types encountered and evaluate how well the AEM results match up relative to the cross-sectional data. The resulting map publication and conclusions will provide those interested in the hydrogeology of central Nebraska a comprehensive and improved understanding of the varying hydrogeological settings. That interpretation will follow the approach used for previous Eastern Nebraska Water Resources Assessment (ENWRA) block areas. The NRDs will use groundwater reservoir delineations and associated maps to address groundwater quality problems occurring in this block and to help mitigate potential quantity concerns in the area.

Upon notice of award of the Water Sustainability Fund grant, the LLNRD will contract with the Consultant to refine the proposed flight area and develop the detailed flight line plan. This will include a Reconnaissance grid developed from a borehole only derived bedrock surface and aquifer model. Payment of 30% of the total contract amount of $417,000, or $125,100 will be due at the time of contract signing. The Consultant, working with the LLNRD, will develop the Reconnaissance flight lines, maximizing the coverage area while avoiding infrastructure that creates electromagnetic interference. After the acquisition of the Reconnaissance lines, approximately 25% of the total acquisition will be remaining. Using the near real-time inversions and processing, in-fill lines will be flown to create localized denser Block flights in areas

requiring more detailed aquifer delineation. The dense Block flights will allow for aquifer volume estimations within the Block areas that would not be available with just the information gained from the Reconnaissance flight lines. The Consultant will combine all Block areas and Reconnaissance flight lines into an efficient flight plan to minimize mobilization, de-mobilization, and logistical costs for the data collection.

The single year of this project grant request will include the collection, processing, and interpretation of AEM data with a final report of the project completed by June, 2023. An additional 50% of the total contract amount of $417,000, or $208,500, will be due to the Consultant at the end of the AEM data collection. The remaining 20% of the total contract amount, or $83,400, will be due at the delivery of the final report.

The interpretations and GIS spatial database will be provided to Nebraska GeoCloud, CSD, and NDNR at the time of the final report delivery. CSD and NDNR will incorporate the findings of the project into existing datasets and models, as appropriate and at their schedule. The work required for incorporation of the datasets into the overall hydrogeologic framework is not included in the funding from this grant application.

8. **IMP**

Do you have an **Integrated Management Plan** in place, or have you initiated one? YES☒ NO☐ Sponsor is not an NRD☐

Section B.

DNR DIRECTOR'S FINDINGS

Prove Engineering & Technical Feasibility

(Applicant must demonstrate compliance with Title 261, CH 2 - 004)

1. Does your project include physical construction (defined as moving dirt, directing water, physically constructing something, or installing equipment)?
YES☐ NO☒

If you answered "YES" you must answer all questions in section 1.A.
If you answer "NO" you must answer all questions in section 1.B.

If "YES", it is considered mostly structural, so answer the following:

1.A.1 Insert a feasibility report to comply with Title 261, Chapter 2, including engineering and technical data; N/A

1.A.2 Describe the plan of development (004.01 A); N/A

1.A.3 Include a description of all field investigations made to substantiate the feasibility report (004.01 B); N/A

1.A.4 Provide maps, drawings, charts, tables, etc., used as a basis for the feasibility report (004.01 C); N/A

1.A.5 Describe any necessary water and/or land rights including pertinent water supply and water quality information (004.01 D); N/A

1.A.6 Discuss each component of the final plan (004.01 E); N/A

1.A.7 When applicable include the geologic investigation required for the project (004.01 E 1); N/A

1.A.8 When applicable include the hydrologic data investigation required for the project (004.01 E 2); N/A

1.A.9 When applicable include the criteria for final design including, but not limited to, soil mechanics, hydraulic, hydrologic, structural, embankments and foundation criteria (004.01 E 3). N/A

If "NO", it is considered mostly non-structural, so answer the following:

1.B.1 Insert data necessary to establish technical feasibility (004.02); N/A

1.B.2 Discuss the plan of development (004.02 A);

In addition to the detailed information provided here, please see the Supplemental Information Attachment (SIA) and Bibliography sections at the end of this application. The SIA includes the following figures:

- Figure 1 – Proposed AEM Survey Project Area Map
- Figure 2 – Project Area Water Quantity Map
- Figure 3 – Project Area Water Quality Map
- Figure 4 – Cedar River at Fullerton Stream Gage Graph
- Figure 5 – Generalized Geologic Cross-Section of Pumping Test Wells
- Figure 6 – Sample Interpreted Geologic Profile
- Figure 7 – Sample Interpreted 3D Fence Diagram
- Figure 8 – Cost Letter From AGF

This proposed project will utilize airborne Time-Domain Electromagnetics (TDEM) to map the subsurface materials of a majority of Nance County, Nebraska, covering approximately 300 square miles (Project Area) (see SIA, Figure 1). The overall steps of the project include finalization of the anticipated flight lines, collection of Airborne Electromagnetics (AEM) data in a Reconnaissance grid, in-fill Block flights in areas identified as having aquifer material, analysis and interpretation of the data, incorporation of the interpretation into the existing understanding and overall framework of the hydrogeology of the area, and completion of a report documenting the overall project and analysis.

Preliminary Reconnaissance flight line spacing, and total flight distance have been estimated for the Project Area (see SIA, Figure 1). Additional refinement of the spacing and flight lines will be needed to ensure efficient data collection and minimal interference from man-made sources such as pipelines or electrical power lines. Additionally, a borehole only aquifer map will be used to guide the final Reconnaissance flight line locations. In-fill Block flight lines will be collected after the Reconnaissance flights have highlighted aquifer areas.

The collection and analysis of the AEM data will be done by a geophysical consulting company (Consultant) to determine the electrical resistivity of the subsurface materials from the raw TDEM data. Electrical resistivity is a measure of how well or how poorly the subsurface materials resist the flow of an electrical current. Electrical resistivity can be correlated with subsurface materials such as gravels, sands, silts, and clays. Highly resistive materials are typically sands and gravels, whereas less resistive materials are typically silts and clays. AEM surveys also have the ability to map the location of fresh, brackish, and saline water at depth. The processed data will be provided to the LLNRD, GeoCloud web-based interface, and CSD for further interpretation with assistance from the Consultant. An example cross-section showing interpretation results is included as Figure 6 in the SIA.

The initial interpretation of the types of subsurface materials will be compared with the known hydrogeologic framework of the area to adjust and verify the initial interpretations. The verification will be done utilizing existing understanding of the

hydrogeologic units from test hole drilling and previous AEM work in areas adjacent to the Project Area. These interpretations comprise the overall hydrogeologic framework necessary for understanding the location, extents, potential recharge, groundwater flow, hydraulic connection of groundwater to surface water, and discharge characteristics of the aquifer systems. A final report will be provided by the Consultant describing the data collection, processing, and interpretation of the AEM. Included with the final report are geospatial data files that can be readily shared with interested parties to assist landowners, drillers, and local agencies with decisions regarding groundwater resources.

With the hydrogeologic framework updated through this project, the LLNRD will be better equipped to assess the overall susceptibility of the groundwater resources within the Project Area to impacts from contamination and increasing use and development. The updated hydrogeologic framework will directly inform the delineation of the groundwater resources to be included in the update of the LLNRD Groundwater Management Plan (GWMP). The AEM data will be used for other studies or products beyond their original intent. For example, CSD may use the AEM data to update bedrock maps, transmissivity and specific yield maps, and maps of secondary aquifers, or a contractor may use the data to site and construct an intentional recharge project.

1.B.3 Describe field or research investigations utilized to substantiate the project conception (004.02 B);

AEM utilizes a helicopter to carry electromagnetic transmitting and receiving equipment along a predetermined flight path. In all types of AEM, the equipment remotely senses the electrical characteristics of the subsurface materials which can be used to interpret the type of subsurface materials that are in place such as clay, silt, sand, or gravel. This survey provides a nearly continuous set of subsurface information, i.e. a virtual borehole approximately every 50 feet, along the flight lines. Due to the aquifer depths and variability of overlying material, Time-Domain Electromagnetics AEM has become the standard for large scale remote sensing of aquifer characteristics in Nebraska because of its depth of investigation. TDEM has been successfully implemented in much of Nebraska with extensive flights across the eastern portion of the state. Eastern Nebraska Water Resources Assessment, the Nebraska Department of Natural Resources, and the University of Nebraska Conservation and Survey Division assisted the local Natural Resources Districts with the funding, data collection, and interpretation, as well as the test hole drilling to ground-truth the interpretations. A map of the flight lines is included as Figure 1 in the SIA. Concerns over water supply in areas of Nance County require additional data and interpretation of the hydrogeologic setting through the collection of additional AEM. The proposed project is an extension of the recently collected AEM data from the Columbus area that was used in the development of the Columbus Area Water Resource Assessment. The Columbus AEM data was instrumental in the identification and ranking of locations that would provide the greatest groundwater recharge benefit to the Columbus area.

The previously collected AEM data and interpretations and work done as part of this project will be utilized by the LLNRD in the current update to the GWMP (LLNRD,

GWMP, 1985), and the voluntary Integrated Management Plan (IMP), adopted by the NDNR in May 2016 (LLNRD, IMP, 2016).

1.B.4 Describe any necessary water and/or land rights (004.02 C);

Remote sensing of aquifer materials requires some ground-truth of the aquifer characteristics through traditional drilling and sampling techniques. The existing set of CSD test holes (see SIA, Figure 2), as well as existing DNR drilling logs, can be utilized as ground-truth locations. Flight lines for this project will be developed to make use of the existing test holes and other hydrogeologic information where possible. Where test holes are not available but the need for ground-truth locations is critical, additional test holes may be drilled at additional cost to the LLNRD. The collected AEM data will allow for optimization of the locations of any critical test hole needs allowing for efficient use of test hole drilling expenditures. Should test holes be required, access agreements with landowners would be needed. Test hole drilling requires the use of a drilling rig on location for approximately three days to drill and describe the geologic materials. All drilled test holes are back-filled with bentonite grout and the land surface returned to its original condition. Access agreements for this type of work typically are readily obtainable as there are limited impacts to the land surface and the landowners benefit from the findings.

1.B.5 Discuss the anticipated effects, if any, of the project upon the development and/or operation of existing or envisioned structural measures including a brief description of any such measure (004.02 D).

Each year LLNRD produces an annual report characterizing trends in groundwater levels in the groundwater management areas (GWMAs) in the District. Well interference in this area of Nance County has caused local conflicts for water development due to the limited aquifer materials and the lack of understanding of aquifer geometry. For example, in one case, two landowners in the Nance County area reported irrigation well pumping interference during the 2019 and 2020 growing seasons. The wells are located over 2,000 feet in distance. The east well was constructed in 1975 and the new, west well in 2018, operating for the first time in the summer of 2019. Both wells rely on a sand/sandstone unit for their water source located at the base of the High Plains aquifer, or more specifically, the Ogallala Group of the Tertiary geologic period of the High Plains aquifer (Ogallala). Based on geologic boring logs, this sand/sandstone unit within the Ogallala is estimated at around 20–40 feet of thickness, pinching out completely at an estimated distance of less than a mile to the east (see SIA, Figure 5). During an LLNRD-monitored pumping experiment a drawdown of 11.3 feet was recorded on the older, east well when the new, west well was set at the default 550 gallons per minute (GPM) pump rate for 25 hours. The older, east well was not set to pump during the experimental period in order to test best-case scenario drawdown. A second recording was done during the same experiment over a 7-hour period, which produced a 4.9 feet drop in water level in the east well. When both wells are pumping at their default rates, 550 GPM for the west well and 440 GPM for the east well, more significant drawdown occurs, as reported by the landowners in both the 2019

and 2020 growing seasons. It should be noted that 2019 and 2020 were considered generally wet seasons with regard to precipitation and groundwater availability in the District, so the pumping effect during a dry season when both wells are pumping for consistently longer periods of time could be much greater than what has been experienced in this area of Nance County.

Relying on geologic boring logs and static water level measurements to understand the hydrogeologic dynamics in the case described above and in other parts of the LLNRD-designated “well interference zone” has been difficult. What is needed is better data. The results of this mapping project are anticipated to provide a detailed hydrogeologic framework to be used for identifying aquifer able to transmit and store groundwater, as was done with the Columbus area AEM study in 2016 and Buffalo County area AEM study in 2019. The project will provide further information regarding aquifer connectivity and composition throughout the area of concern.

Furthermore, the AEM data is expected to provide LLNRD with the tools to redraw the currently estimated well interference zone boundary with a more accurate one. An accurate well interference zone will be used in LLNRD’s water quantity management process to limit or prohibit the development of new wells and new irrigated acres, as well as prohibiting irrigated acre transfers into this area. The AEM data will also be used within the new zone to assist LLNRD in determining possible well pumping allocations in periods of water shortage, as this area of the District is particularly vulnerable to drought. LLNRD will be finishing a drought management plan in early 2022 which was funded in part by a 2019 Water Sustainability Fund grant award. The AEM data, and well interference zone that will be drawn as a result of the AEM data, will play an important part in the mitigation and management actions to be determined by the drought management plan, specifically as it relates to the future possibility of well pumping allocations in the District.

Prove Economic Feasibility

(Applicant must demonstrate compliance with Title 261, CH 2 - 005)

2. Provide evidence that there are no known means of accomplishing the same purpose or purposes more economically, by describing the next best alternative.

The traditional method of collecting hydrogeologic information is accomplished through test hole drilling, where a geologist describes the recovered materials, collects a borehole geophysical log, and interprets the contacts of the hydrogeologic units encountered. Individual test holes provide a single point of information about the area hydrogeology which can be supplemented with existing drillers logs. The geology and the aquifer materials between these points is interpolated utilizing the experience and expertise of trained hydrogeologists. The interpolation of the hydrogeology between points is simply an estimation of the subsurface materials present, but aquifer materials and their properties may change dramatically in as little as a few tens of feet from the individual test hole locations. Individual points of information, like test holes, therefore, provide limited information about the broader aquifer characteristics.

While limited, test holes have been the best available method for assessing aquifer characteristics until the recent improvement of AEM which essentially provides

thousands of virtual test holes along the flight path, thereby collecting a nearly seamless cross-section of the aquifer materials. The AEM survey method can remotely cover large areas of the subsurface in a short amount of time and with great detail. This type of seamless cross-section cannot be collected through any other known method in the same amount of time for AEM data acquisition.

Recent experience using AEM for projects with ENWRA has shown that the benefit-to-cost ratio for developing a hydrogeologic framework is significantly improved relative to traditional methods. The continuous nature of the virtual bore-holes provided by AEM cannot be repeated through any other methods. The average cost per line mile for AEM is $680 which includes collection, interpretation and reporting. A single mile of AEM represents approximately 100 virtual test holes with an approximate average maximum depth of 1,000 feet, all collected without trespass or ground disturbance. This, therefore, represents approximately 100,000 feet of traditional drilling and sampling (100 test holes of 1,000 feet each), a physical and economic impossibility. To make the cost comparison anyway, the current per foot costs of traditional test hole drilling is $10 to $15 per foot. Even if it were physically and logistically possible to drill 100 test holes in a one-mile line, the cost would be anywhere from $1,000,000 to $1,500,000 as compared to the price of $680 per mile of AEM.

3. Document all sources and report all **costs** and **benefit data** using current data, (commodity prices, recreation benefit prices, and wildlife prices as prescribed by the Director) using both dollar values and other units of measurement when appropriate (environmental, social, cultural, data improvement, etc.). The period of analysis for economic feasibility studies is the project life, up to fifty (50) years; *or*, with prior approval of the Director up to one hundred (100) years, (Title 261, CH 2 - 005).

The project improves the LLNRD's ability to provide tailored approaches to management to ensure the long-term conservation and protection of the water resources. For example, the LLNRD can use the AEM data to establish a scientifically based boundary for a well interference zone to be used for regulatory purposes, including management of certified irrigated acres and well permitting, in order to prevent landowner conflicts involving water availability and stabilize groundwater levels in the area. Other activities that could be implemented as a result in the use of the data include: new well installation, rotating of land use related to irrigation scheduling and aquifer performance, and mapping boundary conditions related to hydrologic connection with surface water. In using the AEM data to gain an understanding of the groundwater/surface water relationships, the District can work to improve water quality issues, such as nitrates, which is a concern in the LLNRD Water Quality Management Area (WQMA) occupied by the eastern portion of Nance County, WQMA #18 (LLNRD, SWLR, 2021). The AEM data will also provide the best data for use of the LLNRD's full-time wellhead protection staff to work with the City of Fullerton and the City of Genoa, which are located in the Project Area, to develop a Wellhead Protection Plan (WHPP). Both cities are currently in a wellhead protection area but do not have a WHPP in place.

These tailored approaches can assist the users of the water resources with understanding their capacity for continued development and protect existing and future

development. One form of benefit from this project could be realized by the ability to avoid constructing replacements of wells impacted by the migration of high nitrates or avoidable interference. Mapping through the AEM process will also give the LLNRD a better understanding of potential cross-contamination threats of multiple aquifers. Further benefits are realized from the public use of the data and enhanced management of the quality and quantity of groundwater.

3.A Describe any relevant cost information including, but not limited to the engineering and inspection costs, capital construction costs, annual operation and maintenance costs, and replacement costs. Cost information shall also include the estimated construction period as well as the estimated project life (005.01).

N/A

3.B Only primary tangible benefits may be counted in providing the monetary benefit information and shall be displayed by year for the project life. In a multi-purpose project, estimate benefits for each purpose, by year, for the life of the project. Describe intangible or secondary benefits (if any) separately. In a case where there is no generally accepted method for calculation of primary tangible benefits describe how the project will increase water sustainability, in a way that justifies economic feasibility of the project such that the finding can be approved by the Director and the Commission (005.02).

N/A

3.C Present all cost and benefit data in a table to indicate the annual cash flow for the life of the project (005.03).

N/A

3.D In the case of projects for which there is no generally accepted method for calculation of primary tangible benefits and if the project will increase water sustainability, demonstrate the economic feasibility of such proposal by such method as the Director and the Commission deem appropriate (005.04). (For example, show costs of and describe the next best alternative.)

This Project will collect information necessary to assist the LLNRD Board with decisions regarding the conservation and protection of water resources. Those decisions may result in the establishment of additional regulations through Groundwater Management Areas (GWMA) for either quantity or quality concerns, the development of additional rural water districts, the prioritization of Wellhead Protection Plans, or other programs sponsored by the LLNRD for aquifer protection. As the program, project, or action that may result from the information is not yet known, there is not currently a method for calculating the primary tangible benefits of the project in a quantitative way.

While quantifying the benefits from the project is not possible, there is an ability to discuss the overall benefits from a qualitative standpoint.

The purpose of the mapping through AEM is to identify and define the relationship of the aquifer systems to one another, as well as to the land surface and the surface water systems. The water available for use from an aquifer system is dependent upon the relationships among overall use, recharge, and discharge. The project will improve the overall identification of confining layers between aquifers, thereby improving the understanding of the interrelationships of use, recharge, discharge, and potential contamination threats. This improved understanding will be used to make informed management decisions regarding the quantity available for the various groundwater demands in the area. The conservation of the water resources would be accomplished with management actions that prioritize use and limit total groundwater withdrawals as needed and where needed. Prioritization and limits on use would result in greater understanding of the water available to individual users, which improves the user's ability to plan for continued use and development. This ability to plan for use and development would result in a greater ability to allow for additional economic development that is dependent upon the water resource.

The relationships among groundwater use, recharge, and discharge also informs potential actions related to groundwater quality. Where groundwater resources are more protected from surface related contaminants, management actions could prioritize use in those areas. Tailoring the locations of groundwater use decreases the potential need for expensive treatment and improves the longevity of capital investments related to water supply. Additionally, the understanding of where the groundwater resources are most susceptible to surface contaminants can be used to tailor the approaches to management of activities that can threaten those groundwater resources. This greater understanding of the groundwater/surface water interaction reduces the need for additional, expensive test hole drilling by those looking to utilize the resource, as well as preventing undue regulation resulting from a lack of knowledge of the resource.

Prove Financial Feasibility

(Applicant must demonstrate compliance with Title 261, CH 2 - 006)

4. Provide evidence that sufficient funds are available to complete the proposal.

The LLNRD's budget for July 1, 2020 to June 30, 2021 was $18,436,788.53 with a property tax levy of 0.029264 resulting in approximately $4,736,484.19 of local property taxes. Property tax accommodates approximately 25.7% of the total budget. This proposed project is considered part of the surface and groundwater quality program, and a Board motion to pursue resources to conduct the AEM data collection unanimously passed by the LLNRD Board of Directors at the May 27, 2021, meeting.

5. Provide evidence that sufficient annual revenue is available to repay the reimbursable costs and to cover OM&R (operate, maintain, and replace).

N/A

6. If a loan is involved, provide sufficient documentation to prove that the loan can be repaid during the repayment life of the proposal.

N/A

7. Describe how the plan of development minimizes impacts on the natural environment (i.e. timing vs nesting/migration, etc.).

Data collected during the AEM flight is remotely sensed and has no potential impact to the natural environment, including zero ground disturbance. This AEM survey will be flown in late summer or early fall before major bird migrations occur, with an expected duration of only 3-5 days total flight time.

8. Explain how you are qualified, responsible and legally capable of carrying out the project for which you are seeking funds.

The Nebraska Ground Water Management and Protection Act, passed in 1975, established the NRDs as the preferred local entities for groundwater regulation and protection. NRDs work cooperatively with cities, counties, state, and federal agencies to accomplish groundwater resource protection through programs, projects, and regulations. Each NRD is required to have in place a Groundwater Management Plan (LLNRD, GWMP, 1985), based upon the best available information, and approved by the Director of the Nebraska Department of Natural Resources (NDNR). The LLNRD completed and approved a voluntary Integrated Management Plan (IMP) for the hydrologically connected surface water and groundwater (LLNRD, IMP, 2016).

The District voluntarily entered into the IMP development process with NDNR to take a proactive approach to the protection of the interconnected water resources. The LLNRD staff, management, and Board of Directors (Board) devote significant time and resources toward their duties to understand and manage the groundwater resources. The District's existing, previously collected groundwater data will be combined by the staff and management of the LLNRD with the information collected during this project. The Board will utilize the full set of information regarding the groundwater resources to make future decisions about the management and protection of the groundwater resources.

9. Explain how your project considers plans and programs of the state and resources development plans of the political subdivisions of the state.

The data collected by the project will be submitted to the NDNR as the "best available" information for use in the Annual Evaluation of Availability of Hydrologically Connected Water Supplies; aka FAB Report (NDNR, 2021). The FAB Report is a statutory requirement of the NDNR which evaluates the long-term availability of the hydrologically connected water supplies of the state. The previous collection of AEM data done by ENWRA was partially funded by the NDNR for use in modeling efforts to determine the impacts of groundwater use on surface water availability in hydrologically connected reaches. The results of those modeling efforts, when complete, will be

incorporated into the FAB Report which determines if a basin is fully appropriated or not. The project will update the overall hydrogeologic framework and improve upon the previous AEM work that supports the FAB Report.

All Natural Resources Districts are statutorily required to have a completed Groundwater Management Plan (GWMP) which includes information about the aquifers of the NRD, supplemental supplies, integrated and coordinated use, and the boundaries of management areas. The LLNRD has an adopted GWMP, last revised in 1985 (LLNRD, GWMP, 1985). Results of this project specifically meet the objectives of the GWMP to address specific problems of groundwater quality. Furthermore, the GWMP is meant to be adaptive in nature, the collection of new information is a critical path to keeping the GWMP up to date and effective now and in the future.

The LLNRD will incorporate the project information to determine the need for and type of groundwater management protection areas (Protection Areas) in the Loup River, Cedar River, Plum Creek, and Beaver Creek Watersheds. Protection Areas are a management tool available to NRDs to improve the protection and conservation of the groundwater resources. The LLNRD GWMP refers to the groundwater reservoir and its management multiple times throughout the document. The AEM data gives the LLNRD a contiguous view of the aquifer and will allow management and flexibility in dealing with localized issues for both water quantity and quality.

The LLNRD developed a voluntary Integrated Management Plan in conjunction with the NDNR in May 2016 (LLNRD, IMP, 2016). Draft goals outlined in the IMP include protecting existing groundwater users while allowing for future development, as well as continued development of water supply and use inventories based upon the best available data and analysis. Other goals of the IMP are to better manage hydrologically connected ground and surface water. Obtaining a better understanding of aquifer connectivity, through activities like this project, is a critical component to achieving these goals. The IMP is meant to be adaptive in nature, and the collection of new information is a critical path to keeping the IMP up to date and effective now and in the future.

In recent years landowner conflicts over water availability have arisen in the District in Nance County. According to The Nebraska Groundwater Atlas (UNL-CSD, 2013), this area reports very low estimates for both saturated thickness and transmissivity of the unconfined portions of the High Plains aquifer. Analysis of the geologic boring logs from existing area wells shows that aquifer-bearing soil materials, like sands and gravels, are minimally represented. As a result, in Fall 2019 the District prohibited new development of certified irrigated acres in an area defined as a “well interference zone”. A more scientifically based approach is needed for establishing this new regulatory boundary, and the acquisition of AEM data and maps will allow LLNRD to define the lateral extent and depth of the area’s aquifer.

As part of the LLNRD’s GWMP, groundwater management areas (GWMAs) are established in the District. The study area for this project covers parts of GWMA #10, boundary located east and south of the City of Genoa (see SIA, Figure 2 – Water Quantity Map). Each year LLNRD produces an annual report characterizing trends in groundwater levels in the GWMAs (LLNRD, SWLR, 2021). The most recent reports indicate a long-term decline in the static water table in GWMA #10. Of the ten GWMAs in the District, four GWMAs report declining trend lines below the 1982 readings as per the Groundwater Management Plan, one of which is GWMA #10. Also, in GWMA #10,

groundwater levels below the 1982 readings were reported in thirteen of the last twenty years. The wet springs of 2018 and 2019 moved the GWMA static water level yearly average above the 1982 level, but the last two year's spring average in 2020 and 2021 have resulted in another dip in the average water level, with an expectation that 2022 measurements may produce an average below the 1982 level. Collection of AEM data and subsequent analysis will help the LLNRD better understand the hydrogeology in the area and allow the LLNRD to most effectively manage GWMA #10, a vulnerable GWMA in the District.

Groundwater quality monitoring conducted by the LLNRD has shown a portion of Nance County to have elevated levels of nitrates. In an evaluation of nitrate levels using 2020 groundwater sampling data, the geographic area covered by this Project included a high concentration location of more than seven (7) times above the EPA standard for drinking water (MCL) of 10 mg/L, with a concentration of 72.3 mg/L (LLNRD, WQR, 2020). This same domestic well also reported consistently high nitrate concentrations in the previous four years, including 65.8 mg/L in 2019, 66.6 mg/L in 2018, 63.3 mg/L in 2017, and 45.4 mg/L in 2016 (LLNRD, WQR, 2020). Other wells in the area also reported elevated nitrate concentrations. This includes two sites sampled in 2020 with values of 53 mg/L and 37 mg/L, as well as fifteen other sites that reported concentrations greater than the EPA drinking water standard of 10 mg/L. All of these sites are located within a seven-mile range of the City of Genoa and are located inside the Project Area (see SIA, Figure 3 – Water Quality Map). As a result of the AEM survey, LLNRD will have a better understanding of the hydrogeology in this area and can make better water quality management decisions. This includes the possibility of defining a new water quality management sub-area using knowledge of the hydrogeologic boundaries defined by AEM data. Establishing a new sub-area sets the stage for allowing the District to bring high nitrate areas under a managed level of control.

Furthermore, Beaver Creek, a stream that flows through the Project Area and is located near the City of Genoa, is on EPA's Clean Water Act Section 303(d) list of impaired waters. This stream segment is impaired due to elevated levels of *E. coli* bacteria (EPA, 2021). The data collected as a result of this AEM study will be used to provide an understanding of the potential of groundwater contaminants threatening surface water quality. This is done by direct examination of the aquifer materials and how they are hydrologically connected to the streams.

Finally, given the known levels of contamination of the groundwater in the Project Area, the LLNRD has a dedicated, full-time staff member available to work with the City of Fullerton and City of Genoa to develop a Wellhead Protection Plan (WHPP), as neither community has one in place. The AEM data will provide a better understanding of surface/ground water connectivity around both Fullerton and Genoa, providing our wellhead protection staff with the tools to develop a robust WHPP for those communities.

In summary, with the reported well interference issues, groundwater level declines, elevated nitrate concentrations, *E. coli* stream impairment, and lack of a WHPP in the communities of Fullerton and Genoa in Nance County, this AEM study area is a high priority area in the District for understanding the hydrogeologic framework and groundwater/surface water connectivity.

10. Are land rights necessary to complete your project? YES☐ NO☒

If yes:

10.A Provide a complete listing of all lands involved in the project.

N/A

10.B Attach proof of ownership for each easements, rights-of-way and fee title currently held.

N/A

10.C Provide assurance that you can hold or can acquire title to all lands not currently held.

N/A

11. Identify how you possess all necessary authority to undertake or participate in the project.

The LLNRD is a political subdivision of the State of Nebraska with authority to levy property taxes and enter into contracts and Interlocal Cooperation Act agreements. The contract for professional services with the Consultant to collect the AEM data will require approval from the LLNRD Board of Directors and be signed on behalf of the LLNRD by the General Manager.

12. Identify the probable consequences (environmental and ecological) that may result if the project is or is not completed.

Remote sensing projects such as AEM do not have a physical impact on the environment or ecologic communities. There are no known environmental or ecological consequences from AEM data collection. There are no human health impacts from this type of survey.

Section C.

NRC SCORING

In the NRC's scoring process, points will be given to each project in ranking the projects, with the total number of points determining the final project ranking list.

The following 15 criteria constitute the items for which points will be assigned. Point assignments will be 0, 2, 4, or 6 for items 1 through 8; and 0, 1, 2, or 3 for items 9 through 15. Two additional points will be awarded to projects which address issues determined by the NRC to be the result of a federal mandate.

Notes:

- The responses to one criterion ***will not*** be considered in the scoring of other criteria. Repeat references as needed to support documentation in each criterion as appropriate. The 15 categories are specified by statute and will be used to create scoring matrixes which will ultimately determine which projects receive funding.

- There is a total of 69 possible points, plus two bonus points. The potential number of points awarded for each criteria are noted above. Once points are assigned, they will be added to determine a final score. The scores will determine ranking.

- The Commission recommends providing the requested information and the requests are not intended to limit the information an applicant may provide. An applicant should include additional information that is believed will assist the Commission in understanding a proposal so that it can be awarded the points to which it is entitled.

Complete any of the following (15) criteria which apply to your project. Your response will be reviewed and scored by the NRC. Place an N/A (not applicable) in any that do not apply, an N/A will automatically be placed in any response fields left blank.

1. Remediates or mitigates threats to drinking water;

    - Describe the specific threats to drinking water the project will address.
    - Identify whose drinking water, how many people are affected, how will project remediate or mitigate.
    - Provide a history of issues and tried solutions.
    - Provide detail regarding long-range impacts if issues are not resolved.

The proposed Project Area includes much of Nance County centered around the City of Fullerton, a wellhead protection area without a Wellhead Protection Plan (WHPP) from the Nebraska Department of Environment and Energy (NDEE) in place,

with a population of 1,307 (2010 US Census); and the City of Genoa, a wellhead protection area with a population of 1,003 (2010 US Census), also without a WHPP in place. The LLNRD has a dedicated, full-time staff member available to work with these two cities on the development of a WHPP. The AEM data collected in this project will provide a better understanding of ground/surface water connectivity around Fullerton and Genoa, providing wellhead protection staff with the tools to develop a robust WHPP for those communities. Potential mitigating actions which may occur as a result of this study include deeper domestic well construction, future well construction modification, enhanced groundwater recharge information and management, and improved water quality monitoring.

Detailed information collected from AEM, combined with traditional hydrogeologic information that is incorporated into an aquifer framework, provides a far more complete understanding of the physical extents and potential interactions of the local and regional aquifers and surface waters. A hydrogeologic framework includes not only the depth to the top of the aquifer and extents of the aquifer materials, but also the depth to the bottom of the aquifer. Beyond the information collected about the aquifer, information about the materials that overlay the aquifer area are also important in providing greater understanding of how the recharging water migrates to the aquifer system. If AEM data is collected in a reconnaissance grid and then a dense block flight pattern of ~900 feet or less between flight lines, a determination of aquifer volume and groundwater in storage can be calculated. For an example of how AEM reconnaissance lines can be used to cover large area as well as detailed mapping to determine aquifer volume, refer to the SIA, Figure 7.

Water quality problems in aquifer systems that can impact drinking water are often related to activities at or near the land surface. A particular aquifer's susceptibility to surface contaminants is partially determined by the type of overlying materials. An understanding of the overlying materials, whether the materials readily allow percolating water to recharge the aquifer or not, determines the rate at which surface contaminants can reach the aquifer. Sandier materials above an aquifer with limited clay content allow more rapid recharge, whereas thick sections of clay reduce the rate of downward migration and recharge. Other sources of information about the overlying materials, such as soils maps, only include the very near surface materials. The standard soil mapping practices also only typically sample the soil every 2.5 acres versus the data rich sampling done with the virtual boreholes of AEM. AEM provides information about the full sequence of material that overlays an aquifer. Greater understanding of the extents of materials that limit or transmit percolating water can provide LLNRD with the ability to tailor management activities intended to protect drinking water quality.

Typically, contamination from the land surface tends to remain in the uppermost portion of the aquifer system versus mixing more deeply in the aquifer. Nitrate is a good example as it tends to stratify in the upper aquifer. The mapping of shallow clay zones through AEM helps delineate areas protected from contaminant transport from the surface. Locating future domestic and municipal drinking water supplies in areas where these protected aquifer units exist can help with wellhead protection and limit the impacts of the downward migration of contaminants.

Through an understanding of the full depth of the aquifer, LLNRD can establish best management practices to be used by well drillers during the construction of new drinking water wells. Typical domestic well construction occurs in the uppermost portion of the aquifer as, once the driller has encountered enough water bearing sands, the drilling is stopped, and the well is completed. Additional depth of drilling is considered an unnecessary expense once a sufficient quantity of water bearing sands are encountered. The additional drilling can, however, provide a domestic well with greater longevity and reduced impact from surface contaminants. Where sufficient depth of aquifer materials is available, recommendations for drilling to a deeper portion of the aquifer for well completion could be made. Completing the drinking water well in the deeper portion of the aquifer and sealing off the upper portion of the aquifer is an effective way to limit the wells susceptibility to contaminants. A deeper drinking water well also reduces the potential interference from nearby wells as they draw down the aquifer during use. A deeper drinking water well also has greater protection from water level declines that occur during times of drought.

Understanding the hydrogeologic properties of the Project Area through AEM data collection will allow the LLNRD to better evaluate drinking water availability for future generations. Knowing the characteristics of the underlying aquifer will impact management use/supply decisions in the area. In shallow aquifers, for example, the impacts of excessive pumping of wells can lead to cones of depression within the water table, and produce significant groundwater depletions, directly affecting drinking water supplies. Other negative effects of groundwater depletion include: drying up of wells, reduction of water in streams and lakes, increased pumping costs, land subsidence, and water quality deterioration, all of which threaten the accessibility of water for drinking.

The LLNRD has monitored groundwater quality in the Project Area for the past several decades as part of its current Groundwater Management Plan (GWMP). This includes a total of 255 well sampling locations for nitrates, 209 of which have been sampled in the last 5 years, since 2016 (see SIA, Figure 3 – Water Quality Map). This extensive monitoring effort conducted by the LLNRD has shown a portion of Nance County to have elevated levels of nitrates. In an evaluation of nitrate levels using 2020 groundwater sampling data, the geographic area covered by this project included a high concentration location of more than seven (7) times above the EPA standard for drinking water (MCL) of 10 mg/L, with a concentration of 72.3 mg/L (LLNRD, WQR, 2020). This same domestic well also reported consistently high nitrate concentrations in the previous four years, including 65.8 mg/L in 2019, 66.6 mg/L in 2018, 63.3 mg/L in 2017, and 45.4 mg/L in 2016 (LLNRD, WQR, 2020). Other wells in the area also reported elevated nitrate concentrations. This includes two sites sampled in 2020 with values of 53 mg/L and 37 mg/L, as well as fifteen other sites that reported concentrations greater than the EPA drinking water standard of 10 mg/L. All of these sites are located within a seven-mile range of the City of Genoa and are located inside the Project Area (see SIA, Figure 3). There is a need to understand the higher concentrations detected in the Project Area that are not detected basin-wide. High levels of nitrogen, as nitrate, in drinking water can be harmful to young infants or young livestock. Excessive nitrate can result in restriction of oxygen transport in the bloodstream. Infants under the age of 4 months lack an enzyme necessary to correct

the restricted oxygen transport resulting in what is known as "blue baby syndrome". The long-term impacts from not fully understanding the sources of nitrate contamination and the susceptibility of the aquifer system to contamination can potentially put human health at great risk.

The LLNRD has also monitored groundwater quantity in the Project Area for the past several decades as part of its current GWMP. This includes a total of 28 well locations for measuring static water levels, 22 of which have been measured in the last 5 years (see SIA, Figure 2 – Water Quantity Map). As part of the LLNRD's GWMP, groundwater management areas (GWMAs) are established in the District. The study area for this project covers parts of GWMA #10, boundary located east and south of the City of Genoa (see SIA, Figure 2). Each year LLNRD produces an annual report characterizing trends in groundwater levels in the GWMAs (LLNRD, SWLR, 2021). The most recent reports indicate a long-term decline in the static water table in GWMA #10. Of the ten GWMAs in the District, four GWMAs report declining trend lines below the 1982 readings as per the Groundwater Management Plan, one of which is GWMA #10. Also, in GWMA #10, groundwater levels below the 1982 readings were reported in thirteen of the last twenty years. The wet springs of 2018 and 2019 moved the GWMA static water level yearly average above the 1982 level, but the last two year's spring average in 2020 and 2021 have resulted in another dip in the average water level, with an expectation that 2022 measurements may produce an average below the 1982 level.

Furthermore, as it relates to groundwater quantity, when compared to other regions of the District, the Project Area located in Nance County has a much lower level of groundwater well development. As of 2021, there are approximately 40,710 certified irrigated acres for groundwater use only located in the Project Area, which is roughly 202,262 total acres in size (see SIA, Figure 2). Thus, 20.1% of the Project Area contains certified irrigated acres for groundwater use only. In comparison, 47.5% of Boone County, directly to the north of Nance County and the Project Area, is occupied by groundwater-only certified irrigated acres, and for Platte County, located to the north and east, 54.6% of the county is groundwater-only irrigated acres. Nance County has limited well development due to the area's hydrogeologic conditions and limited aquifer resources, as is reflected by the low density of groundwater irrigated acres when compared to the rest of the District. Limited well development for households is a drinking water accessibility issue. This problem can be understood more fully and managed more effectively with a thorough mapping of the aquifer in size and depth; a result of this AEM survey.

2. Meets the goals and objectives of an approved integrated management plan or ground water management plan;

    - Identify the specific plan that is being referenced including date, who issued it and whether it is an IMP or GW management plan.
    - Provide the history of work completed to achieve the goals of this plan.
    - List which goals and objectives of the management plan the project provides benefits for and how the project provides those benefits.

The LLNRD developed a voluntary Integrated Management Plan (IMP) in May, 2016, in conjunction with the NDNR (LLNRD, IMP, 2016). Meeting the goals and objectives of the IMP is a District priority. The overall goals of the LLNRD IMP are to better manage hydrologically connected water through a greater understanding of aquifer connectivity between surface water and groundwater, and potential aquifer components that may have an impact on the resource. This project will address objectives and action items related to these goals by: (1) utilizing the best available data and analysis tools to estimate consumptive water use; (2) assess the need for additional monitoring; (3) continue to gather and analyze hydrogeologic data; (4) evaluate the need to develop new rural water systems; and (5) coordinate with public water supplies to enhance education and conservation.

In addition to developing the voluntary IMP, the LLNRD has an adopted GWMP, formed in 1985 (LLNRD, GWMP, 1985). Results of this project specifically meet the objectives of the GWMP to address specific problems of groundwater quality. Groundwater quality monitoring conducted by LLNRD staff has shown the area around the City of Genoa in Nance County to have elevated levels of nitrates.

3. Contributes to water sustainability goals by increasing aquifer recharge, reducing aquifer depletion, or increasing streamflow;

   List the following information that is applicable:

   - The location, area and amount of recharge;
   - The location, area and amount that aquifer depletion will be reduced;
   - The reach, amount and timing of increased streamflow. Describe how the project will meet these objectives and what the source of the water is;
   - Provide a detailed listing of cross basin benefits, if any.

A primary goal in collecting AEM data for this project is to establish a scientifically based well interference zone in order to better manage groundwater quantity and to reduce aquifer depletion in this area of the District with low transmissivity and low saturated thickness. Significant well interference issues have been reported to LLNRD in recent years in the Project Area. For example, in one case, two landowners in the Nance County area reported irrigation well pumping interference during the 2019 and 2020 growing seasons. The wells are located over 2,000 feet in distance. The older, east well was constructed in 1975 and the new, west well was constructed in 2018, operating for the first time in the summer of 2019. Both wells rely on a sand/sandstone unit for their water source located at the base of the High Plains aquifer, or more specifically, the Ogallala Group of the Tertiary geologic period of the High Plains aquifer (Ogallala). Based on geologic boring logs, this sand/sandstone unit within the Ogallala is estimated at around 20–40 feet of thickness, pinching out completely at an estimated distance of less than a mile to the east (see SIA, Figure 5). During an LLNRD-monitored pumping experiment a drawdown of 11.3 feet was recorded on the older, east well when the new, west well was set at the default 550 gallons per minute (GPM) pump rate for 25 hours. The east well was not set to pump during the experimental period in order to test best-case scenario drawdown. A second recording was done during the same

experiment over a 7-hour period, which produced a 4.9 feet drop in water level in the east well. When both wells are pumping at their default rates, 550 GPM for the west well and 440 GPM for the east well, more significant drawdown occurs, as reported by the landowners in both the 2019 and 2020 growing seasons. It should be noted that 2019 and 2020 were considered generally wet seasons with regard to precipitation and groundwater availability in the District, so the pumping effect during a dry season when both wells are pumping for consistently longer periods of time could be much greater than what has been experienced in this part of Nance County. Reducing aquifer depletion will reduce the potential for these types of landowner conflicts and is a primary goal of this project.

The collection of hydrogeologic data and assembly of that data into an overall aquifer framework provides the information necessary to help determine area recharge characteristics, aquifer extents, volume of available groundwater, interconnection with other aquifers, and stream-aquifer interactions. AEM, along with interpretation of the collected data, provides highly detailed information about the materials within the aquifer, as well as the materials above, below, and adjacent to the aquifer. An example of the type of aquifer delineation that AEM can provide is included in the SIA, Figure 6.

Aquifer recharge is determined by the water available from precipitation for deep percolation after taking into account runoff, evapotranspiration, soil characteristics, and other factors. Recharge is also impacted by the materials that overlay the aquifer which influence the way in which the deeply percolating water reaches the aquifer. Generally speaking, the sandier the materials that overlay the aquifer, the faster the recharge will be, while more clay-rich materials will tend to slow the recharge. AEM can be utilized to improve the LLNRD's understanding of recharge potential by delineating the layers of material types overlying, as well as underlying, an aquifer. Recharge potential can then be utilized by the LLNRD to better assess projects designed to increase recharge as well as inform the LLNRD's management of preferred development zones in areas where recharge is higher.

Preferred development areas can be used to tailor development of additional uses of groundwater to those areas where recharge more readily replenishes withdrawals, where aquifer thickness is greatest, where effects from aquifer extents are reduced, and/or where well impacts to streams are minimized. Management decisions for Groundwater Management Areas (GWMAs) would seek to balance the needs for groundwater development with the existing uses of groundwater in an area. A more complete framework of the hydrogeology will improve the LLNRD's ability to make those management decisions and improve the sustainability of the overall water resources. Potential management decisions to utilize allocations, rotation, limits on development, well spacing requirements, or other groundwater controls as part of a GWMP or IMP can be better tailored to protect existing users and promote sustainable use of the water resources.

Finally, managed aquifer recharge projects that utilize the AEM survey data in the lower end of the Loup River Watershed will help with water supply issues downstream on the lower Platte River. Nebraska communities downstream, including the cities of Lincoln and Omaha, would ultimately benefit from the upstream recharge projects that may be designed and installed in the Project Area as a result of collecting and implementing this AEM data.

4. Contributes to multiple water supply goals, including, but not limited to, flood control, agricultural use, municipal and industrial uses, recreational benefits, wildlife habitat, conservation of water resources, and preservation of water resources;

   - List the goals the project provides benefits.
   - Describe how the project will provide these benefits
   - Provide a long range forecast of the expected benefits this project could have versus continuing on current path.

Conservation and preservation of water resources for the beneficial use of the residents of the state requires detailed information about the aquifer characteristics and interactions of the groundwater and surface water resources. Sound strategies for conservation and preservation in this area, whether management actions, programs, or projects, depend on that detailed information to understand the volume and distribution of available groundwater and water quality concerns.

AEM data collection in this area of Nance County will not only benefit the communities of Fullerton and Genoa, through a greater understanding of the aquifer resource as a whole, but also provide invaluable amount of data for the various studies taking place to better understand and potentially conserve water resources through informed management recommendations. Some of those studies include but are not limited to: Elkhorn-Loup (ELM) Model, Central Nebraska (CENEB) Model, United States Geological Survey (USGS) High Plains Aquifer Water-level Monitoring Study, Cooperative Hydrology Study (COHYST), ENWRA, and the recent Nebraska GeoCloud and Airborne Electromagnetic (AEM) Data Integration project.

AEM surveys have greatly advanced groundwater management efforts by providing cost-effective, high-resolution subsurface information. AEM has revolutionized aquifer mapping in Nebraska. In the last 13 years, taxpayers have invested over $12 million on 25,000 line-miles of AEM collected by different consultants and sponsors using different survey methods, software, and analytical approaches. GeoCloud, a statewide internet storage network designed specifically for AEM data, was developed in order to permit seamless data integration and sharing of results between organizations, like the Conservation and Survey Division, U.S. Geological Survey, and Nebraska's NRDs, aimed at mapping the bedrock surface and hydrostratigraphic units to improve estimation of groundwater in storage. The AEM data from this Nance County project will be added to Nebraska GeoCloud, making the data readily available in a standardized format to water resource managers, scientists, and planners across the state. Furthermore, by providing access to "best available" science through the Nebraska GeoCloud, this project will contribute to the goals and objectives of the LLNRD's voluntary Integrated Management Plan (IMP), approved by Nebraska DNR in May, 2016.

5. Maximizes the beneficial use of Nebraska's water resources for the benefit of the state's residents;

- Describe how the project will maximize the increased beneficial use of Nebraska's water resources.
- Describe the beneficial uses that will be reduced, if any.
- Describe how the project provides a beneficial impact to the state's residents.

The beneficial use of Nebraska's water resources is established and prioritized in the Nebraska constitution with drinking water use being the highest priority and agricultural use and industrial use following from there. Water is considered a necessity and a shared resource of the state. The LLNRD has long worked with other area NRDs and the State of Nebraska to best manage the water resources for beneficial use. The aquifer framework developed through this AEM collection project will further the District's understanding of the aquifer systems and their interaction with the land surface and area streams. This understanding will be shared with other NRDs as well as state agencies including NDNR and CSD. The shared understanding of the water resources will allow the agencies tasked with understanding and managing Nebraska's water resources the best available information to make the best possible decisions regarding the beneficial use of the water resources.

The primary impact to beneficial use of the groundwater resources through the proposed project can be addressed through better recognition of the limited availability of groundwater in the aquifer system. Understanding the limits to the groundwater supply in the Project Area will allow the LLNRD to tailor any potential best practices or limits to use to accommodate the available supply. A primary goal of this project is to minimize aquifer depletion by establishing a new well interference zone boundary where regulatory measures will be enabled, limiting new well development and possibly limiting pumping from existing wells. A new regulatory boundary is not only expected to reduce landowner conflicts from groundwater irrigation use, but is also expected to prevent drinking water supply issues from domestic and municipal wells in this part of Nance County. The preservation of groundwater resources is absolutely necessary to protect drinking water for rural residents in the Project Area.

Additional protection of the beneficial uses can be addressed through limiting potential contamination of groundwater used as a drinking water source. The hydrogeology in the area is defined by low transmissivity and low saturated thickness. Landowners in the area have experienced significant well interference. With the unknown level of connectivity among all types of wells in the area, understanding the susceptibility of the aquifer systems to surface contaminants is a high priority. Knowledge of the aquifer characteristics through AEM data collection will allow the LLNRD to adjust approaches to programs, projects, and actions by the Board to provide greater protection of the water resources. The need for GWMAs with best management practices for activities that may contribute surface contaminants to the groundwater can be more readily assessed and implemented. GWMAs may also have restrictions or limitations on activities in areas particularly susceptible to groundwater contamination. The LLNRD may also provide recommendations for preferred development areas to minimize development in areas where the potential for surface contaminants reaching the aquifer system is highest.

Furthermore, this project will maximize beneficial use by submitting all AEM data and models to the Nebraska GeoCloud, which will publicly serve AEM data to the State of Nebraska and its 1.8 million residents where AEM survey data and interpretations can be used for other purposes beyond their original intent.

6. Is cost-effective;

- List the estimated construction costs, O/M costs, land and water acquisition costs, alternative options, value of benefits gained.
- Compare these costs to other methods of achieving the same benefits.
- List the costs of the project.
- Describe how it is a cost effective project or alternative.

As mentioned in Section B-2, recent experience using AEM for projects with ENWRA has shown that the benefit-to-cost ratio for developing a hydrogeologic framework is significantly improved relative to traditional methods. The continuous nature of the virtual bore-holes provided by AEM cannot be repeated through any other methods. The average cost per line mile for AEM is $680 which includes collection, interpretation and reporting. A single mile of AEM represents approximately 100 virtual test holes with an approximate average maximum depth of 1,000 feet, all collected without trespass or ground disturbance. This, therefore, represents approximately 100,000 feet of traditional drilling and sampling (100 test holes of 1,000 feet each), a physical and economic impossibility. To make the cost comparison anyway, the current per foot costs of traditional test hole drilling is $10 to $15 per foot. Even if it were physically and logistically possible to drill 100 test holes in a one-mile line, the cost would be anywhere from $1,000,000 to $1,500,000 as compared to the price of $680 per mile of AEM.

AEM data collection and interpretation provide an understanding of the aquifer systems that cannot be developed through traditional drilling and sampling techniques. The only real alternatives to consider for the collection and interpretation of data that provides a hydrogeologic framework are the different methods of AEM. The work of the USGS has provided the necessary studies to review the methods of AEM data collection to conclude that TDEM, the method proposed for this Project, is the most effective method given the types of overlaying materials (Hobza, Bedrosian, Bloss, 2012).

The total cost of the project for collection, processing, interpretation, and reporting is $417,000 (see SIA, Figure 8). Other forms of AEM data collection would be nearly identical in price but would lack the ability to differentiate the subsurface materials to a sufficient depth for the development of a hydrogeologic framework. The benefits are potentially many and economically substantial. Without the full hydrogeologic framework, the LLNRD does not have the ability to make science-based decisions regarding the need for specific programs, projects, or actions. Once complete, the hydrogeologic framework will inform the activities of the LLNRD which will result in the conservation and protection of the water resources for the beneficial use of drinking water, agricultural, and industrial users maintaining the resource for continued development.

7. Helps the state meet its obligations under interstate compacts, decrees, or other state contracts or agreements or federal law;

    - Identify the interstate compact, decree, state contract or agreement or federal law.
    - Describe how the project will help the state meet its obligations under compacts, decrees, state contracts or agreements or federal law.
    - Describe current deficiencies and document how the project will reduce deficiencies.

LLNRD recently designated a "well interference zone" to limit the development of high-capacity wells (50 gallons per minute or more) in a large portion of Nance County (see SIA, Figure 2 – Water Quantity Map). This new regulatory zone was a result of landowner conflicts that arose when a landowner placed an irrigation well over 2,000 feet away from another landowner's existing irrigation well. Nebraska Revised Statute 46-611 requires a minimum distance of 600 feet for irrigation water wells, if under different ownership. Due to the low transmissivity and low saturated thickness of the Ogallala aquifer in the Project Area, the 600-foot distance requirement by the State is insufficient for irrigation wells, especially during the peak growing season and/or time periods when little or no precipitation is available. By collecting AEM data and developing an accurate boundary of well interference to be used in well development and irrigated acres regulation, this project will help the LLNRD and the State fulfill the intention of the minimum distance requirement for wells, which is, at least in part, to avoid large cones of depression in the aquifer and thus water availability issues from wells. Regulating the area for development of new irrigated acres will reduce or even eliminate future water conflicts between landowners and thus reduce operating deficiencies for LLNRD and the State in the Project Area.

AEM can also be utilized to improve the LLNRD's understanding of recharge potential by delineating the layers of material types overlying an aquifer. Recharge potential can then be utilized by the LLNRD to better assess projects designed to increase recharge as well as inform the LLNRD's management of preferred development zones in areas where recharge is higher. Managed aquifer recharge projects that utilize the AEM survey data in the lower end of the Loup River Watershed will help with water supply issues downstream on the lower Platte River. Nebraska communities downstream, including the cities of Lincoln and Omaha, would ultimately benefit from the upstream recharge projects that may be designed and installed in the Project Area as a result of collecting and implementing this AEM data.

8. Reduces threats to property damage or protects critical infrastructure that consists of the physical assets, systems, and networks vital to the state or the United States such that their incapacitation would have a debilitating effect on public security or public health and safety;

    - Identify the property that the project is intended to reduce threats to.

- Describe and quantify reductions in threats to critical infrastructure provided by the project and how the infrastructure is vital to Nebraska or the United States.
- Identify the potential value of cost savings resulting from completion of the project.
- Describe the benefits for public security, public health and safety.

By designing a scientifically based well interference boundary as a result of AEM data collection and aquifer mapping, this project will reduce future threats to property damage, which includes reducing the threat of shutting down or reducing new irrigation water well infrastructure from operation. As per the Groundwater Management Area Rules & Regulations, Rule 6, Paragraph (L) “Any new water well or replacement well that is constructed after May 9, 2016, may be subject to additional restrictions as the Board of Directors deems reasonable and necessary in light of hydrologic conditions within the District” (LLNRD, GWMP, 1985). As landowner conflicts over groundwater have arisen recently in the Project Area, this GWMP Rule 6 has been implemented on a landowner’s well developed after May 9, 2016, and may be implemented somewhere in the area again if future groundwater conflicts arise. The development of an accurate well interference boundary and the regulation of new well development within that boundary will likely reduce or eliminate the need to implement GWPM Rule 6, especially by prohibiting the construction of a new well and related well infrastructure in the first place. In other words, if the LLNRD can prohibit the construction of a new well that may likely cause groundwater availability issues for landowners with existing wells, then that is arguably better than initially allowing well construction in the area only to regulate the well post-construction per GWMP Rule 6. It is better for the LLNRD, the State, and the landowner to not allow expensive well construction up front than to allow it and then shut down or reduce the use of the well. The well interference zone developed as a result of this AEM survey will act as a regulatory boundary with a preventative effect, intending to reduce or eliminate threats to existing and future well infrastructure.

Information resulting from this project will also help protect critical infrastructure, primarily the municipal and domestic drinking water wells which serve the communities of both Fullerton and Genoa, with an estimated combined population of 2,310 (2010 US Census), as well as the surrounding rural population. Declining water levels impact wells, often requiring well owners to deepen their wells or drill new wells. This data can help protect these drinking water supplies by helping to protect future overuse of the aquifer and reducing the threat of groundwater contamination. Understanding the entire aquifer framework is essential in preventing future drinking water supply contamination and ensuring a reliable public water supply for the future development of this area. Water quality concerns, such as high nitrate concentrations in and around the City of Genoa and *E. coli* stream impairments on Beaver Creek, are also present in the Project Area (see SIA, Figure 3 – Water Quality Map). The AEM data is expected to result in improved management for water quality concerns in Nance County, a benefit to public health and safety. Cost savings resulting from the completion of this project are unknown at this time.

9. Improves water quality;

- Describe what quality issue(s) is/are to be improved.
- Describe and quantify how the project improves water quality, what is the target area, what is the population or acreage receiving benefits, what is the usage of the water: residential, industrial, agriculture or recreational.
- Describe other possible solutions to remedy this issue.
- Describe the history of the water quality issue including previous attempts to remedy the problem and the results obtained.

Groundwater quality in the Project Area, specifically nitrate contamination, is an issue around the City of Genoa in Nance County. The District's WQMA #18, which includes the City of Genoa, the northeastern portion of Nance County, and the southeastern portion of Boone County, shows a rising trend of median nitrate concentrations (LLNRD, WQR, 2020). This trend includes data measured annually for 43 years, going back to 1978. High nitrates around the Genoa area are the primary reason for the rise in the median nitrate concentration in WQMA #18. Further, WQMA #28, which shares the Loup River as a boundary with the Project Area, has been in the highest phase of water quality management (Phase III) since 2002, with a median nitrate concentration of 20.7 mg/L in 2020 on 805 sampling locations (LLNRD, WQR, 2020); see SIA, Figure 3. Nitrates have been a concern in this area for years, particularly WQMA #28, but have become a growing concern in WQMA #18 as the LLNRD sampling program has expanded over time and more data has been collected in the Project Area.

Drinking water users in this area are susceptible to the same type of nitrate contamination to varying degrees depending upon the location and depth of the municipal or domestic wells. Where drinking water supplies are impacted, and the owners of those wells are aware of the impacts, costly filtration systems are needed to remove the contamination. Creation of a hydrogeologic framework that delineates the extents, thickness, and interaction of the area aquifer systems allows the LLNRD Board to make science-based decisions regarding the protection of the water resources.

The project would provide the information necessary for those informed decisions. Large-scale uses, such as agricultural or industrial, have withdrawals that can potentially impact other users. The understanding of the extents and interaction of the aquifer system also allows for science-based decisions for the conservation of the water resources for the long-term beneficial uses of the residents and businesses. While the primary benefit from the project is an understanding of the water quantity available, the improvement of groundwater quality is also a concern. The LLNRD would be able to create programs or projects that directly impact water quality, protect the water resources from further degradation, and protect the health of the residents that are dependent upon the groundwater for their drinking water supply. An estimated 3,000 or more people get their drinking water from groundwater supplies, municipal or domestic, in the Project Area.

Given the known levels of contamination of the groundwater in the Project Area, the LLNRD has a dedicated, full-time staff member available to work with the City of Fullerton and the City of Genoa on developing a Wellhead Protection Plan (WHPP). Nebraska's Wellhead Protection Program is a voluntary program which assists

communities in preventing contamination of their water supplies through active planning in conjunction with the Nebraska Department of Environment and Energy (NDEE) and local NRD. At this time, Fullerton and Genoa do not have an approved WHPP, so the data obtained through the project would be invaluable in the development of one. These features include identifying potential sources of groundwater contamination and delineation of the protection area based on approximate paths groundwater would take on a 20-year flow line. AEM data emphasizing connectivity would result in a robust WHPP for these communities.

10. Has utilized all available funding resources of the local jurisdiction to support the program, project, or activity;

- Identify the local jurisdiction that supports the project.
- List current property tax levy, valuations, or other sources of revenue for the sponsoring entity.
- List other funding sources for the project.

The LLNRD devotes substantial time and resources to the assessment of the overall water quality of the groundwater resources of the District. This proposed project was discussed and voted on by the LLNRD Board of Directors during the May, 2021 meeting. The motion to pursue resources to proceed with this project passed unanimously. Past financial input from the LLNRD to support these types of projects include annual water quality and quantity monitoring, installation of monitoring wells, AEM study of Columbus area, AEM study of Buffalo County, and partnerships with CSD, NDNR and other local NRDs to collect data of this sort.

The LLNRD's budget for July 1, 2020 to June 30, 2021 was $18,436,788.53 with a property tax levy of 0.029264 resulting in approximately $4,736,484.19 of local property taxes. Property tax accommodates approximately 25.7% of the total budget. This proposed project is considered part of the surface and groundwater quality program. The total project costs for this proposed AEM data collection, interpretation and reporting is $417,000. Of that total project cost, the LLNRD will use general funds to cover the required local match of 40%, or $167,000. The remaining $250,000 of funds needed for the project are this grant request.

11. Has a local jurisdiction with plans in place that support sustainable water use;

- List the local jurisdiction and identify specific plans being referenced that are in place to support sustainable water use.
- Provide the history of work completed to achieve the goals of these plans.
- List which goals and objectives this project will provide benefits for and how this project supports or contributes to those plans.
- Describe and quantify how the project supports sustainable water use, what is the target area, what is the population or acreage receiving benefits, what is the usage of the water: residential, industrial, agriculture or recreational.
- List all stakeholders involved in project.
- Identify who benefits from this project.

The LLNRD developed a voluntary IMP with the NDNR in May, 2016, which establishes measurable goals and targets for managing this aquifer (LLNRD, IMP, 2016). The results of this project will support sustainable water use by creating an aquifer framework to better manage domestic, municipal, agricultural, and industrial water supplies and water quality. Benefits of the project will address the threat of nitrate contamination for an estimated population of around 3,000. Stakeholders involved in the project will include the Board and staff of the LLNRD, NDNR, UNL-CSD, and local residents.

The LLNRD has an adopted Groundwater Management Plan (GWMP), last revised in 1985. Results of this project specifically meet the objectives of the GWMP to address specific problems of groundwater quality. Groundwater quality monitoring by LLNRD staff, as part of the GWMP, has shown a part of Nance County to have elevated levels of nitrates. Surface water quality is also a concern, with a TMDL approved in December 2013 for the Beaver Creek stream segment located within the Project Area, due to *E. coli* bacteria impairments (EPA, 2021).

12. Addresses a statewide problem or issue;

- List the issues or problems addressed by the project and why they should be considered statewide.
- Describe how the project will address each issue and/or problem.
- Describe the total number of people and/or total number of acres that would receive benefits.
- Identify the benefit, to the state, this project would provide.

AEM can be utilized to improve the LLNRD's understanding of the underlying aquifer's lateral extent and depth by utilizing reconnaissance flights over the Project Area. Accurately mapping the aquifer allows the District to delineate a scientifically based "well interference zone", which will be used as a regulatory boundary that prohibits construction of future high-capacity irrigation wells by not allowing development of new certified irrigated acres or the transfer of existing irrigated acres. As groundwater accessibility issues and related conflicts between landowners have arisen in the Project Area, the need for defining an accurate well interference zone is necessary. Better management of the aquifer in this area could result in more consistent and potentially increased base flows and thus higher stream flows to the downstream portion of the Project Area's rivers and streams, including Cottonwood Creek, Cedar River, Plum Creek, Council Creek, Beaver Creek, Looking-Glass Creek, and Loup River. Higher stream flows on the downstream portion of these rivers ultimately addresses water supply issues downstream on the lower Platte River, a primary drinking water supply for nearly 800,000 people. Nebraska communities downstream, including the cities of Lincoln and Omaha, would ultimately benefit from this detailed aquifer mapping project and delineated well interference zone as a result of collecting and implementing this AEM data.

13. Contributes to the state's ability to leverage state dollars with local or federal government partners or other partners to maximize the use of its resources;

- List other funding sources or other partners, and the amount each will contribute, in a funding matrix.
- Describe how each source of funding is made available if the project is funded.
- Provide a copy or evidence of each commitment, for each separate source, of match dollars and funding partners.
- Describe how you will proceed if other funding sources do not come through.

As an in-kind contribution, CSD geologists will evaluate the AEM survey results with CSD cross-section and ancillary data to make interpretations of the regional geologic setting types encountered and evaluate how well the AEM results match up relative to the cross-sectional data. The resulting map publication and conclusions will provide those interested in the hydrogeology of central Nebraska a comprehensive and improved understanding of the varying hydrogeological settings. That interpretation will follow the approach used for previous ENWRA block areas. The NRDs will use groundwater reservoir delineations and associated maps to address groundwater quality problems occurring in this block and to help mitigate potential quantity concerns in the area.

14. Contributes to watershed health and function;

- Describe how the project will contribute to watershed health and function in detail and list all of the watersheds affected.

Regarding surface water hydrology, the Project Area for this AEM data collection project is geographically located within the following two USGS hydrologic unit code (HUC) 8 watersheds: Loup River (HUC #10210009) and Cedar River (HUC #10210010) (see SIA, Figure 2 – Water Quantity Map). These two HUC 8 basins intersect with the LLNRD's designated groundwater management areas (GWMAs). The GWMAs are managed differently based on their geology, hydrology, and land use, as part of the State of Nebraska Groundwater Management and Protection Act. The GWMAs are monitored and reported on annually by the LLNRD. The Project Area for this study intersects with a portion of GWMA #10 (see SIA, Figure 2). This GWMA has experienced groundwater declines in recent years, with levels below the 1982 readings reported in thirteen of the last twenty years. The flooding year of 2019 brought the water level trend above 1982 levels, but a decrease in 2020 and 2021 levels have moved the trend back in the negative direction (LLNRD, SWLR, 2021). Note that 1982 is often used as a benchmark year in data trends, as that was when the State of Nebraska required NRDs to develop and submit groundwater management plans to NDNR via Nebraska Revised Statute 46-709.

Regarding surface water flows, the Project Area encompasses the Cedar River at Fullerton DNR stream gage (Site #06792000) (see SIA, Figure 2), which reports a relatively flat trend in surface water flows from 2005 to 2018 (see SIA, Figure 4 – Cedar

River at Fullerton Stream Gage Graph). Note that the historic flood year of 2019 dramatically changes the all-years trend to reflect increasing stream flows since 2005, but if the extreme event of 2019 is excluded from the dataset, the Cedar River at Fullerton gage stream flows are relatively flat and possibly in slight decline. In large part it is because of these non-increasing stream flows that the LLNRD has not allowed the development of new certified irrigated acres in the Cedar River Watershed, and thus not allowed new development of irrigation water wells, for several years. The results of this AEM study will provide the LLNRD with the tools to understand the ground/surface water connection in this area and provide the potential to improve groundwater quantity and surface water flow issues, thus resulting in the improvement of the watershed health and function of the Cedar River Watershed.

Finally, the Project Area encompasses a part of the District with very low transmissivity (< 20 thousands of gallons per day per foot) and low saturated thickness (< 100 feet) of the High Plains aquifer, based on The Groundwater Atlas of Nebraska (UNL-CSD, 2013). Water availability issues have arisen in recent years as a result of the hydrogeologic conditions of the underlying aquifer and demand by competing wells. As demand for groundwater increases during the peak growing season, especially in time periods with little or no precipitation, the health of the aquifer becomes a growing concern. Subsequently, the health of the Loup River and Cedar River HUC 8 watersheds also become a concern, which is why there is a need to collect AEM data in this watershed-sensitive area and accurately map the aquifer's lateral extent and depth in order to make the correct regulatory decisions.

15. Uses objectives described in the annual report and plan of work for the state water planning and review process issued by the department.

- Identify the date of the Annual Report utilized.
- List any and all objectives of the Annual Report intended to be met by the project
- Explain how the project meets each objective.

The Annual Report and Plan of Work for the Nebraska State Water Planning and Review Process (NDNR, 2018) lists the following objectives:

1) Maintain data, information, and analysis capabilities for water planning, including specific programs for collecting, maintaining, and distributing information on streamflows, as well as analyzing water uses and water supplies across the state;
2) Provide staff and resources to support planning and implementation of water resources projects;
3) Support locally developed water management plans for managing hydrologically connected water supplies;
4) Provide resources to map and identify areas vulnerable to flood damage; and
5) Participate in interagency collaboration with federal agencies, state agencies, local natural resources districts (NRDs), and other water interests for the development of water resources programs and projects.
6) Consolidate and present information in a form that is understandable and useful to the public and interagency collaborators.

The collection of AEM data and the incorporation of that data into an overall aquifer framework directly supplements Objective 1 through improved data, information, and analysis capabilities. The data collected provides greater understanding of the extents, thickness, and interconnectedness of aquifer systems. That greater understanding directly informs analysis of streamflow in the hydrologically connected water resources of the state. Water uses and supplies are analyzed as part of the FAB Report, done annually by the NDNR, through modeling of those hydrologically connected areas (NDNR, 2021). The AEM data and the resulting interpretation and framework will be submitted to the NDNR as the best available data for use in the FAB Report.

The project directly supplements the staff and resources of the state for planning and management of the water resources of the state. The project partners will utilize the data collected and the interpretation of that data to further their expertise in the local hydrogeologic framework. That expertise is utilized by the management and Board of the LLNRD to develop the appropriate plans, programs, and projects for the protection and conservation of the water resources. The LLNRD partners with many agencies of the state including NDNR, NDEE, Nebraska Department of Health and Human Services (DHHS), Nebraska Game and Parks Commission (NG&PC), and others with an interest in the protection and conservation of the state's water resources.

The project partners represent local, regional, and state level interests, cooperatively studying the water resources of the state. Additionally, the data collected is shared with other non-partner agencies and the general public to provide an overall greater understanding of the hydrogeologic framework. That understanding is fundamental to any program or project undertaken to protect and conserve the water resources.

16. Federal Mandate Bonus. If you believe that your project is designed to meet the requirements of a federal mandate which furthers the goals of the WSF, then:

    - Describe the federal mandate.
    - Provide documentary evidence of the federal mandate.
    - Describe how the project meets the requirements of the federal mandate.
    - Describe the relationship between the federal mandate and how the project furthers the goals of water sustainability.

Better management of the aquifer in the Project Area could result in more consistent and potentially increased base flows and thus higher stream flows to the downstream portion of the Project Area's rivers and streams. Higher stream flows on the downstream portion of the Loup River and its related tributaries ultimately addresses water supply issues downstream on the lower Platte River, a primary drinking water supply for an estimated 800,000 people. Nebraska communities downstream, including the cities of Lincoln and Omaha, would ultimately benefit from this detailed aquifer mapping project and delineated well interference zone as a result of collecting and implementing this AEM data.

Supplemental Information Attachment (SIA)

Figure 1 - Proposed AEM Survey Project Area Map

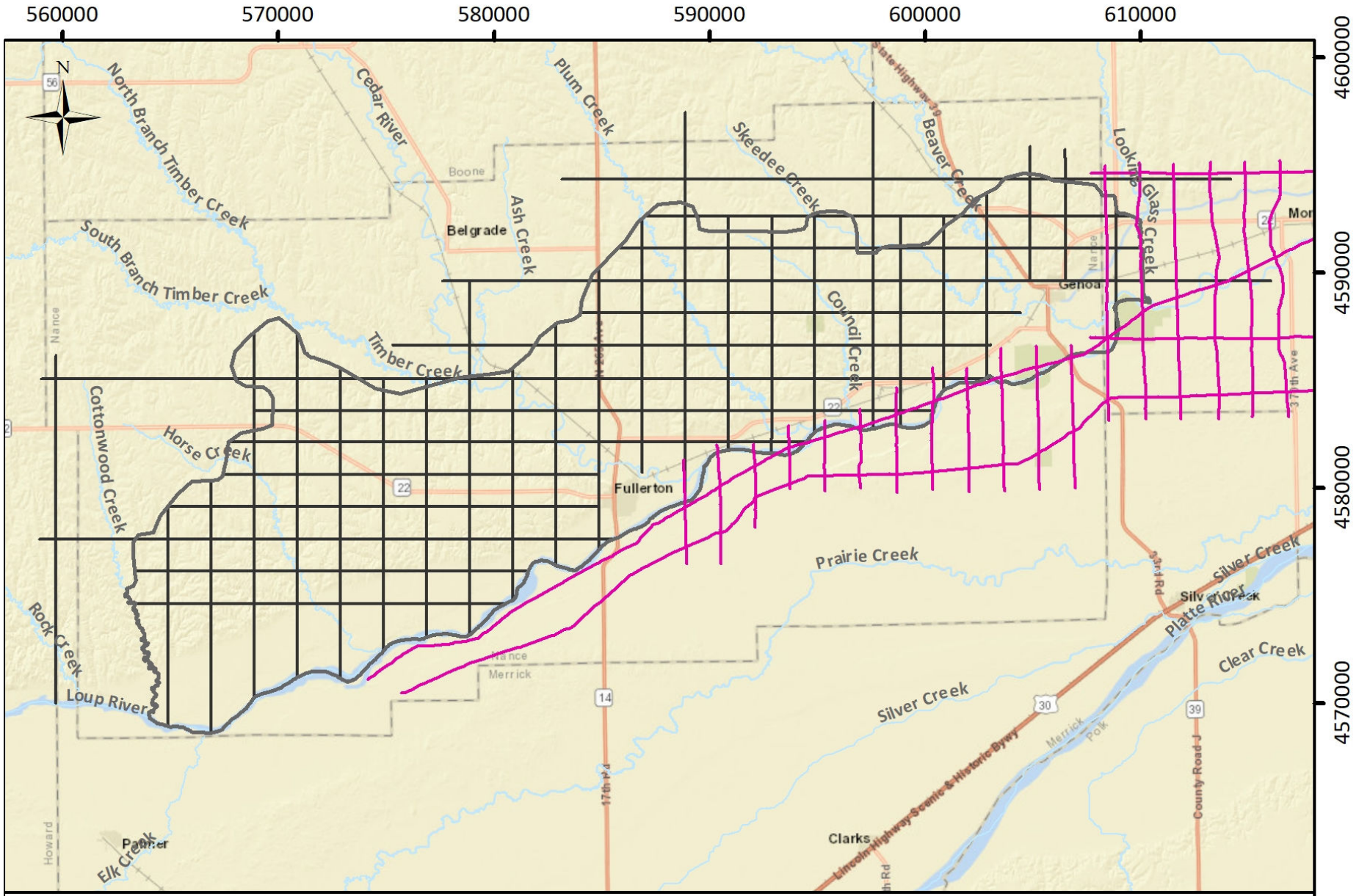
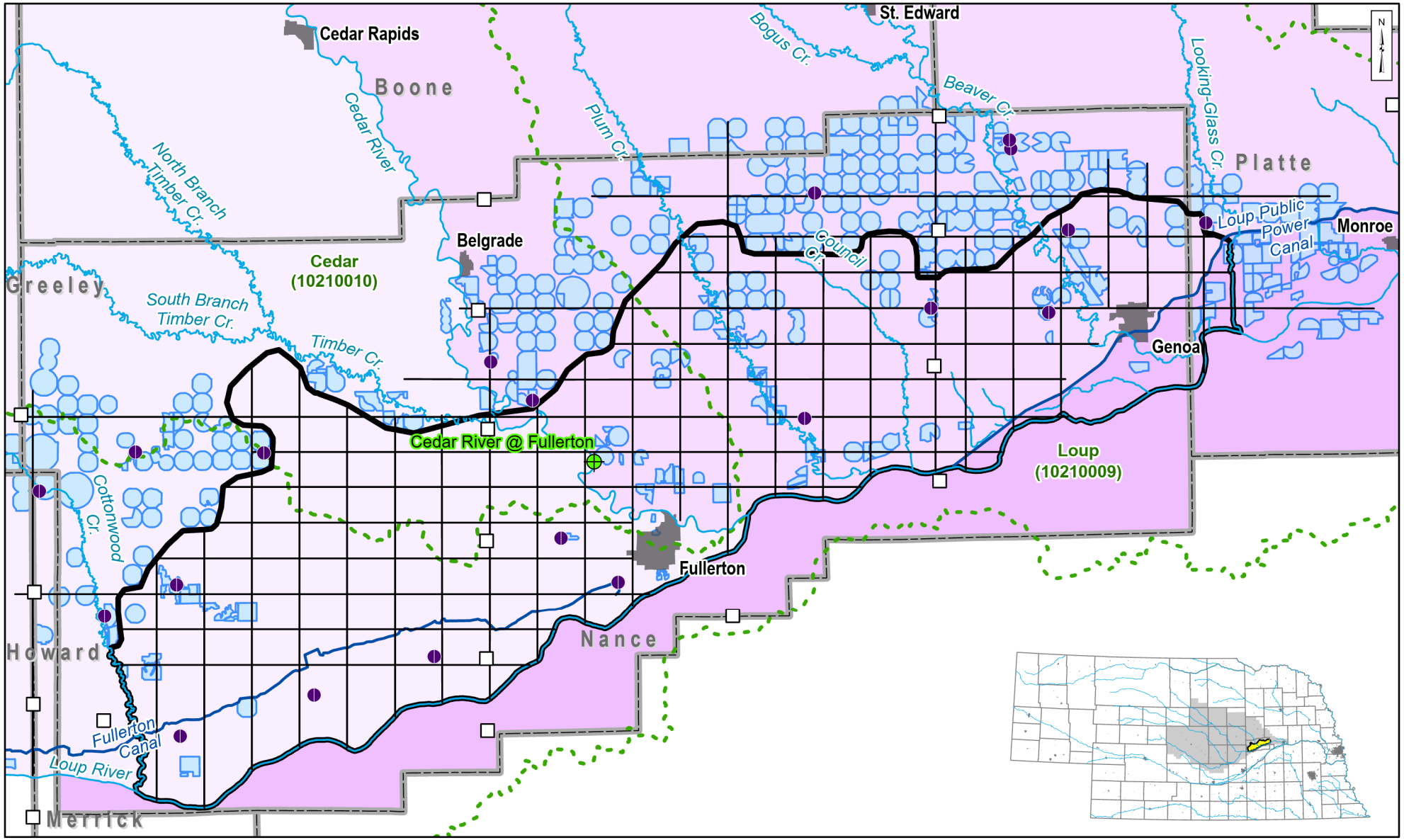


Figure 2 - Project Area Water Quantity Map



Groundwater Management Area (GWMA)
- GWMA #5
- GWMA #6
- GWMA #10
- Static Water Level Location
- NDNR Stream Gage
- CSD Test Hole
- Certified Irrigated Acres for GW Only that Intersect Flight Lines
- Proposed AEM Survey Flight Line
- Well Interference Zone (DRAFT)
- River
- Canal
- City
- County
- USGS Watershed HUC 8

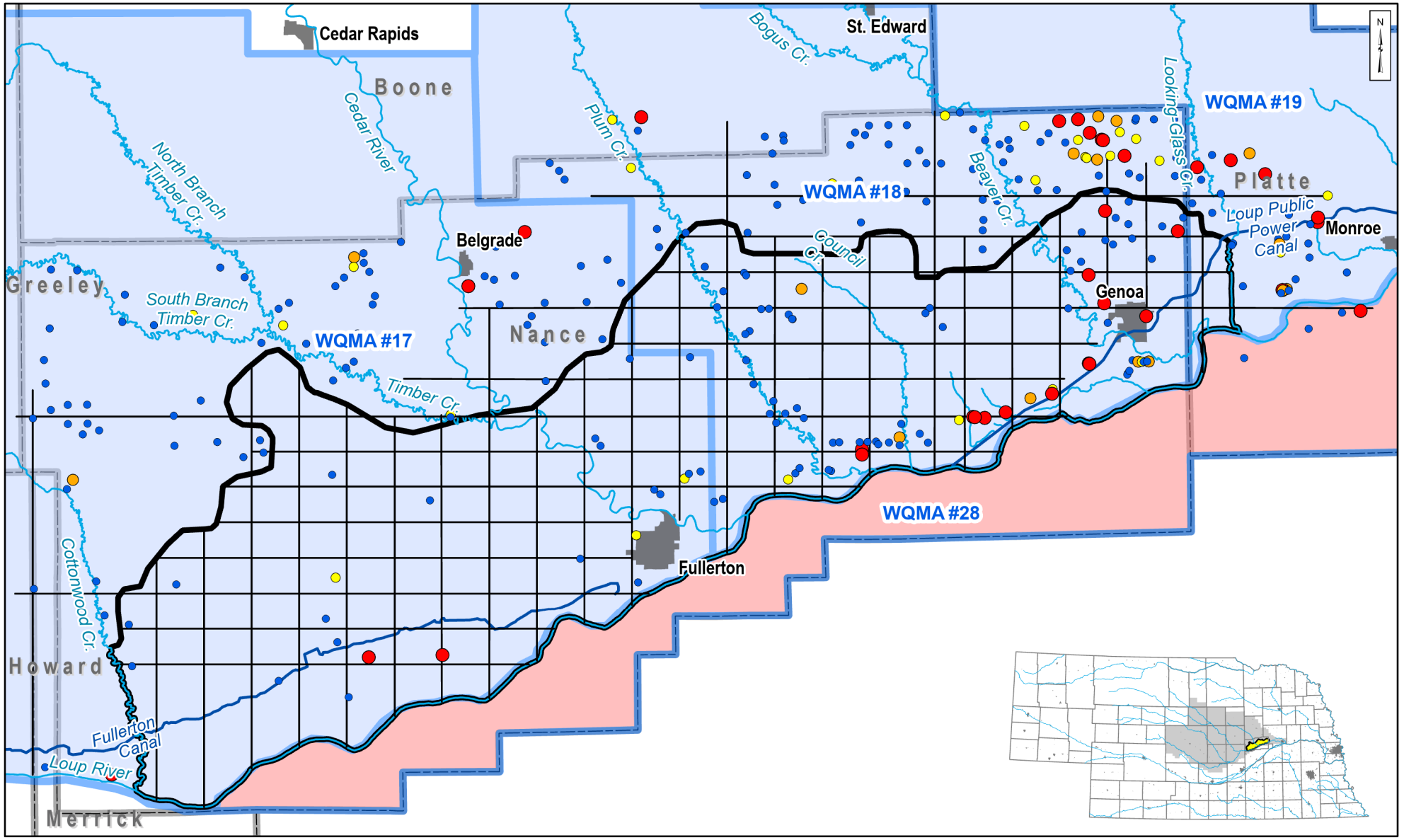
0 2.5 5 10 Miles

LOWER LOUP NATURAL RESOURCES DISTRICT

PROPOSED AEM SURVEY PROJECT AREA WATER QUANTITY

Lower Loup Natural Resources District
Nance County, NE
Figure 2

Figure 3 - Project Area Water Quality Map



Well Nitrates from 2000-2020
Avg NO3 (mg/L)

- 0 - 6.5 (Phase I)
- 6.6 - 8.5 (Phase II)
- 8.6 - 10.0 (Phase III)
- > 10.0 (Phase III+)

Water Quality Management Area (WQMA)

- Phase I
- Phase III

- Proposed AEM Survey Flight Line
- Well Interference Zone (DRAFT)
- River
- Canal
- City
- County

0 2.5 5 10 Miles

LOWER LOUP NATURAL RESOURCES DISTRICT

PROPOSED AEM SURVEY PROJECT AREA
WATER QUALITY
Lower Loup Natural Resources District
Nance County, NE
Figure 3

Figure 4 – Cedar River at Fullerton Stream Gage Graph

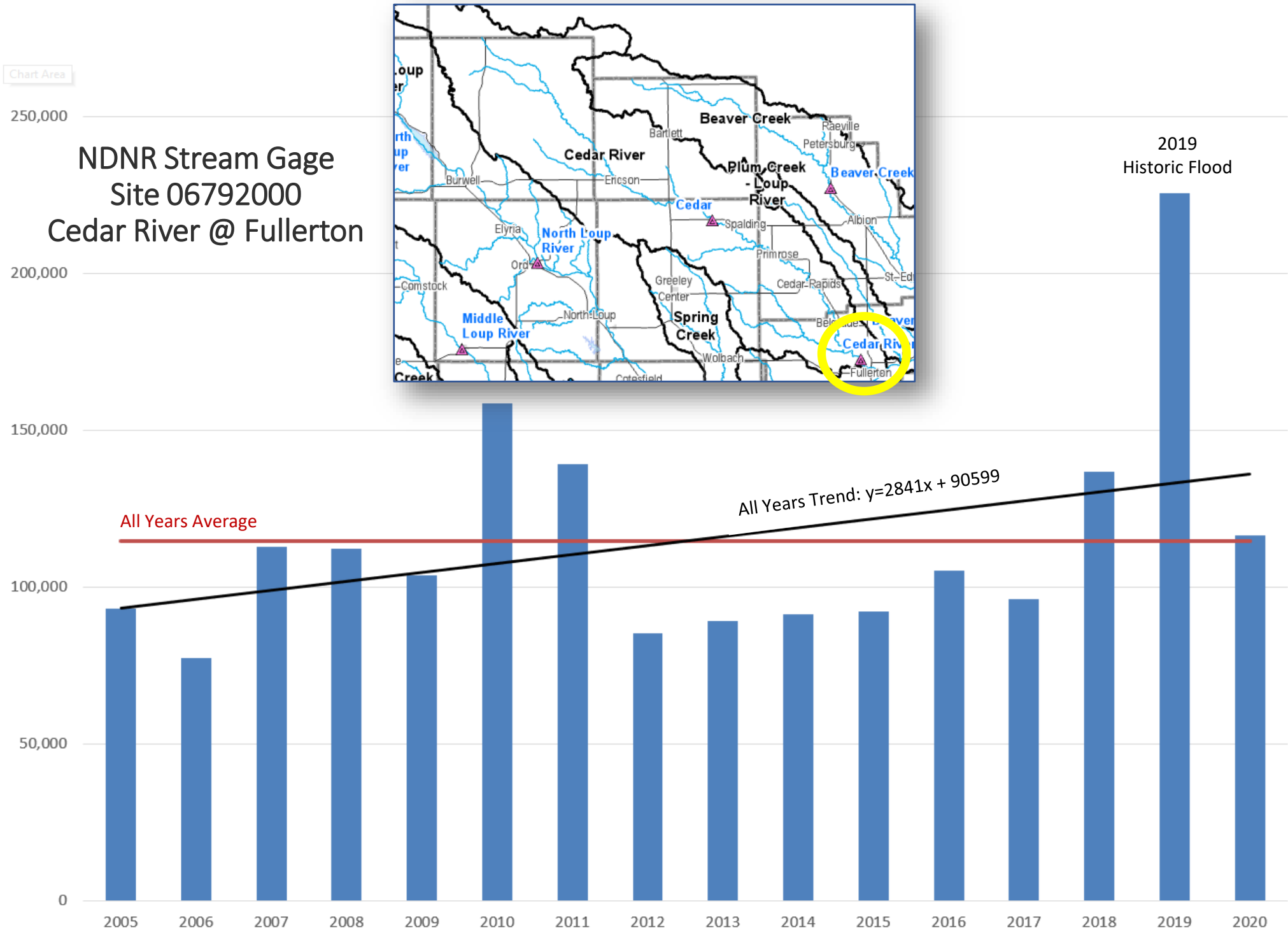


Figure 5 – Generalized Geologic Cross-Section of Pumping Test Wells

Generalized Cross-Section

New Well Test – Turned On 9/16 @ 9:19 & Off 9/17 @ 10:30
Green = Levels in Old Well during pumping
(cross-section drawn by Sue Lackey, CSD Geologist; with LLNRD additions)

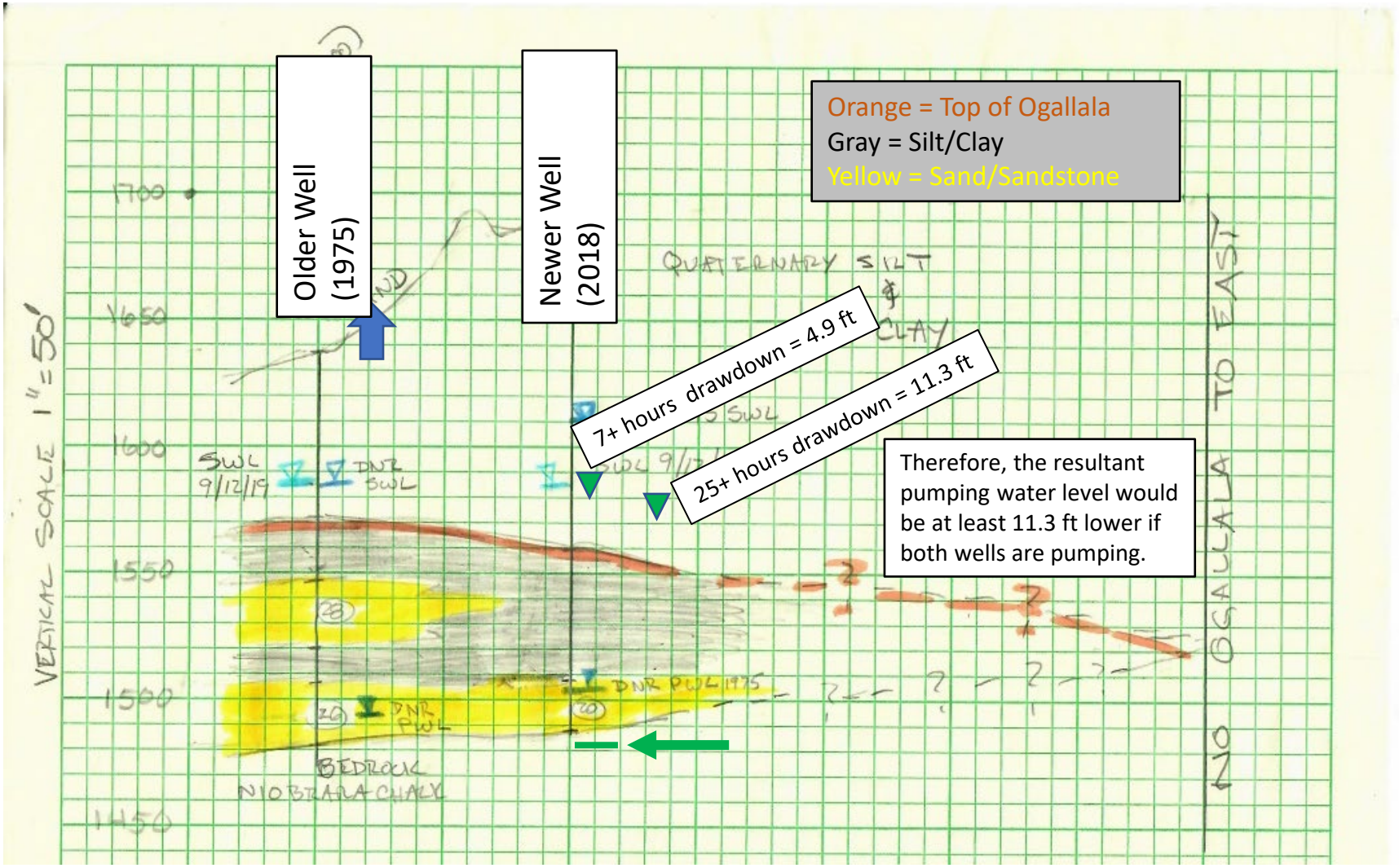
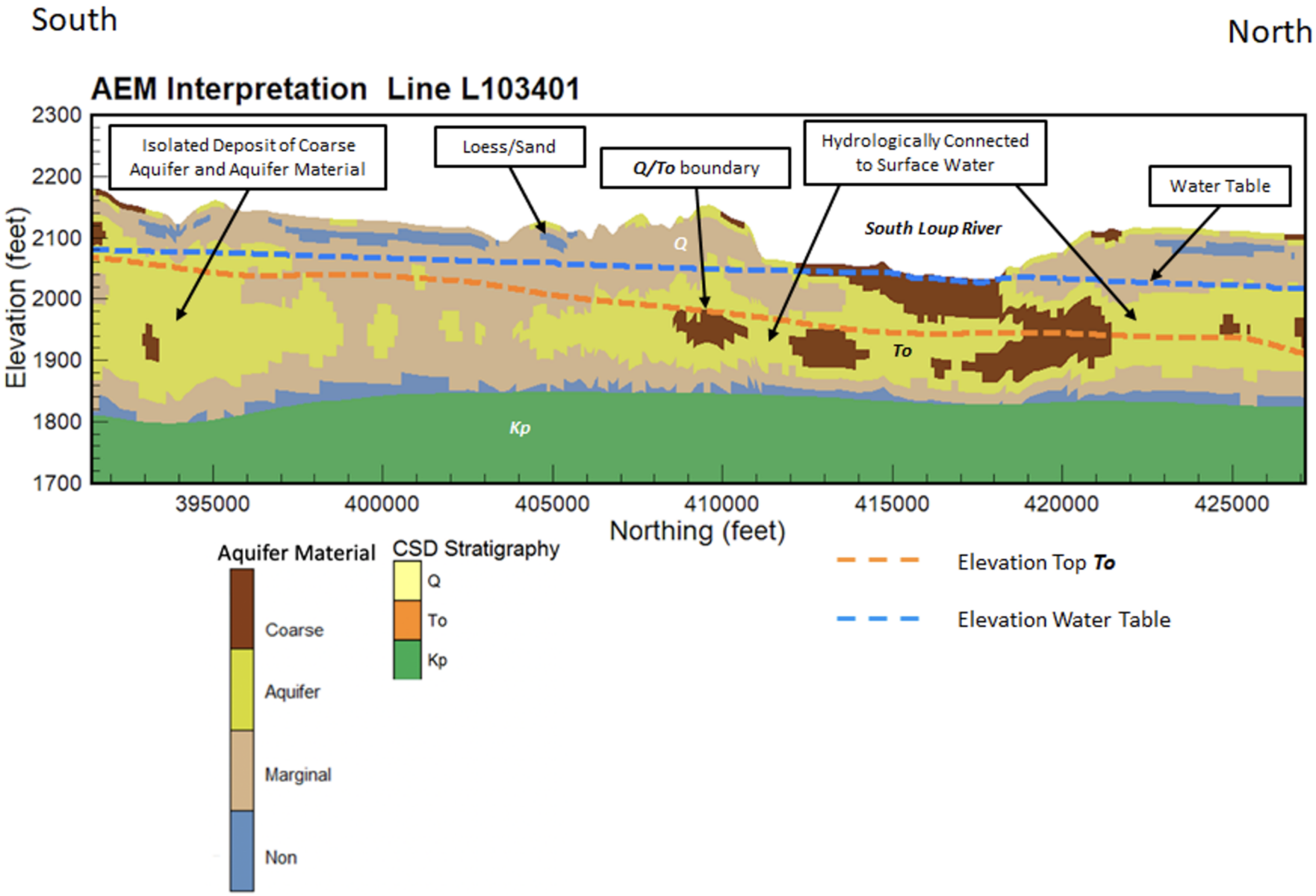
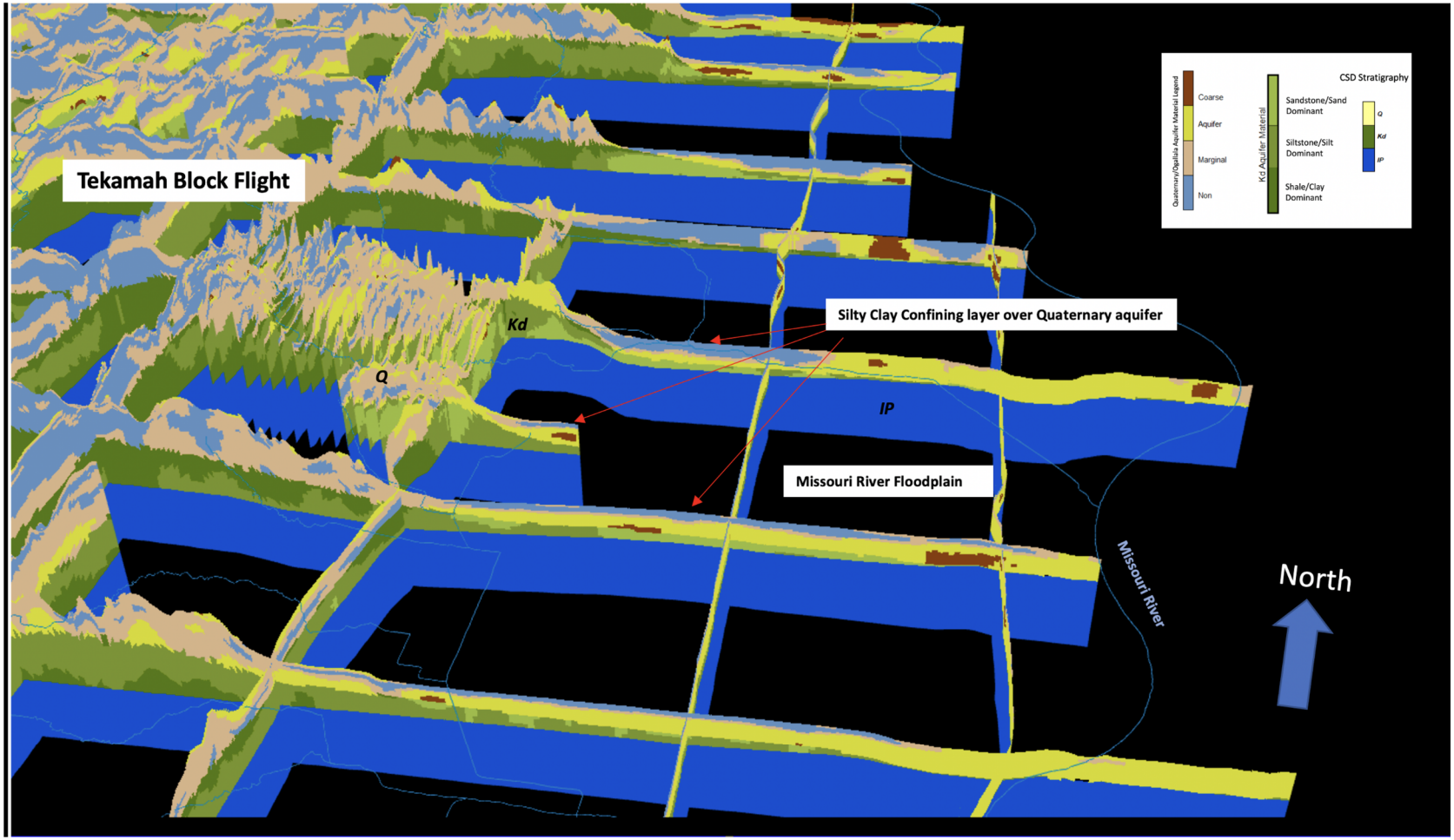


Figure 6 - Sample Interpreted Geologic Profile



Profile view of north-south line L103401 showing *Q* (Quaternary) and *To* (Tertiary Ogallala Group) aquifer materials overlie the *Kp* (Cretaceous Pierre Shale). Groundwater from the *Q* and *To* is hydrologically connected to the South Loup River. The water table is the dashed blue line. The top of the *To* is the dashed orange line. From the 2019 LLNRD AEM study in Buffalo County. (AGF, 2020)

Figure 7 - Sample Interpreted 3D Fence Diagram



3D Fence diagram of a combination of reconnaissance and block flights within the P-MRNRD. Q = Quaternary, Kd= Cretaceous Dakota, and IP = Undifferentiated Pennsylvanian units
Vertical Exaggeration is 1:10 **(AGF, 2021)**

Figure 8 - Cost Letter From AGF

Aqua Geo Frameworks, LLC.

10848 Ridge Road
Fort Laramie, WY 82212
(303)-905-6240

05/20/2021

Mr. Russell Callan
General Manager
Lower Loup NRD
2620 Airport Drive
Ord, NE 68862

Dear Russell,

As requested, the estimated costs for an Airborne Electromagnetic (AEM) survey and hydrogeological framework of the Nance County portion of the Lower Loup NRD is as follows. Approximately 518 line-miles of AEM data will be collected as part of the project. AGF will build the database, perform the geophysical analysis and inversion, and complete the interpreted hydrogeologic framework and report.

Costs:

AEM Survey	$191,780
Database Development	$29,190
Geophysical Analysis	$54,280
Hydrogeological Framework and Report	$141,750
Total	$417,000

If you have any questions, please do not hesitate to call.

Sincerely,

Jared Dale Abraham P.G.
jabraham@aquageoframeworks.com

Bibliography

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