



PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM (PRRIP -or- Program) REQUEST FOR PROPOSALS (RFP)

SUBJECT: 2024-2026 Annual Bathymetric LiDAR and Aerial Photography
PROJECT NUMBER: P24-002
REQUEST DATE: XX, 2024
CLOSING DATE: XX, 2024
POINT OF CONTACT: Justin Brei
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I. OVERVIEW

The Platte River Recovery Implementation Program (Program) was initiated on January 1, 2007 between Nebraska, Wyoming, and Colorado and the Department of the Interior to address endangered species issues in the central and lower Platte River basin. Program “target species” include the whooping crane, piping plover, interior least tern (now de-listed), and pallid sturgeon. The Program has been charged with management of land and water along the central Platte River to achieve management objectives for these target species.

A Governance Committee (GC) has been established that reviews, directs, and provides oversight for activities undertaken during the Program. The GC is comprised of one representative from each of the three states, three water user representatives, two representatives from environmental groups, and two members representing federal agencies. Headwaters Corporation serves as the Executive Director’s Office of the Program. Program staff are located in Nebraska and Colorado and are responsible for assisting in carrying out the various Program-related activities.

Aerial photography has been collected annually by the Program since 2007. Annual LiDAR collection began in 2009. These data are integral to several of the Program’s research and monitoring efforts and are our principal tools for assessing physical changes in river habitat through time.

The GC submits this Request for Proposals (RFP) to solicit proposals from contractors to acquire bathymetric LiDAR and aerial photography during the period of 2024 - 2026.

II. PROJECT DESCRIPTION

This scope of work set forth in this RFP includes three summer Program area aerial photography flights and three fall/winter bathymetric LiDAR and Aerial photography flights that cover the entire 90-mile reach. Further background information on how the Program uses the data acquired through this RFP is available in an excerpt from the Program’s Remote Geomorphology and Vegetation Monitoring Protocol located in Appendix A.

This RFP describes a multi-year program of work encompassing acquisition of aerial imagery and LiDAR in 2024 through 2026 according to the following schedule:



- Summer 2024: Full Program area aerial photography
- Fall 2024: Bathymetric LiDAR and concurrent aerial photography
- Summer 2025: Full Program area aerial photography
- Fall 2025: Bathymetric LiDAR and concurrent aerial photography
- Summer 2026: Full Program area aerial photography
- Fall 2026: Bathymetric LiDAR and concurrent aerial photography

Summer imagery acquisition window is typically from mid-June to mid-July. Fall Acquisitions window is typically from mid-October to mid-November.

III. SCOPE OF WORK

The Program is requesting proposals from potential bidders to provide bathymetric LiDAR and digital aerial imagery of the project area as described below. Minimum product specifications follow:

1) Schedule

- a) Sub-Project 1 - Fall concurrent bathymetric LiDAR and Aerial photography.
 - i) LiDAR and imagery will be acquired each year between October 15 and November 15 under low Platte River flow conditions beginning in 2024. Bidder must be flexible and work with Program staff during that time to schedule flights such that river flows in the project area are as low as possible (ideally under 1,000 cfs).
 - ii) Imagery will be acquired on cloud-free days with the sun at a sufficient angle to reduce the effect of shadows from trees and structures and efforts should be made to reduce sun glare on water surfaces.
 - iii) Imagery will be acquired in combination with LiDAR such that the imagery reflects the condition of the river during the LiDAR acquisition. River conditions can change daily, and imagery must be flown at least the same day, if not at the exact same time as the LiDAR.
 - iv) The Central Platte River is subject to artificial hydrocycling from hydropower operations, and close coordination and care in timing is required to acquire products acceptable to the Program.
 - v) The acquisition area must be free of snow and ice, and extraneous environmental conditions such as rain, fog or smoke should be avoided.
 - vi) **Final delivery of Sub-Project 1 aerial imagery deliverables will be within 60 days of final acquisition flight each year.**
 - vii) **Final delivery of all other Sub-Project 1 deliverables will be within 120 days of final acquisition flight each year.**
- b) Sub-Project 2 – Summer Aerial photography.
 - i) Imagery will be acquired each year between June 15 and July 15 beginning in 2024. Bidder must be flexible and work with Program staff during that time to schedule flights such that river flows in the project area are as close to 1,200 cfs as possible.
 - ii) The Central Platte River is subject to artificial hydrocycling from hydropower operations, and close coordination and care in timing is required to acquire products acceptable to the Program.



iii) Imagery will be acquired on cloud-free days with the sun at a sufficient angle to reduce the effect of shadows from trees and structures and efforts should be made to reduce sun glare on water surfaces.

iv) **Final delivery of Sub-Project 2 deliverables will be within 60 days of final acquisition flight each year.**

c) Flight Cancellations

i) The Program, at its sole discretion, may choose to cancel any individual acquisition or part of an acquisition (aerial imagery, LiDAR) over the course of the project. This could occur if river conditions are such that the products received would not be of a quality acceptable to the Program. If an acquisition is partially or fully cancelled, the contract price would be adjusted and the cost of those acquisitions and products removed.

2) Project Area

a) The area of interest for Sub-Project 1 consists of an area generally between the high banks of the Platte River beginning near the junction of U.S. Highway 283 and Interstate 80 near Lexington, Nebraska, and extending eastward to near Chapman, Nebraska (approximately 128 square miles). A polygon shapefile of the acquisition area is included on the Program website (www.platteriverprogram.org) in the same location as this solicitation.

b) The area of interest for Sub-Project 2 consists of an area 3.5 miles either side of the centerline of the Platte River beginning at the junction of U.S. Highway 283 and Interstate 80 near Lexington, Nebraska, and extending eastward to Chapman, Nebraska (approximately 750 square miles). A polygon shapefile of the acquisition area is included on the Program website (www.platteriverprogram.org) in the same location as this solicitation.

3) Sub-Project 1 Technical Specifications

CIR aerial photography and bathymetric LiDAR over approximately 128 sq. mi.

a) LiDAR Technical Specifications

i) Topo-bathymetric LiDAR (green LiDAR) is required.

ii) The LiDAR data will be collected at a mean resolution of 2.3 ft (0.7 m) GSD or better.

iii) The contractor shall ensure that the area of interest is fully and sufficiently covered with no data voids due to gaps between flightlines or system malfunction.

iv) Data voids in the bare-earth not caused by classification of geographic features shall not exceed three times the point spacing. Data voids of this size are sufficient reason to reject the dataset.

v) LiDAR data should be classified using the following ASPRS Standard LiDAR Point Classes:

- Class 1 – Unclassified
- Class 2 – Ground
- Class 7 – Low point and noise
- Class 9 – Water
- Class 12 – Overlap
- Class 40 – Bathymetric Bottom
- Class 41 – Water Surface



- Class 45 – Water Column
 - (1) Class 1 will be used for feature points that are not in Classes 2, 7, 9, 12, 40, 41, or 45. These typically represent returns from man-made structures, vegetation etc.
 - (2) Class 2 will be used for feature points that represent the bare-earth.
 - (3) Class 7 will be used for artifacts that do not represent the ground, manmade structures or vegetation. Typically these are extraneous points that are either below, or well above the surface not representing any true feature.
 - (4) Class 9 will be used to identify NIR points found within water bodies, including streams and rivers.
 - (5) Class 12 will be used for LiDAR points in the overlap portion of flight lines that have been removed due to redundancy (if necessary).
 - (6) Class 40 will be used for green sensor returns that characterize the bathymetric topography.
 - (7) Class 41 will be used for green sensor returns determined to be the water surface.
 - (8) Class 45 will be used for green sensor returns within the water column that are not the water surface or the bathymetric bottom.
 - (9) No points shall be deleted from the LAS files.
 - vi) Bare-earth classification shall adhere to the following specifications using both automated and manual filtering classification routines:
 - 90% of artifacts classified
 - 95% of outliers classified
 - 95% of vegetation classified
 - 98% of building classified
 - vii) Special attention must be applied to the classification process due to the geographic nature of the project area which consists of extremely flat terrain mixed with important hydrographic characteristics. Channel geometry of streams and drainage features must be maintained as well as the ability to identify sand bar features within the Platte River. Dense vegetation data voids must also be minimized by the automatic removal process and “over smoothing” due to aggressive classification must be avoided.
 - viii) Vertical accuracy for LiDAR will meet or exceed 0.3 ft (9.2 cm) RMSE (Accuracy = 0.6 ft (0.18 m) at the 95% confidence level).
 - ix) Horizontal accuracy for LiDAR will meet or exceed 1.97 ft (0.6 m) RMSE (Accuracy = 3.41 ft (1.04 m) at the 95% confidence level).
 - x) The vertical datum for LiDAR is NAVD88 (Geoid03), and the horizontal datum is Nebraska State Plane (1983). Elevation and projection in feet.
- b) Aerial Photography Technical Specifications
- i) The imagery will be six-inch (0.5 ft) pixel resolution.
 - ii) The imagery will be color-infrared.
 - iii) The imagery will be ortho-rectified and seamless, and will be tone-balanced with adjacent images across the project area.
 - iv) Imagery will be acquired on cloud-free days with the sun at a sufficient angle to reduce the effect of shadows from trees and structures and efforts should be made to reduce sun glare on water surfaces.
 - v) The imagery will be projected in Nebraska State Plane Feet (1983 datum).



- vi) The imagery must be acquired concurrently with the LiDAR so as to reflect river conditions during acquisition. The imagery must be collected at least the same day, if not at the exact same time, as the LiDAR. Imagery acquired at flows significantly different than that of the LiDAR acquisition may require reflight.

4) Sub-Project 2 Technical Specifications

Four-band aerial photography over approximately 750 sq. mi. LiDAR over approximately 26 sq. mi.

a) Aerial Photography Technical Specifications

- i) The imagery will be six-inch (0.5 ft) pixel resolution.
- ii) The imagery will be 4-band (R, G, B, NIR).
- iii) The imagery will be ortho-rectified and seamless, and will be tone-balanced with adjacent images across the project area.
- iv) Imagery will be acquired on cloud-free days with the sun at a sufficient angle to reduce the effect of shadows from trees and structures and efforts should be made to reduce sun glare on water surfaces.
- v) The imagery will be projected in Nebraska State Plane Feet (1983 datum).
- vi) Deliverables will include both RGB and CIR products described in Section III.6.

5) Project Deliverables

All project deliverables should be processed and delivered according to the schedule in Section III.1.

a) LiDAR (terrestrial and bathymetric)

- i) LiDAR point data meeting or exceeding 2.3 ft (0.7 m) GSD resolution in a classified LAS file format and adhering to the technical specifications in III.3 above. LAS file projected to Nebraska State Plane Feet (1983 datum) and vertical reference NAVD88 feet (Geoid 03). Classified LAS file will include all LiDAR points, including first and last returns.
- ii) Daily reports during acquisition that display all flight lines, as well as completed areas. Once acquisition is complete, a project summary report that shows time and date of all flightline acquisitions. Time of day, not just the day, is important to match river flow condition to acquisition.
- iii) Tiling scheme shapefile for identifying LAS and DEM file locations. Tile size and file size is flexible and will be discussed upon award of project.

b) Digital Elevation Model

- i) Hydro-enforced and bathymetric bare-earth digital elevation model raster tiles (3-foot cell size), projected in Nebraska State Plane coordinate system – elevation and projection in feet.
 - (1) See pages 23-25 of the USGS LiDAR Base Specifications 2023 rev. A for details on hydro-flattening: <https://www.usgs.gov/media/files/lidar-base-specification-2023-rev-a>. In the proposal, provide details of the software/methodology to be used for this alternative.
 - (2) Breaklines used in the generation of the hydro-enforced and topobathymetric DEM are also a required deliverable.
- ii) Highest-hit (first return) digital elevation model raster (3-foot cell size). Used to approximate vegetation height.



- iii) Full project area mosaic of digital elevation model tiles (3-foot cell size).
- iv) NOTE: Two versions of the DEM will be required. One hydro-enforced DEM for the given flow conditions during the flight, and one DEM that incorporates bathymetry below the water surfaces.

c) Imagery

- i) Color-infrared (Sub-Project 1) and 4-band (Sub-Project 2) digital orthophotography with a six-inch (0.5 ft) pixel resolution (or better), covering the entire project area seamlessly and without data gaps.
- ii) The imagery should be geo-referenced and provided in tiled GeoTIFF (.tif) format.
- iii) Compressed imagery mosaic (.sid). Typically entire reach compiled into one mosaic but may be split due to file size. Sub-Project 2 will require both an RGB mosaic and a CIR mosaic. Sub-Project 1 will be a CIR mosaic only.

d) LiDAR and Imagery

- i) Shapefiles of LiDAR and aerial photography flight lines or photo centers that identify the date and time of the flight line or photo center.
- ii) FGDC-compliant metadata to include, but not limited to: flight dates and times, flight altitude, camera system information, LiDAR system information, aircraft information, imagery resolution, LiDAR point density, horizontal accuracy, post-processing software and steps, and horizontal and vertical control references.
- iii) All LiDAR data, photography, and supplemental products will be delivered on USB external hard drives or flash drives and will become the property of the Program. All media and data collected under the contract shall be the sole property of and can be freely distributed by the Program. No restrictions shall be placed on the data by the contractor.

e) Ground Survey

- i) Proposals should discuss the ground control and survey approach for ensuring accuracy of elevation and imagery deliverables. Accuracy and reporting are important to the Program and emphasis will be placed on approach and discussion of ground control.
- ii) The Program owns several thousand acres of land across the entire acquisition area and can provide access to multiple river survey areas for bathymetric LiDAR ground survey verification.
- iii) Year-to-year compatibility of the deliverables is extremely important and post-processing and ground survey should ensure that datasets are comparable year to year (i.e., immobile objects such as paved roads should not report differing elevations across years).

6) Permits and Clearances

- a) It is the contractor's responsibility to file all required flight plans and obtain all necessary approvals to fly over and acquire aerial imagery and LiDAR in the Project area.

**IV. CONTRACT TERMS**

The selected contractor will be retained by:

Nebraska Community Foundation
PO Box 83107
Lincoln, NE 68501

Terms and conditions will be negotiated as mutually agreeable. It is understood that the Governance Committee reserves the right to accept any proposal that, in its judgment, is the best proposal, and to waive any irregularities in any proposal.

Proposal costs incurred in response to this RFP will be the responsibility of the bidder. Neither the Nebraska Community Foundation nor the Governance Committee will be liable for any costs incurred by the bidder in the completion and submission of the proposal.

V. SUBMISSION REQUIREMENTS

All interested parties having experience providing the services listed in this RFP are requested to submit a proposal.

Instructions for Submitting Proposals

One electronic copy of your proposal must be submitted in PDF format to Justin Brei at breij@headwaterscorp.com no later than 5:00 p.m. Central Time on Friday, XXX, 2024. Maximum allowable PDF size is 8MB. A proposal is late if received any time after 5:00 p.m. Central Time and will not be eligible for consideration.

Questions regarding the information contained in this RFP must be SUBMITTED IN WRITING by 5:00 p.m. Friday, XXX, 2024. No questions on content can be submitted after this time. Questions and answers will be shared with all interested parties. These can be emailed to Justin Brei at breij@headwaterscorp.com or mailed to the address at the top of this RFP. Questions can be submitted any time before the above time and answers may be posted intermittently to the Program website during the proposal period. Final questions and answers will be made available on the Program website in the location of this RFP by EOB Monday, XXX, 2024.

RFP Schedule

The EDO expects to complete the selection process and award the work by XXXXX, 2024. The following table represents the RFP schedule:

Description	Date	Time (CST)
Issue RFP		
Last day for respondents to submit questions regarding the RFP		
Proposals due from Consultants		
Evaluation of Proposals		
Award of Work		
Start of Work		



Completion of year 1 tasks	
Completion of year 2 tasks	
Completion of year 3 tasks	

Proposal Content

Proposals must include:

1) Technical information including:

- Aircraft/LiDAR/camera system details
- Ground control/verification methodology/plan including both terrestrial and bathymetric collection and calibration to past products.
- Post-processing software and summary of methodology, especially bathymetric processing. This includes how these acquisitions will be tied vertically and horizontally to previous acquisitions.
- Design accuracy information

2) **Relevant bathymetric LiDAR and aerial photography experience** from the last two years, especially projects related to natural resources and river geomorphology. Example projects should demonstrate experience collecting and processing bathymetric LiDAR in river systems. Please provide a minimum of two project references including the name, location, and brief summary of the projects; name, address, and phone number of the contracting officer for the client; and when the project was completed.

3) **Statement of annual availability** within the acquisition window of October 15 to November 15 for Sub-Project 1 and June 15 to July 15 for Sub-Project 2.

4) **Estimated timeline** for activities including mobilization, acquisition and processing. Also, specify the estimated flight time necessary to complete each acquisition over entire project area (for planning purposes related to river operations in order to achieve lowest possible flow).

5) **Detailed firm fixed price proposal.** At minimum, project budget should itemize Sub-Project 1 and Sub-Project 2 on an annual basis inclusive of any applicable taxes. **Budget will be considered, but contract will not be awarded solely on a lowest cost basis.** Governance Committee approval is needed before the contractor is authorized to begin implementation. A sample budget table is included for reference. A similar table should be included in the proposal:

	Summer 2024 SP2	Fall 2024 SP1	Summer 2025 SP2	Fall 2025 SP1	Summer 2026 SP2	Fall 2026 SP1	Total Project Costs
LiDAR Cost by Acquisition	n/a		n/a		n/a		
Imagery Cost by Acquisition							



6) **Conflict of interest statement** addressing whether or not any potential conflict of interest exists between this project and other past or on-going projects, including any projects currently being conducted for the Program.

7) **Suspension and Debarment.** Contractor must not be suspended or debarred from receiving federal funds. Proposal must include statement of eligibility to receive federal funds and must provide contractor Dun & Bradstreet (D-U-N-S) number or other means of identification in the U.S System for Award Management site (www.sam.gov).

8) **Description of insurance** shall be provided with the proposal. Proof of insurance will be required before a contract is issued. Minimum insurance requirements will include \$1,000,000 general liability per occurrence.

VI. CONTRACTOR SELECTION

The GC will appoint a Proposal Selection Panel that will evaluate all proposals and select a Consultant based on the following principal considerations:

1. The Consultant's understanding of the overall project objectives, acquisition constraints including hydroplant schedules and turbidity, and Program's use of deliverables.
2. The Consultant's approach to each task in the outlined Scope of Work, especially elements of ground control and QA/QC, post-processing methods, and calibration to past products.
3. Qualifications and the relevant experience of the proposed project team members and firm. Highlight experience with bathymetric LiDAR acquisition in sand-bed river systems.
4. The overall clarity and content of the Consultant's proposal.

Consultant's proposed budget will be a consideration for the Proposal Selection Panel, but contract will be awarded primarily on the basis of consultant's qualifications and project approach. Interviews may be held if necessary, as determined by the Proposal Selection Panel.

VII. PROGRAM PERSPECTIVE

The GC of the Program has the sole discretion and reserves the right to reject any and all proposals received in response to this RFP and to cancel this solicitation if it is deemed in the best interest of the Program to do so. Issuance of this RFP in no way constitutes a commitment by the Program to award a contract, or to pay contractor's costs incurred either in the preparation of a response to his RFP or during negotiations, if any, of a contract for services. The Program also reserves the right to make amendments to this RFP by giving written notice to contractors, and to request clarification, supplements, and additions to the information provided by a contractor.

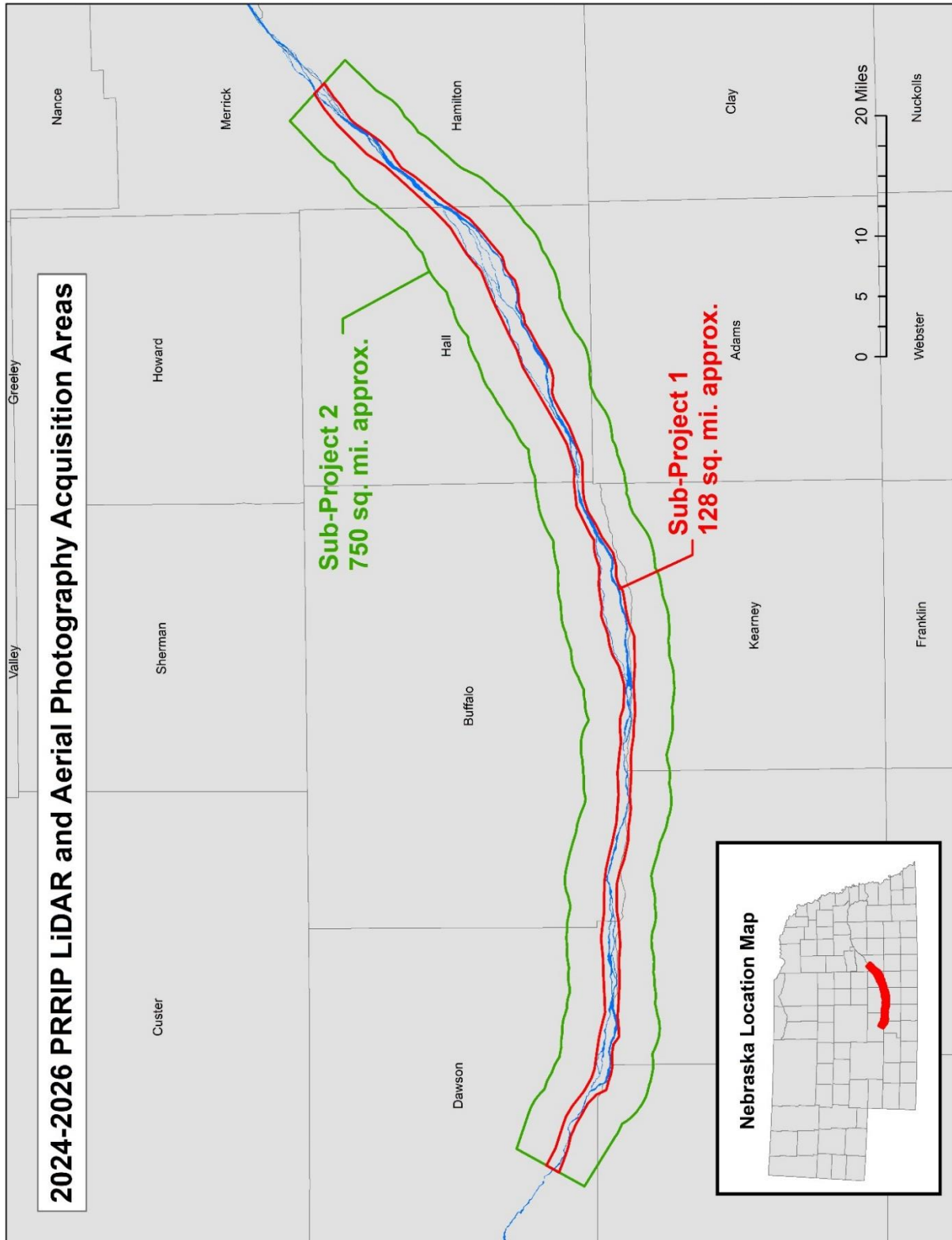
By submitting a proposal in response to his solicitation, contractors understand and agree that any selection of a contractor or any decision to reject any or all responses or to establish no contracts shall be at the sole discretion of the Program. To the extent authorized by law, the contractor shall indemnify, save, and hold harmless the Nebraska Community Foundation, the states of Colorado, Wyoming, and Nebraska, the Department of the Interior, members of the GC, and the ED Office, their employees,



employers, and agents, against any and all claims, damages, liability, and court awards including costs, expenses, and attorney fees incurred as a result of any act or omission by the contractor or its employees, agents, subcontractors, or assignees pursuant to the terms of this project. Additionally, by submitting a proposal, contractors agree that they waive any claim for the recovery of any costs or expenses incurred in preparing and submitting a proposal.

VIII. AVAILABLE INFORMATION

A shapefile of the acquisition area for Sub-Projects 1 and 2 are available on the Program website (www.platteriverprogram.org) at the same location as this RFP solicitation. A map of the acquisition area is found on the last page of this solicitation.





Appendix A:

Excerpt from PRRIP Remote Geomorphology and Vegetation Monitoring Protocol

<https://platteriverprogram.org/document/prrip-remote-geomorphology-and-vegetation-monitoring-protocol>

IV. Data Analysis

A. Preliminary Processing of Aerial Imagery and LiDAR

- The aerial imagery and LiDAR products delivered from the aerial mapping contractor will be processed prior to analyzing the data to reduce file size to a manageable level using the following procedure:
- The imagery and LiDAR surfaces will be degraded to 3-foot pixel resolution, clipped to the channel shapefile discussed in Section IV. A., snapped to a common raster grid system, and merged to facilitate vegetation classification using the Trimble eCognition software. Through this process, care must be taken to ensure that all 4 bands in the aerial imagery are maintained in the processed aerial imagery files.
- A vegetation-height raster file will be created by subtracting the Hydroflattened DTM raster from the highest hit DSM raster.
- A topographic DEM of differences (DOD) will be created by subtracting the processed topobathymetric DTM for the current year from the DTM from the previous year. The DTM will provide base elevation data for cross sections and two-dimensional (2-D) model nodes for the habitat-related analyses, and the DOD will be used to quantify aggradation/degradation changes for purposes of monitoring the system-wide sediment transport balance.

B. Volume Change Analysis

Channel bed-sediment volume change (aggradation/degradation) for each geomorphic reach will be calculated from the topobathymetric DOD by developing a histogram of volume change with bins in 0.1 foot increments, multiplying the number of points in each bin by the square of the pixel resolution (i.e., 9 ft²) and the magnitude of the corresponding elevation change, and summing the resulting volumes. A consistent sign convention will be used for the analysis, with negative (-) values indicating degradation and positive (+) values indicating aggradation. Consistent with recommendations in Lane, et al., (2000), all pixel values, regardless of their magnitude, will be used in computing the best-estimate magnitude of the volume change. Uncertainty in the estimate will then be computed based on the reported uncertainty for the subaerial and subaqueous portions of the surfaces using the following formula (Lane, et al., 2000):

$$\sigma_v = \pm t * d^2 \left(\sum_{i=1}^4 N_i \sigma_i^2 \right)^{\frac{1}{2}} \quad (1)$$

Where σ_v is the uncertainty in the estimate volume change, t is the t-statistic associated with the desired level of confidence (e.g., $t=1.96$ for the 90% confidence bands), d is the pixel resolution, N_i is the number



of pixels in each error category (i), and s_i is the propagated error between the two comparative surfaces, computed by the following formula:

$$\sigma_i = (\sigma_j^2 + \sigma_k^2)^{1/2} \quad (2)$$

where s_j and s_k are the Root Mean Square Errors (RMSE) of the relevant zones for the current and previous-year surfaces, respectively. Since the mapping error for the LiDAR is different for subaerial and subaqueous areas, there will be two values for s_j and s_k for each year of data, and there are, therefore, four possible combinations (i) of j and k for each pixel:

1. Subaerial in both surfaces
2. Subaerial in the prior-year surface and subaqueous in the current-year surface
3. Subaqueous in the prior-year surface and subaerial in the current-year surface
4. Subaqueous in both surfaces

Degradational areas (negative elevation change) will also be differentiated into lateral and general bed erosion components by assuming degradational values of greater than 3 feet represent lateral bank erosion. The 3-foot value is based on EDO observations of average bank height in the AHR and may be adjusted in the future as more data becomes available. Areas initially identified as bank erosion will be manually checked, and those that occur in the middle of the channel reclassified back into bed erosion, because scour holes and erosion into the sides of mid-channel bars can also exceed 3 feet.

Volume change will be reported in cubic yards (CY) as well as tons using a conversion factor of 1.5 tons per CY.

C.Channel Morphology and Hydraulics Assessment and Analysis

Two-dimensional (2-D) hydrodynamic models will be developed internally and updated annually to identify changes in width, depth, and channel depth/height distribution over a range of discharges. Nine hydraulic models will be constructed, one for each geomorphic reach. The model geometries will be bound longitudinally by the adjoining bridges in the bridge segments and laterally by the eCognition analysis hulls. The model will be calibrated for the recorded discharges at the time of the LiDAR flights and ground surveys, and to water-surface profiles from the remote sensing data, surveyed water surface elevations, and stage loggers located throughout the analysis area. Manning's roughness values will be specified for the vegetation polygons from the eCognition analysis, and adjusted, as appropriate, to achieve calibration. A range of flows from 500 cfs to 5,000 cfs will then be run with the calibrated models. It is tentatively assumed that the following 5 discharges within this range will be sufficient to quantify the relationships: 500 cfs, 1,200 cfs, 2,000 cfs, 3,000 cfs and 5,000 cfs. The difference between the predicted water surface elevations and the corresponding channel bed elevation will be computed to quantify the following analysis metrics, by discharge, for each geomorphic reach:



- Total inundated area
- Water volume – Total volume of water within the reach at the indicated water-surface elevation
- Average depth – Ratio of water volume to total inundated area
- Average Top width –Ratio of total inundated area to channel length
- Width-Depth (W/D) ratio – Ratio of average top width to average depth
- Area of inundation of 0.7 foot or less

D. In-Channel Vegetation and Land Cover Classification and Analyses

Trimble eCognition software will be used, along with the training and validation data, to evaluate in-channel vegetation and land cover, primarily to assess the whooping crane metrics. For the basic vegetation and landcover analysis, annual vegetation classifications within the area of interest that include the active channel and approximately 50 feet to 100 feet of the overbanks, will be delineated from the annual aerial imagery using eCognition. To accommodate software limitations, the processed 3-foot pixel resolution fall aerial imagery and vegetation height DEMs developed under Section VII. A. will then be segmented into shorter reaches of river (generally Lexington – Odessa, Odessa – Shelton, Shelton – HWY 281, and HWY 281 – Chapman) prior to initiating the supervised classification to provide more manageable file size. The imagery and vegetation height DEM files will then be imported into eCognition and used to classify imagery into the vegetation and land cover classes defined in Section IV. D. 2. The final vegetation classification file will be exported as a shapefile and evaluated for accuracy in ArcGIS using the field-collected validation data. During the accuracy assessment, wet sand, dry sand, and water will be combined into a single class as these classes are highly variable depending on discharge.

Vegetation classifications will be validated annually to determine the accuracy of the remote-sensing results. For each remote survey, the accuracy for each vegetation classification will be calculated by dividing the number of correct classifications by the total number of field-based classifications collected in each class using the validation data set. In addition, a geodatabase will be developed with an attribute table that will detail the coverage of each vegetation class.

Maximum unvegetated channel width (MUV CW), to be used in evaluating drivers of vegetation change, will be computed by dividing the total unvegetated area (water, bare sand, and sparse short vegetation) by the reach length for each geomorphic reach. This metric will be reported in acres by geomorphic reach.

Final vegetation and land cover class areas and MUV CW will be compared to the corresponding areas from previous years to quantify yearly changes. The results will be reported in acres of change by geomorphic reach for both main and side channels.