# PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
## Monitoring the Channel Geomorphology and In-Channel Vegetation of the Central Platte River

## I. PURPOSE

The purpose of geomorphology monitoring is to document trends in channel geomorphology parameters in the area of interest during the thirteen-year First Increment (2007-2019) of the Platte River Recovery Implementation Program (Program), including documenting channel shape (including width), channel plan form, channel degradation or aggradation, grain sizes, and sediment loads.

The purpose of the in-channel vegetation survey is to provide system-wide status in areal coverage and elevation range of in-channel seedlings and invasive vegetation. This information is designed for use in the annual and long-term planning for implementation of the Program's Adaptive Management Plan (AMP) and use of water in the Environmental Account (EA) to evaluate the extent of existing native and non-native invasive species infestations, and to serve as a mechanism for identification of new invasive species populations before infestations become widespread.

Several priority hypotheses identified in the AMP are directly linked to river morphology and are influenced by in-channel vegetation. Data collected through this monitoring protocol will be utilized to determine effects and relationships that relate back to these priority hypotheses, the two management strategies identified in the AMP, and overall AMP implementation. Several priority hypotheses related to system form and function, physical processes, terns and plovers, whooping cranes, and pallid sturgeon (AMP, Table 2) are linked to aspects of geomorphology.

## II. DESIGN CONSIDERATIONS

### II.A. Area of Interest

The area of interest for geomorphology and vegetation monitoring consists of channels within an area 3.5-miles either side of the centerline of the Platte River and tributary basins beginning at the junction of U.S. Highway 283 and Interstate 80 near Lexington, Nebraska, and extending eastward to Chapman, Nebraska (approximately 95 miles). Certain areas within this stretch of the central Platte will be prioritized for monitoring based on key priority hypotheses, ecological need, and Program actions undertaken during the First Increment.

### II.B. Definitions

- Accretion Zone – area encompassed by existing and former channels of the river.
- Active Channel – portion of the channel where inundation by water and movement of bed sediment occurs sufficiently often to maintain the area devoid of permanent woody vegetation.

- Anchor Points – a location every 4,000 meters (2.5 miles) in the main channel with a grouping of three cross sections. The cross sections are spaced approximately 150 meters (500 feet) apart with the middle cross section located at the anchor point.
- Belt Transect – a vegetation survey area centered on an anchor point, generally oriented perpendicular to flow, and extending 150 meters (500 feet) upstream and downstream, and from edge of Vegetation Survey Zone to edge of Vegetation Survey Zone.
- Cross Section – topography data on a line perpendicular to the main channel that traverses the active channel, accretion zone, and the full width of the floodplain.
- Left/Right Bank – the bank location as viewed looking downstream (may also be defined as left/right descending bank).
- Green Line – edge of vegetation on a sand bar or adjacent to a wetted channel, defined by at least 25 percent cover of vegetation.
- Pure Panel – a group of points sampled every year
- Rotating Panel – a group of points with one-fourth of points sampled every year.
- Sampling Point – data collected for analysis from locations such as an anchor point transect.
- Sample Site – an anchor point and 7 cross sections as defined previously.
- Section Data – topography data from either cross sections or transects.
- Species of Interest (for vegetation monitoring):
    - Woody species less than 1.5 meters high located within the belt transect including, but not limited to:
        - Willows
        - Cottonwood
        - False indigo
        - Saltcedar (all heights)
        - Russian olive
    - Herbaceous species of interest within the Vegetation Survey Zone, including but not limited to:
        - Purple loosestrife
        - Phragmites
        - Cattails
        - River bulrush
    - Species of interest can be added or removed from this list during the First Increment.
- Stratigraphy – the arrangement of strata as related to origin, composition, distribution, and succession.
- Thalweg – The line joining the deepest points of a stream or river channel.
- Transect – topography data on a line perpendicular to the channel that may traverse the active channel and/or accretion zone, but may not include the width of the floodplain.
- Vegetation Survey Zone – this is an area within the belt transect that includes active channel but generally excludes areas of permanent woody vegetation taller than 4 meters in height or other areas that are clearly beyond the effect of high water flows.

## II.C. Channel Geomorphology Monitoring

Program geomorphology monitoring is designed to document trends in channel morphology within the entire study area throughout the First Increment. In addition, the data will provide information on trends at specific sites or groups of sites within the entire study area. Monitoring will focus on measuring and tracking changes in river planform, river cross-section geometry (including bed elevation and channel width), longitudinal bed profile, streamflow, sediment loads, and grain size distribution. The monitoring data will be collected through aerial photographs, airborne terrestrial LiDAR, topographic ground surveys, bed material surveys, ground photography, flow measurements at gaging stations, and sediment transport measurements. The overall strategy will focus on a randomized scheme, but there will be some sampling stratification (e.g. grain size) to reduce variability and improve future comparisons.

## II.D. Anchor Points

A probability based systematic sample of points along the river will be “anchors” for data collection. These anchor points were systematically placed along the centerline of the main channel of the river. The anchor points are spaced at approximately 4,000-meter (2.5 mile) intervals along the centerline, and each point has been labeled with a UTM (Universal Transverse Mercator coordinate system) location and a U.S. Army Corps of Engineers (COE) river mile (using COE river mile shape file obtained from the Bureau of Reclamation). The proposed anchor points are listed by river mile in **Table 1**. The locations of anchor points can vary up to 800 meters (0.5 mile) from the 4,000-meter spacing to accommodate previously established cross sections with a historical database, and to potentially accommodate some land access issues. Monitoring will use a sample of these anchor points and three accompanying cross sections as the basic sampling unit for data collection and analyses. The anchor point cross sections will extend laterally across the historic flood plain and incorporate the current main channel as well as all primary split flow channels (i.e., those channels separated from the main channel by islands). Although the south channel (Reach 2) and north channel (Reach 1) of Jeffrey Island share the same anchor points, these two channels are treated as separate reaches of river for monitoring, measuring, and analysis.

## II.E. Pure and Rotating Panels

The anchor points sampled in any year under this protocol will be components of a pure panel and a rotating panel of sites. A panel is made up of a group of sampling sites that are always visited at the same time. The pure panel will consist of a group of sites that are visited at each sampling frequency. The rotating panel will consist of four groups of sites, with only one group visited at each sampling frequency and each group revisited once every four sampling frequencies.

There will be 25 sample sites surveyed each year: 20 pure panel anchor points (three transects per anchor point) and 5 rotating panel anchor points (three transects per anchor point). The sample sites in the pure panel will be surveyed each year while the sample sites in the rotating panel will be surveyed every four years (rotating between R1-R4 sites as denoted in Table 1). Each site in the rotating panel will be surveyed three times in the First Increment.

# TABLE 1 – PROPOSED ANCHOR POINT LOCATIONS

| Anchor Point No. | Systematic Point at 4000 m (2.5 miles) (River Mile) | Closest Existing Cross Section | Recommended Anchor Point (River Mile) | Pure (P) or Rotating (R) Panel | Location |
|---|---|---|---|---|---|
| **40** | 254 | 254.4 | 254.4 | **R1** | Lexington |
| **39** | 251.5 Bridge | 250.5 | 250.8 | **P** | Lexington bridge (Hwy 283) |
| **38** | 249 | 249.5 | 249.0 | **R2** | |
| **37** | 246.5 | 246.5 N & 246.0 S | 246.5 N & S | **P** | J2 Return - Jeffrey Island |
| **36** | 244 | 244.0 N & S | 244.0 N & S | **R3** | |
| **35** | 241.5 | | 241.5 N & S | **P** | |
| **34** | 239 | 239.1 | 239.1 | **R4** | d/s Overton bridge (Rd. 444) |
| **33** | 236.5 | 237.3 | 236.4 | **P** | Cottonwood Ranch transects |
| **32** | 234 | 233.9 | 234.1 Main, N, S | **R1** | |
| **31** | 231.5 | 231.5 | 231.5 | **P** | u/s Elm Creek bridge (Hwy 183) |
| **30** | 229 | 228.6 | 228.6 | **R2** | d/s Kearney Diversion |
| **29** | 226.5 | 226.4 | 226.4 | **P** | |
| **28** | 224 Bridge | 224.3 | 224.3 | **R3** | Odessa Rd. Bridge |
| **27** | 221.5 | 222.0 | 221.9 | **P** | |
| **26** | 219 | 219.8 | 219.0 | **R4** | |
| **25** | 216.5 | | 216.5 | **P** | |
| **24** | 214 | | 214.0 | **R1** | d/s Kearney bridge (Hwy 44) |
| **23** | 211.5 | 210.6 | 211.5 Main & N1,N2 | **P** | |
| **22** | 209 | 208.4 | 208.4 Main & N1 | **R2** | u/s 32 Rd. bridge (Hwy 10) |
| **21** | 206.5 | 206.7 (no N) | 206.7 Main & N1 | **P** | |
| **20** | 204 | 203.3 N&S | 204.0 Main & N1 | **R3** | |
| **19** | 201.5 | 201.1 N maybe S | 201.1 Main & N1 | **P** | d/s Lowell Rd. bridge (Hwy 10C) |
| **18** | 199 | 199.5 | 199.5 | **R4** | |
| **17** | 196.5 | 196.4 | 196.4 | **P** | u/s Shelton Rd. bridge (Hwy 10D) |
| **16** | 194 | 193.9 | 193.8 | **R1** | |
| **15** | 191.5 | 190.9 | 190.7 | **P** | |
| **14** | 189 | 189.3 | 189.3 | **R2** | |
| **13** | 186.5 | 187.0 | 186.7 Main & N1 | **P** | d/s S. Nebraska Hwy 11 bridge |
| **12** | 184 | 183.1 | 184.0 Main & N1 | **R3** | |
| **11** | 181.5 | 181.8 S | 181.8 Main & N1 | **P** | d/s S. Alda Rd. bridge |
| **10** | 179 | 178.38 & 178.4 M & N | 179.0 Main & N1,N2,N3 | **R4** | |
| **9** | 176.5 | 177.1 | 176.5 Main & N1,N2,N3 | **P** | u/s SR 34/281 bridge (Doniphan) |
| **8** | 174 | 174.6 | 174 Main & N1,N2,N3 | **R1** | Grand Island |
| **7** | 171.5 | 172.1 S & SM & N & NM | 171.5 Main & N1,N2,N3 | **P** | d/s I-80 bridge |
| **6** | 169 | 168.7 N & S | 169.1 Main & N1 | **R2** | |
| **5** | 166.5 | 166.9 | 166.9 | **P** | d/s SR 34/Hwy 2 bridge |
| **4** | 164 | 164.6 | 164.0 | **R3** | |
| **3** | 161.5 | 162.1 | 161.8 | **P** | Phillips |
| **2** | 159 | 158.7 | 158.7 | **R4** | |
| **1** | 156.5 | 157.3 | 156.6 | **P** | d/s Bader Park Rd. br (Chapman) |

New survey at systematic point
Use existing site (Holburn et al. 2008)
Use existing site if new transect can be aligned to match existing site using metal pins or coordinates

## II.F. In-channel Vegetation Monitoring

The vegetation survey will document the areal extent and percent cover of woody and herbaceous species located within the Vegetation Survey Zone, with special emphasis on the species of interest. The system-wide anchor points will be used to locate the data collection in order to obtain estimates that are representative of the entire study area. The survey will utilize the topography survey conducted as part of the annual geomorphology monitoring. Since the objective of this monitoring is to identify trends in extent and elevation, the in-channel vegetation monitoring design will be conducted at the same pure panel and rotating panel anchor points as the geomorphology survey.

One fixed width (belt) transect at each anchor point will be used to estimate the area of the channel with vegetation of interest present. The belt transect will be centered on an anchor point and be generally oriented perpendicular to the flow. The length of each transect will be the length of the Vegetation Survey Zone between the historic high banks. The width of each belt transect will be approximately 300 meters (1,000 feet), extending for approximately 150 meters (500 feet) upstream and downstream of the anchor point. Within the belt transect, seven linear vegetation transects spaced approximately 50 meters (165 feet) apart will be established perpendicular to flow and generally parallel to the geomorphology transects. Three of the vegetation transects will correspond with the three geomorphology transects. On each transect, sample points will be assessed for percent canopy cover for each species occurring at the sample point using a plot canopy coverage method, and elevation. Sample points will be spaced on each linear transect at approximately 10 meters (33 feet) intervals within the Vegetation Survey Zone, as defined above.

Current vegetation species of interest include woody vegetation less than 1.5 meters tall, including willows, cottonwood, false indigo, saltcedar (all heights), and Russian olive, as well as purple loosestrife, phragmites, and cattails. The monitoring will identify all vegetation, including the above species of interest, at each sample point within the Vegetation Survey Zone.

## II.G. Statistical Analysis Methods

The data analysis of change will be guided by theoretical laws of science that are focused by the priority hypotheses described in the AMP. In addition to this theoretically based means of analysis, the data will be scrutinized through statistical means. The statistical analysis is intended to complement the theoretical analysis by aiding in the detection of small changes, and by aiding in the determination of confidence in theoretically based conclusions.

All raw data will be retained in the Program database and will be summarized for each sample point. Summarization metrics will be calculated with this data and difference metrics will be calculated for each sample unit as the difference of any metric between two time periods.

The monitoring sampling program described in this protocol is designed as an observational study through time. There is no comparison of control and treatment. This monitoring plan is designed to detect trends in physical habitat and geomorphology metrics. Data will be summarized for each sampling point or location, such as anchor points or gage stations, and statistics such as the mean and standard deviation will be compiled for the sample unit. In system-level monitoring, inferences will be made to the entire study area (or a river reach of interest) since each point will be placed systematically along the length of the river.

Analysis of trends for each parameter will follow the recommendations in the research and management protocols. Difference metrics will be calculated between survey times for each sampling unit. Trend analyses will be conducted using non-parametric techniques, least squares regression, or mixed models for longitudinal data (Chen et al. 1999, Helsel and Hirsch 1992). Selection of the method used to determine if trends are statistically significant will depend on the amount of missing data, data distribution, and historical use of methods for each parameter.

Post-stratification of the river by classifying sites into strata will enable analyses of the data within each stratum (Thompson 1992). Sites will be grouped into geomorphologic segments for analyses that are consistent with analyses that were conducted previously. Sites will be classified into strata before each analysis so that sites that have changed strata affiliation will be in the correct stratum for analysis.

## III. SAMPLING AND ANALYSIS METHODS

### III.A. Airborne Mapping of Topography

Topography information in the form of contour base mapping will be developed from airborne terrestrial LiDAR. Mapping with a plus or minus six-inch horizontal accuracy and one-foot contours (vertical accuracy) covering the area between the historic outer banks (approximately one mile in width) will provide baseline topographic information from Lexington to Chapman for monitoring channel changes. Topography information within the active channel will also be obtained from transect ground surveys (GPS or total station). Transects from ground surveys will then be extended to the full width of the floodplain (i.e., cross sections) and to the outer historic banks using LiDAR topography. Vegetation on the floodplain and on islands within the outer historic banks makes ground surveys laborious and costly outside the active channel or disked ground. Airborne terrestrial LiDAR flights for mapping will be flown at the beginning (baseline conditions) and end of the First Increment. LiDAR mapping will provide data for: planform mapping; topography for extending transects to cross sections; basic input to 1-D and 2-D flow, sediment, and vegetation modeling; and data for base mapping for designing sediment and planform (flow consolidation and other mechanical actions) management actions.

### III.B. Ground Survey of Transects and Longitudinal Profile

Sample sites will be surveyed according to the schedule for pure and rotating panels, while the longitudinal survey will occur once at the start-up of the program and a second time a year before the end of the First Increment. The transect surveys should occur during an annual low flow [ideally between 250 and 500 cubic feet per second (cfs)] between July 1 and August 31 to track changes in measures of channel shape and slope. The longitudinal profile survey could be conducted at higher flows, preferably during spring runoff, to allow for the use of survey-grade, boat-mounted, GPS-based, depth-sounding equipment (e.g., fathometer). A GPS-based hydrographic survey is preferential because it is less time consuming and easier to conduct (i.e., using a boat versus physically walking the channel), is less costly (fewer person-hours and lower equipment costs), and provides significantly more topographic data. Regardless, the performance of survey work should be conducted in an effort to avoid tern and plover and whooping crane nesting seasons when possible.

The locations of established control points and permanent benchmarks will be identified prior to conducting the surveys. Where control points or benchmarks have been destroyed, damaged, or displaced, those points will be reestablished. In areas where there is insufficient survey control, new control points or permanent benchmarks may need to be established for use in conducting the transect and longitudinal profile surveys. All new or reestablished benchmarks and control points will be established and monumented using standard survey techniques and criteria.

### III.B.1. Ground Transects

A group of three transects at 150 meter (500 feet) spacings, with the middle transect centered at the anchor point, will be measured at each anchor point selected for sampling. Each transect represents the surveyed active channel portion of a cross section at an anchor point. Each cross section will extend across all channels and islands of the Platte River in the 100-year flood plain, or between outer historic banks. The cross sections will be generally oriented perpendicular to average flow direction and high flow direction in the main channel.

Doglegs in the cross section may be used to align the cross section perpendicular to flow on other secondary channels that are not parallel to the main channel. However, future channel shifts may be problematic with regard to previously established dogleg alignments as well as with estimating year-to-year volumetric changes relative to channel aggradation or degradation at a cross section. Therefore, the hinge points for doglegs should be established on relatively permanent surfaces (such as islands) and far enough from the active channel to avoid the effects of active bank erosion and long-term channel migration. Dogleg hinge points should also be monumented with marker pins. Once a dogleg has been established in the first survey year, the dogleg should be maintained and surveyed as-is throughout the First Increment in order to accurately estimate year-to-year volumetric changes relative to channel aggradation or degradation at a cross section

Ground surveys will provide transect data within the active channel (accretion zone), while LiDAR mapping will be used to extend transects across the full width of the flood plain (i.e., translate transects to full cross sections). Ground-surveyed transects only need to extend along the cross sections where the ground has been inundated since the previous survey and should include areas where the ground has been disturbed by anthropogenic activities (i.e., areas that have been disked or mowed), where natural processes have created significant topographic changes (i.e., channels and islands where sediment could have deposited or been eroded), or locations where new dikes or other river training structures have been placed or removed by landowners (should be described and recorded in survey notes). The transect survey will include the channels, banks, and small islands within the accretion zone, but will not include the upland portions of the cross section beyond the potential bank erosion/deposition zone.

Because of the presence of multiple active secondary channels separated by large islands, ground surveys between Kearney and Grand Island may require four or more sets of transect measurements with two marker pins per transect, to record measurements of all the active channels in a cross section. The transects on the secondary channels will only be surveyed once every four years, with the transects of the pure panel anchor points being surveyed in Year 1 and every time the R1 rotating panel anchor points are surveyed. The secondary channel transects on all the rotating panel points will be surveyed during the first year of their rotation and each time that rotating panel point is resurveyed.

When a transect is re-visited in the First Increment, repeat measurements will focus on breaks in slope. Changes in this measurement over time will indicate aggradation or degradation at a point in the river, indicate changes in the shape of the cross section, and provide geometry data for 1-D and 2-D modeling. The comparison of three transects at each anchor point over time allows calculation of an average change in the volume of sediment stored in the 300 m reach at the anchor point. These estimates will be used to indicate aggradation or degradation within the 300 meter sampled area and to infer changes in sediment storage throughout the 95-mile reach of interest.

### III.B.2. Survey Methods for Ground Transects

The transects will be surveyed using a survey-grade global positioning system (GPS) to document the topography of features within the accretion zone, including the elevation and location of breaks in slope, banks, thalweg, bars, and islands. The horizontal reference datum for all surveys will be the North American Datum of 1983 (NAD 1983) and the vertical reference datum will be the North American Vertical Datum of 1988 (NAVD 1988).

Each transect within each cross section will be generally oriented perpendicular to the principal flow direction and will extend through all channels at the anchor point. Doglegs in the cross section line may be needed to remain perpendicular to flows in major side channels. The location of the cross section will be delineated on both historic outer banks with a permanent metal marker (pin) set above the flood elevation and far enough from the active channel to avoid all but the most severe erosion effects.

The location of cross-section marker pins, their monumentation, and the extent of the survey beyond the pins will be dependent on accessibility and private property requirements and restrictions. The marker pins will be composed of 1/2-inch (#4) rebar, approximately 18-inch long, driven flush with the ground surface, and topped with an aluminum cap that is stamped with the anchor point and transect identifier. The geographic coordinates and elevation of each marker pin will be established with vertical and horizontal accuracies of 0.1 feet or less using standard survey techniques and criteria, and a detailed description of the location of each pin will be documented in the surveyor’s notes. Depending on the type, location, and extent of Program activities and other potential natural or man-made disturbances, marker pins may be lost, damaged, or displaced over time and will need to be reestablished as necessary during annual surveys.

The surveyor will take GPS readings and appropriately identify the following in the data recorder:

- top of bank
- toe of bank
- left and right edge of water
- main and secondary channel thalwegs
- water surface at exposed bars and islands
- bed or ground elevation
- edge of canopy of permanent woody vegetation > 1.5m tall
- edge of vegetation (green line)
- any other significant geomorphic feature in the transect

Surveyor's notes should also specify major substrates and vegetation cover types and boundaries in the section. The major vegetation cover types will be very general and consistent with the aerial photographic maps. When surveying topography in vegetated areas, a maximum height of vegetation will be recorded with the topography point to compute height of vegetation blocking observation view. In order to adequately define the channel bed, GPS readings will be taken at significant breaks in slope. If the channel bed or a portion of the channel bed is flat with no breaks in slope, a GPS survey point will be recorded every fifteen meters (50 feet). The repeat measurements will be taken along the identical orientation as the original transect, as located by the permanent metal pins and the horizontal coordinates. The survey could extend beyond the marker pins if the upland portions of the transects have been inundated since the previous survey.

All transect survey data collected each year will be downloaded and compiled electronically into spreadsheets for future use in identifying volumetric changes of the channel over time. The transect survey data will be differentiated as such in the spreadsheets. LiDAR data will be merged with the transect survey data to extend each anchor point's cross-sections and will be identified in the spreadsheet as LiDAR data. Individual spreadsheets will be developed for each anchor point and will include both the survey data for each transect and the LiDAR data for each cross section at that anchor point. Both the LiDAR and survey points for each cross section will be documented in the spreadsheet by their UTM easting and northing coordinate pair, elevation, and stationing from the left descending bank marker pin. The UTM zone, point identifiers and comments will be included. Formatted annual cross section point data and attributes will also be electronically uploaded and seamlessly incorporated into the Program database. Where the cross section is extended across the floodplain on the left bank, the stationing will be documented as a negative value. Since it is extremely difficult to precisely follow a pre-defined survey line for each transect, the stationing for each survey point will be defined by projecting a line perpendicular to the transect line from the surveyed point and where it intersects the transect line, that is the point at which stationing is calculated based on its distance from the left bank marker pin.

### III.B.3. Measurements of Channel Width and Width/Depth Ratio from Transect Surveys

To detect small changes in wetted width and the width-to-depth ratio, compute these values from ground surveyed transects of the main channel at anchor points using two specified flows: 2,000 cfs generally representing mean annual flow, and 1,200 cfs, the tern and plover habitat reference flow. Flow measurements are based on the USGS discharge gage at Grand Island. The wetted width and width-to-depth ratio are measured for both the entire cross section (total) and for the main channel only. A width-to-depth ratio is the wetted width of the channel divided by the maximum depth of the channel.

Before calculating these values, the specified flow must be distributed between the multiple channels of the cross section, and the water surface computed at normal depth or computed from a step-backwater calculation. The division of flows amongst multiple channels and determination of water surface elevation is most easily and consistently accomplished by using a numerical flow model. This method makes it possible to compare these values consistently and to detect small changes in width to depth ratio and wetted width.

The main channel alignment should be checked when reducing data from annual ground surveys to ensure there have been no significant changes in flow direction at the transects. Large changes in flow alignment could introduce some error in the width and width-to-depth measure if the orientation of the topography survey transects are not adjusted.

The wetted surface width measured from ground survey transect data at a specified flow of 1,200 cfs should be compared to widths measured from aerial photographs at similar flow for the purpose of quality control.

### III.B.4. Longitudinal Profile Survey

The longitudinal profile of the main channel thalweg will be monitored to provide data on irregularities in slope that may affect channel planform and cross section, and to evaluate trends in aggradation and degradation. The longitudinal profile should be measured with a hydrographic survey in Year 1 (or earliest possible year) and Year Twelve of the Program. The survey should include thalweg measurements in the main channel of the river between Lexington and Chapman and the south channel at Jeffrey Island between the Johnson-2 (J2) Return and the confluence with the main channel.

Prior to conducting the survey, the principal flow path within the main channel that contains the primary thalweg will be identified from the most current georeferenced aerial imagery and the flow path will be used to guide the hydrographic survey. Since there are multiple flow paths within and outside of the main active channel, the identified flow path that contains the primary thalweg will provide an accurate boundary within which the hydrographic survey can be conducted.

The profile survey will be conducted using a boat-mounted, survey grade, GPS-based fathometer. The horizontal and vertical accuracy of the survey should be to within 0.1 feet using NAD 1983 as the horizontal reference datum and NAVD 1988 as the vertical reference datum.

Where possible, the profile survey should be performed in a manner that accurately defines the position of the thalweg while minimizing the distance between thalweg points. This may be accomplished by closely following the thalweg where it is evident. If flow depths are sufficiently deep to preclude the accurate identification of the thalweg, a cross-channel zigzag or rectangular pattern of surveying that will identify the thalweg should be used. Where a zigzag or rectangular pattern is used, a maximum spacing between cross-channel survey lines of no more than 150 meters (500 feet) should be used. However, since the presence of numerous islands, high bars, and dense vegetation may locally limit a detailed survey at that spacing, every effort should be used to collect a reasonable number of surveyed points in those areas to accurately define the thalweg.

All survey point data will be downloaded and compiled electronically into a spreadsheet and defined by UTM easting and northing coordinate pairs and elevation. The main channel thalweg points will be extracted and compiled in a separate Excel spreadsheet, which will be used to develop the longitudinal thalweg profile for the project reach. The formatted thalweg survey point data and attributes will also be electronically uploaded and seamlessly incorporated into the Program database. Stationing for the profile can be based on the straight-line point-to-point distance upstream of the Chapman bridge (Bader Park Rd.) or can be rectified to COE river mile markers by projecting a line from the surveyed thalweg point perpendicular to a straight line connecting the mile markers. Where it intersects the mile marker connecting line that is the point at which stationing is calculated.

## III.C. In-Channel Vegetation Survey

Three hundred meter wide belt transects (approximately 150 meters on either side of the anchor point) at each anchor point in the pure panel as well as that year's rotating panel will be visited once a year during the period specified in Section III.C.1. to document vegetation within the Vegetation Survey Zone.

Within the belt transect, seven linear vegetation transects will be established perpendicular to the flow at approximately 50 meter (165 feet) intervals. Three of the linear vegetation transects will be at the same locations as the geomorphology transects. Vegetation sample points will be taken along these linear transects only within the Vegetation Survey Zone as defined above.

The vegetation sample points will be established at intervals spaced approximately 10 meters (33 feet) apart along the transect. This interval will be continually evaluated for appropriateness and is, therefore, subject to change. At each sample point, a one-meter square quadrat will be used to determine species composition and percent vegetative cover. At each sample point, the following data will be collected:

- the GPS coordinates of the sample point using survey grade GPS equipment
- the elevation of the sample point using survey grade GPS equipment
- a list of all species occurring within the quadrat
- the percent cover of each species by visual estimation, recorded using the Daubenmire (1959) cover classification system (cover classes 1-6)

- an estimate of the average height of the woody vegetation
- an estimate of the average height of the herbaceous vegetation
- the community classification code using the system outlined in Steinauer and Rolfsmeier (2003)

In addition to the vegetation sample points, a data point documenting GPS coordinates and elevation will be taken at these locations:

- each edge of the Vegetation Survey Zone
- the “green line” at the edge of vegetated sand bars and wetted channel

**III.C.1. Timing**

The in-channel vegetation survey will take place annually between July 1 and August 31, water flows permitting, and at the same time as geomorphology monitoring activities. The elevation information will come from implementation of the geomorphology monitoring protocol. The information gained from this monitoring will be summarized for inclusion in planning documents related to implementation of the AMP and the Environmental Account Annual Operating Plan (AOP).

**III.C.2. Analysis**

The average elevation and areal extent of species of interest will be estimated with the in-channel vegetation survey. The data from each sample point will be analyzed to determine which species of interest occur at that point.

<u>Frequency of Occurrence</u> - For each belt transect, the frequency of occurrence for each species of interest will be calculated by dividing the number of sample points at which a species of interest was found by the total number of sample points at that belt transect. In addition, a shapefile will be prepared with an attribute table that will detail the presence or absence of each species of interest at each sample point.

<u>Percent Cover</u> - For each belt transect, the percent cover for each species of interest will be calculated by averaging the percent cover for that species at all sample points. In addition, an estimate of the areal coverage at each belt transect will be obtained by multiplying the percent cover of each species of interest by the estimated belt transect area.

<u>Elevation Data</u> - For each belt transect, and for each species of interest, the elevation data for sample points at which that species occurs will be averaged to determine the average elevation for that species at that belt transect. The average elevation for each species of interest at each anchor point will be converted to the elevation above water level at a base flow using nearby gaging information. The average elevation above water at a base flow for each anchor point will be weighted by the percent area covered for that anchor point, and the result will be combined across anchor points to obtain a frequency distribution of elevation for species of interest in the study area channel. This distribution will be used to determine

the proportion of species of interest present in the main channel at each elevation above the base flow water level.

## III.D. Bed and Bank Material Sampling

Bed and bank material samples will be taken at the anchor point transects to track changes in measures of bed material grain size distribution. Changes in grain size distribution over time will indicate coarsening or fining of the sediment at the system level. Due to natural variation in grain sizes in river channels, a stratified sampling scheme is necessary to reduce variance in order to evaluate long-term trends.

### III.D.1. Bed Material Sampling Methodology

Bed material will be documented using grain size distributions of bed material samples collected during each successive annual topographic survey; however, bank material sampling will not be repeated at successive annual topographic surveys except for the final year of the First Increment. Up to 10 bed material samples and one composite bar sample will be collected at each of the 25 surveyed anchor points annually. The total number of bed and bar samples collected annually will vary depending on site conditions and the number of flow splits associated with active secondary channels at each anchor point. The bed material samples will be collected as follows:

Main and Secondary Channel Bed Samples - Three main channel samples will be collected from each of the three transects at each anchor point. Each transect will be divided into three equally spaced increments with one sample from the thalweg in the increment that contains the thalweg and a representative bed sample from the other two increments. If the channel bed in the other two segments contain flowing water, samples should be collected from the active bed portion of those segments. If there is no flow in one or both of the other segments, samples should be collected from the lowest surface that was most recently exposed. If additional smaller channels separated from the main channel by small islands or large bars are present, one sample will be collected from the thalweg of the middle transect on the second largest channel at the anchor point. The location of each of the samples will be georeferenced using GPS and the range of materials noted/described.

Sand Bars in Main Channel - Samples will be collected from both natural high flow sand bars and, where they exist, mechanically created sand bars at all anchor points. Natural high flow bars are those bars that were naturally formed, were active during the last major flow event, and have elevations significantly different from the existing channel bed. Natural bar sites can be selected for sampling from anywhere in the main channel at the anchor point. Bars that are mechanically created or modified by Program activities and are expected to be maintained by subsequent high flows will be sampled as necessary, since the sampling of these bars will be dependent on the timing of flow events of sufficient magnitude and duration to modify and maintain the bar once it has been created. One set of three samples representing materials found on the sampled sand bars will be collected. The three individual samples should be collected in close proximity to each other at the head of the bar and should be representative of the materials that comprise the bar. The three samples will be combined to form a single composite sample. A location that is central to the samples will be established and georeferenced. The range of materials that comprise the bar will be noted/described. Any surface armor layer or coarse surface lag should also be noted and removed prior to sampling.

Bed sediment samples should be collected using a sampler that will collect a sample that accurately reflects the material in the upper 15-25 cm (6-10 inches) of the channel bed. This would include the top 7.5 centimeters (3 inches) of the surface of the bed in order to provide similar data to the BM-54 cable-and-reel bed-material sampler used at bridge sections (Edwards and Glysson 1999) and to sample bed material that is most readily available for transport.

One method of sampling is to use a rigid can or tube that contains slightly less volume than the sample bags being used to hold the samples. The can or tube should have a beveled end to allow for easy dredging and the other end should be open and covered with a very fine mesh screen or heavy filter cloth that traps all the sediment, but allows water to pass through. Using a sampler that has slightly less volume than the sample bags allows the entire sample to be placed directly into the bag without the potential for sorting or loss of fines. This would also allow for a similar volume of material to be sampled each time at each sample point. Other types of bed material samplers and sampling procedures can be found in Bunte and Abt (2001).

At each sample point within each increment, the can/tube dredge sampler is pushed vertically or diagonally into the bed of the river in the upstream direction until the sampler is full. All bed samples taken from the main channel and any secondary channels will be transferred to individual sample bags that are labeled with the sampled anchor point, transect ID, increment ID or sample number, and the date the sample was taken.

All samples will be transferred to a certified geotechnical lab and analyzed for grain size distributions. Each sample will be oven-dried and weighed to determine total weight and the sample will be placed in a sieve stack and agitated for 25 minutes using a Ro-Tap (or similar) sieve shaker. The weight of material retained on each sieve will be recorded after transferring the material to a tared dish. The process will be repeated for every sieve in the stack to yield the grain-size distribution for a sample (Guy 1969). A dry sieve analysis will be performed on all samples using the following phi sieve sizes: 4.0, 3.0, 2.0, 1.0, 0.0, -1.0, -2.0, and -4.0. The results reported for each sample will be compiled in Microsoft Excel and will include the sample description, total sample weight, and the weight and percent passing for each of the sieve sizes. The $D_{5,}$ $D_{10}$, $D_{16}$, $D_{30}$, $D_{50}$, $D_{60}$, $D_{84}$, $D_{95}$, and sorting (square root of $D_{84}/D_{16}$) of each sample will also be reported.

**III.D.2. Bank Material Sampling Methodology**

Bank material will be documented in the first year of the topographic surveys using stratigraphy and grain size distribution of the bank material; however, the bank material sampling does not have to be repeated at successive topographic surveys. The bank material sampling will only be repeated during the final year of the First Increment. One drawing, accompanied by ground photography, will be created for a left bank and a right bank in the main channel at each pure panel anchor point. Since the bank material sampling occurs on the main channel, the samples will be collected from one or both outer banks or from the bank of an island, depending on the location of the main channel. There will be one sediment sample taken from the same site of each drawing. There will be a total of 40 drawings and 40 bank sediment samples collected.

At each bank, the sediment stratigraphy will be described using sketches and notes in a waterproof field notebook and a sampler will be used to take a representative composite sample of the bank. The bank face will be cleared of vegetation and debris where possible and a representative sample of the entire bank above the low flow water line will be obtained. Sediment samples will be collected using a method that will accurately reflect the volume of the individual sedimentary horizons found within the bank section being documented. This can be accomplished with a hand corer, but the use of a hand corer is often restricted where there is a dense growth of roots at the bank surface or within the bank or where there are coarse materials such as gravels and cobbles within the bank. Therefore, it is recommended that a method of sampling be used that is not extensively affected by these factors. It is also recommended that the sampler that is used should be relatively quick and easy to use as well as inexpensive to construct and operate.

One type of sampler that could be adapted for use in coarse grained and/or rooted bank conditions is an open-faced steel box sampler. This type of sampler is made from sheet steel with the dimensions of approximately 12 inches long by 6 inches wide by 2.5 inches deep. This type of box sampler is pushed into the cleared bank face until it is flush. The corners and outer closed edges of the sampler should be reinforced so that they can be tapped on with a hammer if the sampler edge meets any resistance when being pushed into the bank face. A steel plate that is slightly larger than the box should be used to separate the sediment sample in the box from the bank face by sliding the plate down along the open side of the box. It may be necessary to sharpen the leading edge of the plate to facilitate the cutting of any roots that may extend into the sample in the box. Banks that are taller than the sampler length will require a series of successive stacked samples of the bank face, but any overlap of the sampling zones on the bank face should be avoided to reduce the potential for bias.

The sampled bank material will be composited and transferred to a sample bag that is labeled with the sampled anchor point, transect ID, increment ID or sample number, and the date the sample was taken. All samples will be transferred to a certified geotechnical lab and analyzed for grain size distributions using the same procedures, sieve sizes, and results reporting as described above for the bed material samples (see Section III.D.1).

Documentation of the stratigraphy of the bank face will include the color and texture of each major stratigraphic horizon, the average grain size or range of sizes of each major horizon, and the thickness of each major horizon along the vertical axis of the bank. Where distinct soil or clay horizons exist, Munsell Soil Color Charts should be used to document the texture and color of the material. In addition, photographs will be taken at each bank to provide additional documentation of bank stratigraphy at the sampling sites. Photographs of bank stratigraphy will include an appropriate scale with visible measurement increments (such as a photo scale or stadia rod). The location of the bank material sampling will be georeferenced using GPS and the documented bank stratigraphy and sedimentary characteristics will be incorporated into the Program database.

## III.E. Aerial Photography

Aerial photographs will be used to document changes in river plan form and as verification of the channel width measures from transect surveys. This protocol requires no additional aerial photography than what has been outlined by the Program's aerial photography protocol. The February 19, 2009 draft *Protocol for Aerial Photography in the Central Platte River Valley* calls for annual CIR photography to be obtained between late-May and June, taken at a 2-foot digital resolution (approximately equal to a scale of 1:4800), and will include the entire 90-mile length defined in the proposed Program, plus 3.5 miles either side of the centerline of the river. The photography will be obtained during flows as close to 1,200 cfs as possible. Measurements of total and main channel wetted width from the aerial photography will be used to verify widths from transect surveys in the Cooperative Agreement study area to obtain a system-level estimate. Ortho-rectified aerial photographs (see aerial photo and mapping protocol) will be analyzed after several years of data collection using GIS software.

River planform monitoring will rely on mapping from aerial photography and LiDAR data. Planform descriptions of meandering, anastomosing, and braiding will be assessed by reach from aerial photography. However, planform descriptions are qualitative and coarse in scale so more quantitative indicators such as number of channels, braiding index of the main channel, and width-to-depth ratio will be used to monitor channel change at a finer scale. The width-to-depth ratio is calculated from transect ground surveys (see Measurement of Channel Width and Width-to-Depth Ratio from Transect Ground Surveys), while the number of channels and braiding index are measured from aerial photos in GIS mapping and the number of channels is verified using LiDAR baseline mapping. Measurements of the number of channels and braiding index are made at the anchor points and at locations one-half mile or less between anchor points using GIS to compute average values. Changes in channel width are more accurately monitored through measurements based on transect ground surveys. Measurements of total and main channel wetted width can be approximated from aerial photos and the LiDAR data and used to verify width measurements based on ground surveys.

Measurements of the braiding index, number of channels, and channel width will be acquired from aerial photographs for each year of the First Increment that aerial photos are available. The measurements are made for the main channel of the entire study reach. However, in Reach 4 (Kearney to Grand Island), where the river is divided into two to four channels by large islands, the number of channel measurements are computed only for the main channel. In addition, Reach 1, which encompasses the north channel at Jeffrey Island, is treated separately from Reach 2, which encompasses the south channel at Jeffrey Island.

### III.E.1. Measurement of the Number of Channels from Aerial Photography

Channels are detected in the measure of number of channels, from continuous linear water surfaces, or from continuous lineal breaks in vegetation on aerial photos. Small channels may be difficult to detect on aerial photos due to the presence of vegetation canopies, or the total absence of vegetation resulting from disking. LiDAR mapping provides good definition of ground surfaces and can be used to verify the presence of small channels.

### III.E.2. Measurement of the Braiding Index from Aerial Photography

Braiding index is measured for the main channel only. This will include a count of the average number of sub channels in the main channel (channel that conveys the most flow). The average number is based on bisecting the wetted main channel perpendicular to flow direction a minimum of four bisections per mile, at an approximate flow of 1,200 cfs, the flow specified for aerial photos. A sub-channel is an individual flow path within the main channel, separated from other flow paths by bars or bed forms. The bars or bedforms can be submerged, but are still identifiable from aerial photos. For example, the braiding index is three when the active channel area of the main channel has three flow paths divided by two bedform or bar features. Vegetation removal by disking can confound determination of the active channel area so measuring the braiding index in the wetted area at 1,200 cfs, rather than measuring braiding index in the active channel area, should reduce the associated error.

### III.E.3. Measurements of Channel Width from Aerial Photography

Measures will be made of active channel width and water surface width of the main channel at transects, and of total active channel widths and total wetted surface width (a summation of main and side-channel width measures). The edge of woody and substantial herbaceous vegetation normally denotes the edge of the active channel. The width of the water surface measured from aerial photos is a factor of the flow on the day of the aerial photo flight. The aerial photography protocol specifies 1,200 cfs as measured at the USGS gages at Overton, Kearney, and Grand Island. Measurements of width on the photographs will occur at each anchor point in the associated habitats reach to obtain a system-level estimate.

Measures of active channel width measured from aerial photographs will enable repeatable estimates that are obtained using the same techniques through time. However, disking limits interpretation of this measurement since the definition of active channel width is dependent on the natural edge of vegetation. All areas cleared of vegetation by disking need to be noted on photos. Information on cleared and disked areas may be available from the Vegetation protocol. Water surface widths measured from aerial photography will vary from upstream to downstream due to changes in discharge on the day of the flight, from flow fluctuations, groundwater losses, and withdrawals. Because of these limitations, small changes in width will not be detectable from aerial photos, but this information should be compared to width measurements computed from surveyed ground transects (see Measurement of Channel Width and Width-to-Depth Ratio from Transect Ground Surveys) for quality control.

## III.F. Documentation of Bank and Channel Features Using Ground Photography

Ground photography will be conducted on each transect survey to document and describe bank stability and composition, vegetation type and structure, and the conditions of the main channel. A series of photographs will be obtained at each anchor point. At a minimum, a series of four photographs will be taken at each geomorphic transect to document bank and channel conditions at the transect location: one taken from each bank looking cross-channel toward the other bank and one taken from a short distance out into the channel looking back toward each bank. In addition, a photo looking upstream and one looking downstream should be taken at the downstream and upstream transects, respectively, to document general channel conditions within the site. Additional photographs will be obtained to document the banks and channel conditions in split flow channels and of other unique or special geomorphic or vegetative features as deemed necessary. These photographs will be archived by the Program for use in clarifying changes detected by the topography survey. The vegetation delineations will also be documented with photographs for use in the interpretation of aerial photographs.

All ground photography will be obtained with a good quality digital camera that maintains a time and date stamp, a 3X or greater optical zoom lens, and an effective image capture size of five megapixels or greater. Transect and point identification, photo number, and azimuth will be recorded for each photograph. Photographs will be cataloged after fieldwork is completed and all data/photos will be stored in the Program database. GPS-based cameras or software that georeferences digital ground photography should be used to facilitate incorporation of the ground photos into the Program database.

## III.G. Gaging Stations

Stream gages in the area are operated and maintained by the U.S. Geological Survey (USGS) or the Nebraska Department of Natural Resources (DNR) according to USGS guidelines (Buchanan and Somers 1968, Buchanan and Somers 1969, Carter and Davidian 1968). Discharge and stage will be measured by the USGS at each gaging station and used to estimate a standard USGS rating curve (Kennedy 1984).

### III.G.1. Discharge

Discharge and stage will be monitored continuously using real-time gaging station data from existing gages at Cozad, Overton, Odessa, Kearney, and Grand Island, and from a new gage installed at Shelton. River stage is measured approximately hourly at these gaging stations, and discharge is estimated using rating curves. The rating curves will be maintained by periodic measurements of depth and flow rate and by shifting the rating curves as needed. The uncorrected hourly discharge and stage values, along with corrected daily summaries will be stored in either the Nebraska DNR or the USGS database (depending on the entity overseeing the operation of the gaging station). The rating curves used for predicting discharge will be documented and stored with the data to detect changes in channel morphology (Wahl and Weiss 1995).

## III.H. Sediment Transport Measurements

Transported sediment in the Platte River is primarily composed of bedload, which is of principal interest in understanding channel change. Measuring bedload on an easily deformable bed like the Platte River makes accurate sampling difficult and, therefore, suspended sediment measurements (sediment concentration) in some instances can be used as a surrogate for computing bedload transport and can be less variable since bedload measurements in sand bed rivers are susceptible to variations from migrating dune movement. However, accurate measurements of suspended sediment on the Platte River is also difficult at lower flows (<5,000 cfs). Therefore, both suspended sediment and bedload measurements will be used to estimate absolute values of sediment transport. Estimates of transported sediment load will be combined with volume of aggradation and degradation measured with topographic ground surveys to monitor the sediment budget between Lexington and Chapman. Both Helley-Smith bedload sampling and depth-integrated sampling across the width of the stream at five-gaged bridge sites are proposed since, together, they provide better representation of the channel and are common approaches used historically.

### III.H.1. Bedload and Depth-Integrated Suspended Sediment Sampling

Bedload and suspended sediment will be monitored under specific flow conditions during the course of each year at bridge crossings near Lexington (SH-L24A/Rd 755), at Overton (SH-L24B/Rd 444), at Kearney (SH-44/S. 2nd Ave.), at Shelton (SH-L10D/Shelton Road), and near Grand Island (US-34/Schimmer Drive). Samples will be collected using USGS standards for a bedload sampler and a depth-integrated sampler at 20 equally spaced locations (20 verticals for suspended sediment sampling) in the river cross section. This will allow inclusion of historical bedload and suspended sediment measures from USGS and others in the data set. Samples will be collected at each bridge site annually, but the sampling schedule will be dependent on flow conditions during the year. Ideally bedload sampling should include samples obtained from each of three different flow increments: three samplings in the 1,000 to 3,000 cfs flow range; two samplings in the 3,000 to 5,000 cfs flow range; and if possible at least one sampling of flows greater than 5,000 cfs. A single depth-integrated suspended sediment sampling effort will also be conducted during the bedload sampling under the >5,000 cfs flow increment. Local gaging stations and weather conditions should be monitored regularly throughout the year to identify potential events that may produce these flow ranges.

The 20 bedload samples collected at each bridge site using a Helley-Smith bedload sampler will be combined to make one composite bedload sample for that bridge site. The 20 vertical depth-integrated suspended sediment samples collected at each bridge site will be combined to make a single composite sample for that bridge site. Bedload samples will be collected using procedures defined in Edwards and Glysson (1999) and FISP (1999). Suspended sediment will be measured using procedures from Edwards and Glysson (1999) and Thomas and Lewis (1993).

All bedload sediment and suspended sediment samples will be analyzed by a certified geotechnical lab. The suspended and bedload sediment samples will be analyzed by dry sieving to determine their mechanical composition. Each sample will be dried and weighed to determine total weight. The sample will be placed in a sieve stack (ranging from 4.0 phi to 0.0 phi) with 1/2 phi gradations and agitated for 25 minutes using a Ro-Tap (or similar) sieve shaker. The weight of material retained on each sieve will be recorded after transferring the material to a tared dish. The process will be repeated for every sieve in the stack to yield the grain-size distribution for a sample (Guy 1969). The grain size distributions will be determined and reported as described above (see Section III.D.1).

Total sediment load will be estimated directly from the bedload data and computed from suspended sediment measures using the modified Einstein equation.

## IV. ANNUAL REPORTING AND DELIVERABLES

Annual monitoring deliverables will include draft and final reports (in Microsoft Word) that document the activities completed during each monitoring season, any difficulties encountered, and recommendations, if any, for revising the protocol methodologies. The draft report shall be submitted for review at the beginning of each October to the Program who will have 30 days to review the draft report. A final report that addresses any review comments will be submitted within 14 days after receipt of review comments. Other deliverables to be included with the final annual report will include any raw data (including survey and parametric data), survey and mapping data, UTM locations of monitoring and sampling sites, ground photographs and field documentation of project activities, and other documents or materials collected and/or developed as a part of annual monitoring activities. Where appropriate, all data will be compiled in Excel spreadsheet format and incorporated into the Program database. Data will be reported in accordance with guidelines outlined in the Program’s AMP and the Program’s Database Management System.

## V. FIELD SAFETY

Since this protocol defines a significant field data collection effort, the safety of field personnel should be a priority when conducting the field work. There are inherent risks and hazards associated with field work, especially when working around water and in or near vehicular traffic, so every effort should be made to minimize those hazards and risks. If a corporate or agency safety manual is not available for use by field personnel, it is highly recommended that a safety plan be developed prior to conducting the tasks defined in this protocol. The safety plan should address issues related to working around and on water, boating safety, traffic safety, severe weather, and wildlife.

All federal and state guidelines should be adhered to when conducting field work using boats and other watercraft. Field personnel should wear U.S. Coast Guard approved personal flotation device (PFD) at all times while working on or over water. Safe boating procedures should be followed at all times and standard emergency equipment such as fire extinguishers and first aid kits should be included on all manned watercraft. When working over water such as at bridge railings, field personnel should wear PFD’s and appropriate safety harnesses tethered to the bridge railing or other structural feature that will prevent the wearer from being injured from a fall.

When working in or traversing the river by foot, quicksand can be a potential threat. Although drowning in quicksand is impossible, becoming temporarily trapped in quicksand is possible. Therefore, field personnel working in or traversing the river by foot should wear a PFD and be familiar with the procedures to remove themselves from quicksand, should that be necessary.

It is recommended that weather forecasts for the study area be checked frequently for potentially severe storms. Severe thunderstorms that can include lightning, hail, high winds, and even tornadoes pose a significant hazard to field crews in isolated areas where shelter may not be readily available. Field crews should be prepared for and be able to deal with severe weather at all times.

As part of this protocol, field crews will be required to obtain suspended sediment samples from bridge sites within the study area and, therefore, will be required to deal with traffic and bridge safety issues. Although the Grand Island, Shelton, Kearney, and Overton bridges have a wide shoulder to work from, minimum traffic safety and control items will be required. These include temporary warning signs placed at each end of the bridge, regularly spaced high visibility traffic cones placed along the area where the work will be performed, and appropriate high-visibility reflective apparel to be worn by all field personnel. Field vehicles should be parked as far off of the traveled lanes as practicable. It is recommended that field vehicles have flashing hazard lights and supplemental flashers, such as strobe lights and light bars, on the vehicle activated at all times. Vehicles should be parked such that the visibility of oncoming traffic and the field crews are unobstructed.

In addition, field personnel should be familiar with basic first aid and should know the locations of all local emergency medical facilities and hospitals within the study area. In the case of a severe or life threatening injury, field personnel should rely on emergency 911 services. For non-life threatening and non-severe injuries, injured field personnel should be transported as soon as possible to a local medical facility such as an urgent care facility or hospital.

## REFERENCES


Bonham, C.D, 1989. Measurements for Terrestrial Vegetation, John Wiley and Sons, New York, 338 pp.

Buchanan, T. J., and Somers, W.P., 1968. Stage Measurements at Gaging Stations, U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chapter A7, 28 pp.

Buchanan, T. J., and Somers, W.P., 1969. Discharge Measurements at Gaging Stations, U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chapter A8, 65 pp.

Bunte, K., and Abt, S.R., 2003. Sampler size and sampling time affect measured bedload transport rates and particle sizes measured with bedload traps in gravel-bed streams, In: J. Bogen, T. Fergus and D. Walling (eds.), Erosion and Sediment Transport Measurement in Rivers—Technological and Methodological Advances: IAHS Publication 283, pp. 126-133.

Carter, R. W., and Davidian, L., 1968. General Procedure for Gaging Stations, U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chapter A6, 13 pp.

Chen, A. H., Rus, D. L., and Stanton, C.P., 1999. Trends in Channel Gradation in Nebraska Streams, 1913-95, U.S. Geological Survey Water Resources Investigations Report 99-4103, 29 pp.

Cochran, W.G., 1965. Sampling Techniques, 2nd Edition. John Wiley and Sons, New York, 413 pp.

Colby, B. R., and Hubbell, D. W., 1961. Simplified methods for computing total sediment discharge with the modified Einstein procedure: U.S. Geological Survey Water-Supply Paper 1593, 17 pp.

Daubenmire, R., 1959. A canopy-coverage method of vegetational analysis. Northwest Science. 33(1):43-64

Duncan, G.J., and Kalton, G., 1987. Issues of design and analysis of surveys across time, International Statistical Review 55: 97-117.

Edwards, T.K., and Glysson, G.D., 1999. Field methods for measurement of fluvial sediment: US Geological Survey Techniques Water Resources Investigations, Book 3, Chapter C2, 89 pp.

Evans, R.A., and Love, R.M., 1957. The step-point method of sampling – a practical tool in range research, Journal of Range Management 10:208-212.

Federal Interagency Sedimentation Project (FISP), 1999. Sampling with the US BL-84 BedLoad Sampler, USACE Waterways Experiment Station, 19 pp. (http://fisp.wes.army.mil)

Great Plains Flora Association, 1986. Flora of the Great Plains, University of Kansas Press, Lawrence, KS, 1402 pp.

Guy, H.P., 1969. Laboratory theory and methods for sediment analysis: US Geological Survey Techniques Water Resources Investigations, Book 5, Chap C1, 58 pp.

Helsel, D. R., and Hirsch, R.M., 1992. Statistical Methods in Water Resources, Elsevier, Amsterdam, 522 pp.

Holburn, E.R., Fotherby, L.M., Randle, T.J., and D.E. Carlson, 2006. Trends of Aggradation and Degradation Along the Central Platte River: 1985 to 2005, Bureau of Reclamation, Technical Service Center, 180 pp.

Kaul, R.B., Sutherland, D., and S. Rolfsmeier, 2006. The Flora of Nebraska, University of Nebraska Press, Lincoln, 966 pp.

Kennedy, E. J., 1984. Discharge Ratings at Gaging Stations, Techniques of Water-Resources Investigations, Book 3, Chapter A10, U.S. Geological Survey, Reston, Virginia, 59 pp.

Laycock, W.A., and Batcheler, C.L., 1973. Comparison of distance-measurement techniques for sampling tussock grassland species in New Zealand, Journal of Range Management 28(3), pp. 235 – 239.

Owensby, C.E., 1973. Modified step-point system for botanical composition and basal cover estimates, Journal of Range Management 26:302-303.

Pollard, J.H., 1971. On distance estimators of density in randomly distributed forests, Biometrics 27: 991-1002.

Steinauer, G., and Rolfsmeier, S., 2003. Terrestrial natural communities of Nebraska. Nebraska Game and Parks Commission, Lincoln, 162pp.

Thomas, R. B., and Lewis, J., 1993. A comparison of selection at list time and time-stratified sampling for estimating suspended sediment loads, Water Resources Research, 29(4): 1247-1256.

Thompson, S. K., 1992. Sampling, John Wiley and Sons, New York, pp. 347.

U.S. Department of the Interior (USDI) Bureau of Reclamation, 2000. Central Platte River 1998 Land Cover/Use Mapping Project Nebraska. Prepared by the Remote Sensing and Geographic Information Group (RSGIG) of the Bureau of Reclamation's Technical Service Center as Technical Memorandum No. 8260-00-08, Prepared for the Platte River EIS Team.

Vanoni, V. A. (Ed), 1997. *Sedimentation Engineering*, ASCE Manuals and Reports on Engineering Practice #54, American Society of Civil Engineers, New York, 745 pp.

Wahl, K. L., and Weiss, L.S., 1995. Channel degradation in southeastern Nebraska Rivers, In: Symposium on Watershed Management Planning for the 21st Century, San Antonio, Texas, 1995, Proceedings: New York, American Society of Civil Engineers, p.250-259.