PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

YEAR 2 (2010) FINAL REPORT

Channel Geomorphology and In-Channel Vegetation Monitoring of the Central Platte River

Prepared for:
Executive Directors Office
Platte River Recovery Implementation Program
Headwaters Corporation
4111 Fourth Avenue, Suite 6
Kearney, NE 68845

Prepared by:

AYRES ASSOCIATES

OLSSON ASSOCIATES

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ACKNOWLEDGMENTS

A number of Ayres Associates and Olsson Associates personnel were involved in conducting various aspects of this project. Dr. James Schall, VP Ayres Associates, is the Principal-in-Charge and provided overall oversight of the project. Mr. William Spitz, Senior Geomorphologist for Ayres Associates, is the overall Project Manager. Dr. Joan Darling, Environmental Sciences Team Leader for Olsson Associates, is the Olsson Project Manager. Mr. Spitz and Dr. Darling provided oversight and guidance in conducting the geomorphology and vegetation monitoring aspects of the project. Mr. Nate Van Meter, an Associate Scientist with Olsson conducted the vegetation monitoring activities and was assisted by Dani McNeil and Keith Simmons, also of Olsson. The survey control setup, transect survey, and bedload/suspended sediment sampling effort were overseen by Mr. Joe Robinson, Survey Crew Chief for Ayres, who also collected the anchor point bed and bar sediment samples. The ground survey and bedload/suspended sediment sampling were performed by Mr. Pete Paulus and Mr. Darby Schock of Ayres. Mr. Andrew Phillips, at Olsson's geotechnical lab in Lincoln, conducted the grain size analysis of all sediment samples collected for the project. Mr. Anthony Alvarado, Geomatics Project Manager for Ayres, provided oversight and guidance in conducting the transect surveys and performed the bedload/suspended sediment transport and total load analysis. Dr. E.V. Richardson, a Senior Associate with Ayres, provided QA/QC and oversight on the bedload/suspended sediment transport and total load analysis.

Dr. Jerry Kenny, Headwaters Corporation, is the Executive Director for the Platte River Recovery Implementation Program (PRRIP). He is assisted by Mr. Chad Smith, Director of Natural Resources for the Headwaters Corporation, who is the Program's Technical Point of Contact for this project. They are also assisted by Mr. Jason Farnsworth from Headwaters Corporation. Mr. Smith and Mr. Farnsworth have provided guidance and invaluable assistance in conducting this project. Other Program/Headwaters Corporation personnel that have provided invaluable assistance include Mr. Justin Brei and Mr. Tim Tunnell. Mr. Brei provided assistance in issues related to the Program's geodatabase and the acquisition of the LiDAR data, and Mr. Tunnell provided assistance in dealing with access issues and coordination with landowners.

1. PURPOSE

Per the protocol, the purpose of geomorphology monitoring is to document trends in channel geomorphology parameters in the full program reach of interest during the thirteen-year First Increment (2007-2019) of the Platte River Recovery Implementation Program (Program). Monitoring includes 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 information on trends in extent and elevation range of vegetation species of interest. 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). Specifically this information will be used to evaluate the extent of existing native and non-native invasive species infestations, to provide information in evaluating the effects of program activities, 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 also 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, and habitat features for least tern, piping plover, whooping crane, and pallid sturgeon (AMP, Table 2) are linked to aspects of geomorphology.

2. BACKGROUND

Much of the following section is taken from the monitoring protocol document and is replicated here to provide background for this report.

2.1 Area of Interest

The area of interest for geomorphology and vegetation monitoring consists of channels within an area of approximately 0.5-mile on 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 100 miles). **Figure 2.1** shows the project reach and relevant geographic features. 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.

2.2 Anchor Points

A systematic sample of points along the river are "anchors" for data collection. These anchor points are 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 (USACE) river mile (using USACE river mile shape file obtained from the Bureau of Reclamation). The anchor points are listed by river mile in **Table 2.1**. 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 within the historical database, and to accommodate some land access issues. Three cross sections at an anchor point entail the basic sampling unit for geomorphology data collection and analyses. The anchor point cross sections 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. Those anchor points surveyed in Year 2 are highlighted in yellow in Table 2.1

2.3 Pure and Rotating Panels

The anchor points sampled each year under this protocol are components of a "pure panel" subset and a "rotating panel" subset. A panel is made up of a group of sampling sites that are always visited at the same time. The pure panel consists of a group of sites that are visited annually. The rotating panel consists of four groups of sites, with only one group visited annually and each group revisited once every four years.

There are 25 sample sites that will be surveyed each year - 20 pure panel anchor points and 5 rotating panel anchor points. The sample sites in the pure panel are to be surveyed each year while the sample sites in the rotating panel are to be surveyed every four years (rotating between R1-R4 sites as denoted in Table 2.1). Each site in the rotating panel series are to be surveyed three times in the First Increment. To date, we have completed the two surveys of all of the pure panel anchor points and the first and second set of rotating panel anchor points.

Figure 2.1. Location map showing the project reach for the Channel Geomorphology and In-Channel Vegetation Monitoring. Bedload and suspended sediment sampling bridge sites are shown as red circles.

Table 2.1. Anchor Point Locations Identified in the Monitoring Protocol.					
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					

2.4 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 is focused 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 is collected through aerial photographs, airborne terrestrial LiDAR, topographic ground surveys, bed material sampling, ground photography, flow measurements at gaging stations, and sediment transport measurements. The overall strategy is focused on a randomized scheme, but there is some sampling stratification (e.g., grain size) to reduce variability and improve future comparisons.

Each anchor point consists of seven transects – 3 detailed geomorphology transects and 4 detailed vegetation transects. All transects are spaced 50 meters (165 feet) apart and are generally parallel to each other. General vegetation data is collected on the 3 geomorphology transects and general topographic data is collected on the 4 vegetation transects.

2.5 In-Channel Vegetation Monitoring

The program-level vegetation survey is designed to document the areal extent of species of interest within the Vegetation Survey Zone (as defined in protocol) between the historic high banks. The program-wide anchor points are used to locate the data collection in order to obtain estimates that are representative of the entire study area. The vegetation survey utilizes 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 survey is conducted at the same pure panel and rotating panel anchor points as the geomorphology survey.

One fixed width (belt) transect is used to estimate the area of the channel with vegetation of interest present at each anchor point. The belt transect is centered on an anchor point and is generally oriented perpendicular to the flow. The length of each belt transect is the length of the Vegetation Survey Zone within the historic high banks. The width of each belt transect is 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 transects spaced approximately 50 meters (165 feet) apart were established perpendicular to flow with 4 vegetation transects located between and generally parallel to the geomorphology transects. Three of the vegetation transects correspond to and overlap the three geomorphology transects. On each transect, sample points were assessed for species composition and percent cover, and elevation. Sample points were spaced on each linear transect at approximately 10-meter (33-foot) intervals within the Vegetation Survey Zone. As recommended in the Year 1 proposed protocol revisions, this sampling interval was modified from a 15-meter interval used during the first year to determine if closer spaced data points would provide a more accurate representation of the vegetation within each belt transect.

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, common reed (*Phragmites*), river bulrush, and cattails. The monitoring identifies vegetation, including the above species of interest, at sampling sites located within the Vegetation Survey Zone.

2.6 Airborne Mapping of Topography (LiDAR)

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. Therefore, topographic information in the form of contour base mapping has been developed from airborne terrestrial LiDAR. Airborne terrestrial LiDAR flights for mapping are to be flown at the beginning (baseline conditions) and end of the First Increment. Mapping with a plus or minus 6-inch vertical 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. The LiDAR mapping used for this monitoring effort was completed early last year (2009).

The current LiDAR mapping is providing data for: planform mapping; topography for extending transects into 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. Topographic information within the active channel has been obtained from the GPS ground surveys of the anchor point channel geomorphology transects, which will be extended to the full width of the floodplain (i.e., cross sections) and to the outer historic banks through the use of the LiDAR topography.

3. CHANNEL GEOMORPHOLOGY AND IN-CHANNEL VEGETATION TRANSECT SURVEYS

Surveys of the channel geomorphology and in-channel vegetation transects were conducted per Section III.B of the protocol. Sample sites were surveyed according to the schedule for pure and rotating panels. The locations of established control points and permanent benchmarks were identified prior to conducting the Year 1 (2009) surveys and were re-used for this year's monitoring. Where control points or benchmarks had been destroyed, damaged, or displaced, those points were reestablished. In areas where there was insufficient survey control, new control points or permanent benchmarks were established for use in conducting the transect surveys. All new or reestablished benchmarks and control points were established and monumented using standard survey techniques and criteria and as defined in the monitoring protocol.

3.1 Survey Control

The horizontal reference datum for all surveys is the North American Datum of 1983 (NAD83) and the vertical reference datum is the North American Vertical Datum of 1988 (NAVD88). Primary control was set for the project reach at roughly 12 mile intervals. Each control point was measured with GPS static observations for approximately 4 hours. Raw observations for each were sent to National Geodetic Survey (NGS) Online Positioning User Service (OPUS). OPUS horizontal and vertical coordinates in NAD83 Geographic and NAD83 State Plane Nebraska systems were used to correct values for each monument. Secondary control was also set last year (2009) for the project reach in between the primary control point locations. These monuments were measured with RTK GPS from each adjacent primary control point and then the coordinates were derived from the mean of those two measurements. This control survey was not performed in compliance with the Protocol, but deemed necessary in order to complete both the longitudinal profile (conducted in 2009) as well as the transects survey in a high quality and timely manner.

3.2 Landowner Contact

A protocol for obtaining landowner permission was established by Program and Ayres/Olsson staff prior to conducting the field survey work. Program staff made the initial contact with the landowners and obtained written permission forms allowing access to their properties. Program staff also created a geodatabase that included landowner contact information for each anchor point. The signed permission forms and the geodatabase were provided to Ayres/Olsson staff prior to the start of field work. The landowner permission forms indicated that a phone call would be made to the landowner prior to Program or Ayres/Olsson staff entering the property. During the project kickoff meeting it was determined that Ayres/Olsson staff would be responsible for making the phone call to landowners.

Ayres/Olsson staff's protocol was to make calls to landowners at least one day prior to entering their property. In cases where a phone message was left with a landowner, a contact phone number for a member of the field crew (typically Nate Van Meter of Olsson) was given and the landowner was asked to return the call if they had any questions or concerns. In addition, significant coordination was conducted between Ayres/Olsson and Program staff during the field work to ensure proper property access protocols were followed.

3.3 Ground Survey of Channel Geomorphology Transects

The protocol states that the transect surveys are to 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. However, this year was an unusual year on the Central Platte River in that daily flows exceeded 2,000 cfs for much of the summer and have continued at that rate into the fall. The original survey work, which was scheduled to start in the second week of July, was postponed for a week because of the high flows on the river. **Figure 3.1** shows the 2009 versus 2010 flow hydrographs for the summer months including the period over which the survey work was performed. These high flows made the survey work within the channel sections significantly more difficult and hazardous for both the survey personnel and equipment.

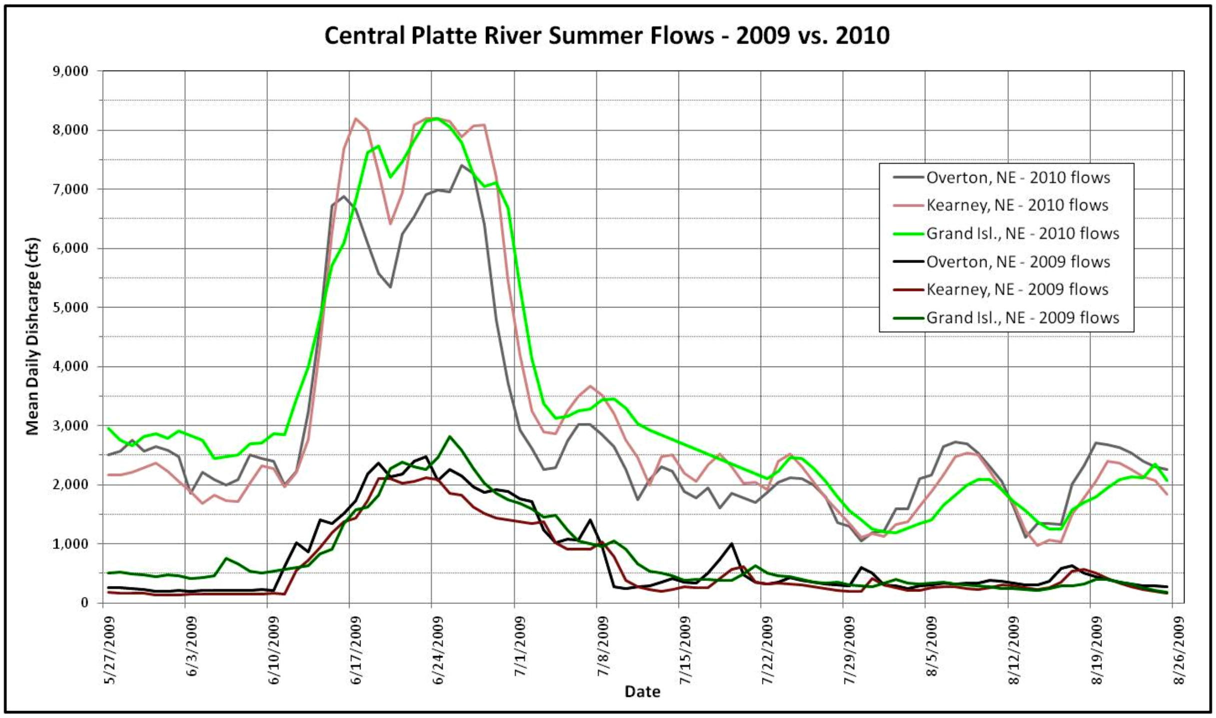

Figure 3.1. Summer flow hydrographs for the Central Platte River for 2009 and 2010.

The ground survey of the channel geomorphology transects were conducted per Section III.B.2 of the monitoring protocol. Per the protocol, a group of three transects at 150 meter (500 feet) spacing, with the middle transect centered at the anchor point, were 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 extends across all channels and islands of the Platte River in the 100-year flood plain, or between outer historic banks. The cross sections are generally oriented perpendicular to average flow direction and high flow direction in the main channel. The survey was started at the upstream end of the reach, at Anchor Point 39, and progressed downstream to Anchor Point 1.

3.3.1 Methodology

The ground surveys are used to provide transect data within the active channel (accretion zone), while LiDAR mapping is used to extend transects across the full width of the flood plain (i.e., translate transects to full cross sections). Ground-surveyed transects only extended along the cross sections where the ground has been inundated since the previous survey and includes 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 (described and recorded in survey notes). The transect survey includes the channels, banks, and small islands within the accretion zone, but not the upland portions of the cross section beyond the potential bank erosion/deposition zone. Because of the presence of multiple active channels separated by large islands, ground surveys between Kearney and Grand Island were also conducted on the split flow channels relative to the associated Year 2 anchor points. The surveys included sets of transect measurements with two marker pins per transect, to record measurements of all the active channels in a cross section.

The transects were surveyed using a Leica survey-grade global positioning system (GPS) per the requirements defined in the monitoring protocol. Each transect within each cross section is generally oriented perpendicular to the principal flow direction and extends through all channels at the anchor point. In some instances, dog-legs in the cross section line were needed to remain perpendicular to flows in major side channels. The location of the cross section has been 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 was dependent on accessibility and private property requirements and restrictions. The marker pins are 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 was 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 was 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 surveyors took GPS readings and appropriately identified the following in the data recorder:

- Top and toe of bank
- Bed or ground elevation
- Left and right edge of water
- Main and secondary channel thalwegs
- Water surface at exposed bars and islands
- Edge of canopy of permanent woody vegetation > 1.5m tall
- Edge of vegetation (green line)
- Any other significant geomorphic feature in the transect

When surveying topography in vegetated areas, a maximum height of vegetation was recorded with the topography point to compute height of vegetation blocking observation view. In order to adequately define the channel bed, GPS readings were taken at significant breaks in slope. If the channel bed or a portion of the channel bed was flat with no breaks in slope, a GPS survey point was recorded every fifteen meters (50 feet).

3.3.2 Results

The primary control that was set as part of the longitudinal profile survey in 2009 was also utilized in the survey of the transects. The transect surveys were performed between July 19 and July 30 and between August 9 and August 25, 2010. Two teams, each with an Ayres survey technician and an Olsson biologist, worked to complete the surveys. Monuments were set on the historic high bank at or behind the tree line. Vegetation sample point data was collected on a 10 meter interval along each cross section beginning at the edge of the permanent woody vegetation line for each Year 2 anchor point. The 10 meter interval was determined using the Leica Line Stakeout program within the Leica 1200 GPS system to calculate and find the vegetation sample point locations. At each sample point location, the survey technician collected the location data via RTK GPS and the biologist performed a visual analysis of all vegetation species within a square meter grid and documented the results on field data sheets. Topographic data was also collected for the top and toe of bank, grade breaks, green lines, water's edge, and the channel thalweg.

The transect survey data was downloaded and compiled electronically into spreadsheets. The actual survey data is differentiated as such in the spreadsheets. The final LiDAR data has been merged with the transect survey data to extend each anchor point's cross sections and is identified in the spreadsheet as LiDAR data. The LiDAR LAS data was clipped into individual LAS files for each anchor point area using Global Mapper 11. Then, using Bentley Microstation and InRoads v8i, a LiDAR digital terrain model (DTM) was generated for each anchor point. For each DTM the LiDAR data in the area of the transect survey was erased and the survey transect data was merged with the LiDAR data into one hybrid surface for every anchor point. The extended transects were then cut from the merged DTMs and exported to spreadsheets at a point every 0.25 feet. This section data was thinned horizontally keeping a point every 50 feet if the vertical difference remained less than 0.5 feet. Vertically, the points were thinned using a parameter of differences of less than 0.2. This reduced the size of the transect files by 15% on average for the final transect.

Individual spreadsheets that were initially developed for each anchor point surveyed in 2009 now include both the 2009 and 2010 survey data for each transect and the LiDAR data for each cross section at that anchor point. The LiDAR and 2009 and 2010 survey points for each cross section are documented in the spreadsheet by their NAD83 State Plane Nebraska easting and northing coordinate pair, elevation, and stationing from the left descending bank marker pin. The State Plane zone, point identifiers, and comments are also included. Where the cross section is extended across the floodplain on the left bank, the stationing is 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 has been 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. **Figure 3.2** shows a typical cross section (Anchor Point 39, Transect 7) based on 2009 and 2010 transect survey and LiDAR data.

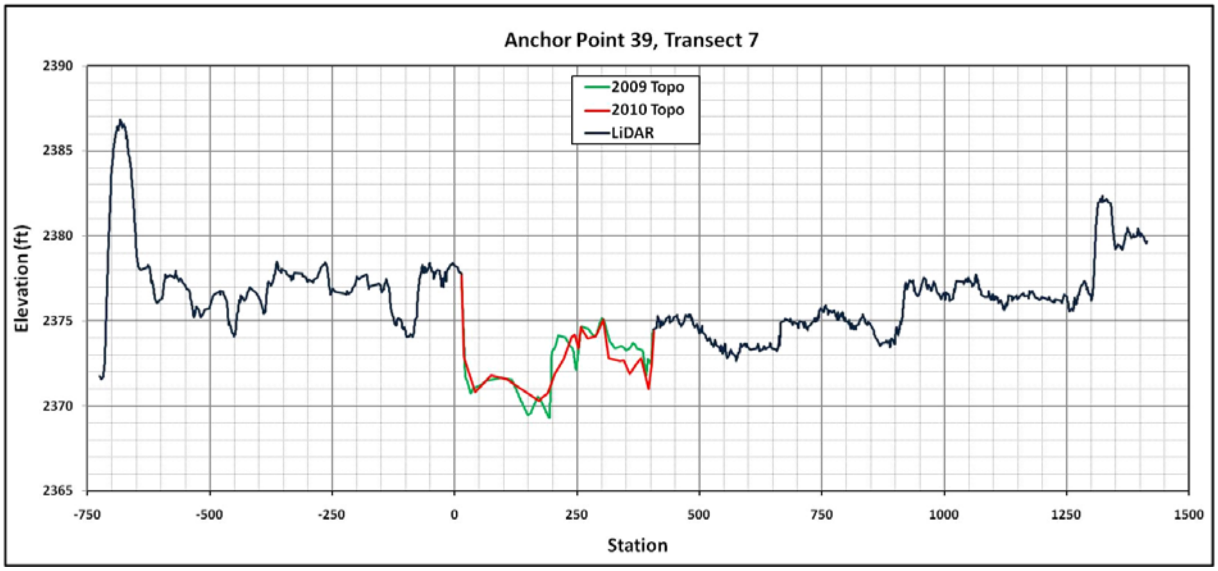

Figure 3.2. View looking downstream of typical cross section (exaggerated scale) compiled from 2009 and 2010 transect survey and 2009 LiDAR data.

A preliminary examination of the 2009 and 2010 survey data reveals that the channel morphology has changed on many of the transects. Because of the long duration, high flow during the summer of 2010, many of the low bars were rearranged and in some places bank retreat occurred. Without a more detailed analysis, it is unknown if there has been an overall volumetric change in the transect data.

Out of all the anchor points surveyed this year, there were two anchor points, AP13b and AP25, that underwent significant changes to the surveys of the channel geomorphology transects. The changes included cross section realignments which resulted in repositioning of transect monuments and, thus, changes in stationing.

The split flow channel anchor point AP13b was not surveyed last year because access had not been granted. As a result, the AP13a cross sections were extended northward along the same line as the 2009 ground survey data using the LiDAR data. However, since anchor point AP13b was shifted upstream from the original designated location, access was granted to the new location this year. Therefore, the ground survey of the geomorphology transects for AP13b were surveyed this year and the intervening portions between AP13a and AP13b were supplemented with the LiDAR data. Because AP13b was surveyed at a different location, this year's submitted cross sections for AP13 include a significant jog in the cross section lines, such that last year's cross section data north of AP13a is now obsolete. The cross section data submitted this year for AP13 includes both the 2009 and 2010 survey data for AP13a as well as the 2010 survey data for AP13b and the intervening LiDAR data for the revised cross section lines. Transect monumentation was also set at the new AP13b site. In addition, the realignment due to the inclusion of AP13b has resulted in a revision of the stationing for the AP13 cross sections. **Figure 3.3** provides an aerial image comparing the 2009 alignment of the AP13 cross section with the revised 2010 AP13 cross section alignment.

Figure 3.3. View of cross section at anchor point AP13 showing the previous LiDAR alignment (red) and the revised LiDAR alignment (yellow). The transect survey data is shown in blue.

The main issue with the revised alignment as shown in Figure 3.3 is that the right bank monuments for AP13b were set in the field based on the surveyed transect alignments. The reason they were set in the field was because access to the site was granted while the crews were still in the area, so the survey work was conducted immediately upon obtaining access. At this time, we would recommend resetting the right bank monuments (currently located along W. Shoemaker Isle Rd.) during the Year 3 survey so that the LiDAR data is more perpendicular to the floodway, similar to the previous alignment (red lines) as shown in Figure 3.3

The other anchor point that underwent significant changes is AP25. The cross section for this anchor point consisted of the ground surveys of the transects for the main channel with the rest of the cross section consisting of LiDAR data. However, the high flows this year appear to have occupied a small split flow channel to the north, so a decision was made to extend the ground survey of the transects northward to that channel and a repositioning of the left bank monuments further to the north. Therefore, the current cross section for AP25 includes the new 2010 survey data for both the main channel and the split flow channel and revised stationing based on the repositioned left bank monuments. **Figure 3.4** shows the AP25 and the revised extent of the survey and LiDAR data coverage.

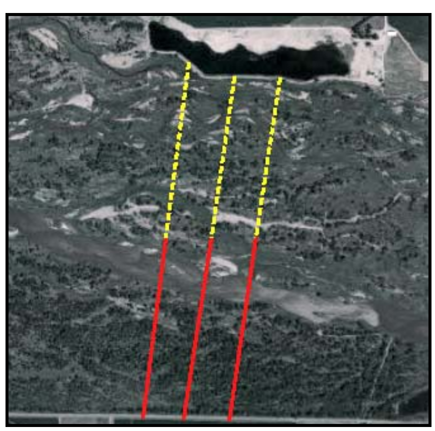

Figure 3.4. View of anchor point AP25 showing main channel survey data (red) and extended 2010 survey data (yellow).

The 2010 ground survey data are provided in Excel files on the attached DVD. The final full cross sections (2010 survey plus LiDAR data) for all anchor points are also included for review.

3.4 Ground Survey of In-Channel Vegetation Transects

The vegetation survey for 2010 was conducted between the dates of July 18 and August 25 starting at the upstream end of the reach, at Anchor Point 39, and progressing downstream to Anchor Point 1. The ground survey of the in-channel vegetation transects were conducted per Section III.C of the monitoring protocol. 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 were visited to document vegetation within the Vegetation Survey Zone. Within the belt transect, seven linear vegetation transects were established roughly perpendicular to the flow at approximately 50-meter (165-foot) intervals. Three of the linear vegetation transects were at the same locations as the geomorphology transects. Vegetation sample points were taken along the linear transects within the Vegetation Survey Zone at the same time as the geomorphology survey.

3.4.1 Methodology

The start and end locations of the Vegetation Survey Zone(s) along each transect were determined in the field by analyzing the vegetation and topography at the site. In general, areas with mature woody vegetation, areas that appeared to have been mechanically cleared of mature woody vegetation, or areas that appeared to be outside the active channel were determined to be outside the Vegetation Survey Zone (VSZ) and therefore were not surveyed. In addition, at several of the anchor point locations surveyed in 2010, there were small side channels or sloughs that were not surveyed. Some of these side channels had minimal or no flow during the survey period, and were considered outside the main channel and major secondary channels.

In general, the vegetation sample points were established at intervals spaced approximately 10 meters (33 feet) apart within the VSZ along each transect. Note that this was a modification of the first year’s protocol, which had data points at 15 meter intervals with some additional data points or shifted points taken in areas where vegetation zones were not otherwise sampled. In Year 2, there were no shifts or additional data points. The first sample on a transect was taken at the start of the Vegetation Survey Zone and additional samples were taken at 10-meter intervals until the end of the VSZ was reached. Occasionally there was more than one start and stop on a transect, as some areas on a transect did not meet the VSZ criteria, but at secondary starts, the sample was taken at the 10-meter interval and not at the start of the zone.

A plot canopy coverage method was used to collect vegetation data. At each sample point, a meter-squared quadrat was placed and all the plant species within the square meter sample point were identified. For species that could not be identified in the field, a sample was collected for later identification. Data collected at each sample point included:

- GPS coordinates of the sample point.
- Elevation of the sample point.
- List of the species occurring within the quadrat.
- Percent canopy cover of each species, in 2010, Daubenmire cover classes were used in field, a change from 2009 when actual percent cover was recorded. This change was instituted to speed data collection and reduce inconsistencies between different

observers. Note that this did not alter the analysis, as the 2009 data were converted into Daubenmire cover classes before the data was analyzed. Daubenmire classes are:

- Cover class 1: 1-5%
- Cover class 2: 6-25%
- Cover class 3: 26-50%
- Cover class 4: 51-75%
- Cover class 5: 76-95%
- Cover class 6: 96-100%

- Estimate of the average height of the woody vegetation. In 2010, height classes were used, a change from 2009 when average height of a plot was recorded. Woody height classes included the following:
  - <59 inches (1.5 meters): 1
  - >59 inches (1.5 meters): 2
- Estimate of the average height of the herbaceous vegetation. In 2010, height classes were used, also a change from 2009. Herbaceous height classes included the following:
  - <12 inches: 1
  - 12-59 inches: 2
  - >59 inches: 3

In addition to the individual species data, a general categorization of the type of vegetative community at each sample point was included in the 2010 data collection, a change from the 2009 data collection. The community types were based on the previous year's observations, and were coded as follows:

- Sandbar/ Mudflat – M
- Perennial sandbar – S
- Freshwater marsh – F
- Sandbar Willow Shrubland – W
- Riparian Dogwood - False Indigo Shrubland – RD
- Wetted Channel – WC

The vegetation data listed above along with (in most instances) transect notes and photo numbers was recorded in the field on a modified Daubenmire form. Data from each transect was recorded separately. Each sample point was assigned an ID in the field which was recorded with the survey equipment and included the anchor point, transect, and sample location number.

The data at each anchor point was collected using two survey teams with each team consisting of one surveyor and one biologist. In general, one team collected the data on transects 1, 4, and 7 (geomorphology + vegetation transects) and another team collected the data on transects 2, 3, 5, and 6 (vegetation only transects). It is important to note that for areas within the Vegetation Survey Zone that lacked vegetation (i.e., an unvegetated bar or wetted channel) the location was still recorded as a vegetation sample location. In many cases, these areas were noted on the modified Daubenmire form, but in some cases the vegetation data was simply left blank.

In addition to the vegetation sample points, a data point documenting GPS coordinate and elevation was taken at:

- Each edge of the Vegetation Survey Zone (if it was not located at a vegetation sample point)
- "Green line" at the edge of vegetated sand bars and wetted channel

Note that the "green line" with regard to this protocol is not the same as that used for many riparian studies, where it represents the location of established perennial vegetation. For this study, the "green line" represents the point at which vegetative cover is at least 25%, regardless of whether the vegetation is annual or perennial. The determination of green line elevation was modified from Year 1 sampling, due to observed different types of green lines during the first year. In Year 2, the green line was identified as either a simple green line at a channel edge, an elevated green line at a cut vertical bank, or an elevated green line on a high sand bar. A code was added in the data collection to indicate either a vertical bank (VB) or high bar (HB).

3.4.2 Results

Almost 5,400 vegetation sample points were collected in 2010. The vegetation data collected in the field and recorded on the field data sheet included, among other things, a list of species present, the percent cover of each species, and the total number of sample locations per transect. Section III.C.2 of the protocol specified the basic analyses to be conducted on the data, including:

- Frequency of occurrence for each species of interest (defined on the following page) at each belt transect. This was calculated by dividing the number of sample locations in which a species of interest was found by the total number of sample locations.
- Percent cover for each species of interest at each belt transect. This was calculated by averaging the percent cover for each species of interest at all sample points per belt transect.
- Average elevation for each species of interest at each belt transect.
- Weighted average elevation above base flow for each species of interest at each belt transect.
- Estimate of areal coverage for each species of interest at each belt transect. This was calculated by multiplying the canopy cover percentage by the estimated size in acres of the VSZ at each belt transect.
- Vegetation sample location shapefile with an attribute table that includes presence or absence for each species of interest.

Data analysis focused on the extent and elevation of species of interest, which are the species that currently thought to have the most influence on in-channel habitat in the central Platte River. Although the species of interest may change over time, the data collection method was designed to allow for comparison of any species in the future. For 2010 the species of interest included the following:

- The following woody species less than 1.5 meters high:
  - Willows
  - Cottonwood
  - False indigo
  - Saltcedar (all heights)
  - Russian olive

- The following herbaceous species:
  - Purple loosestrife
  - Common reed (*Phragmites*)
  - Cattails
  - River bulrush

Frequency of Occurrence and Canopy Cover Analysis

Following the field data collection, the first step to be completed in the data analysis was to review the field data sheets and vegetation samples collected and identify any unknown species. At the time of this report, two plant samples were not identified, but they were not species of interest. We plan to continue to attempt to identify the remaining unknown species for future reference.

The next step was to compile and enter all field data into a modified Daubenmire summary spreadsheet for each belt transect. The total number of vegetation sample locations for each belt transect was also compiled and entered into the spreadsheets. For anchor points that had multiple channels, each of these channels were kept separate.

The modified Daubenmire summary spreadsheets were used to calculate frequency of occurrence (percent of quadrats in which species was identified), percent cover, and an acreage estimate for each species of interest at each belt transect. The spreadsheets were also used to calculate species composition. Although not part of the monitoring protocol, species composition is useful as it compares the total canopy cover for each species of interest with the total canopy for all species. **Figure 3.5** shows the 2010 Daubenmire summary spreadsheet for anchor point AP-1.

Figures 3.6 and **3.7** graph the overall frequency of occurrence and percent canopy coverage for each species of interest for all the data collected in 2010. These figures clearly indicate changes in the occurrence and cover for some of the species of interest between the 2009 and 2010 monitoring years. Eight of the ten species of interest were reduced in both frequency of occurrence and canopy cover, but for many the reduction was relatively small. However, the most common species of interest, common reed and purple loosestrife, were both greatly reduced with regard to both of these parameters, as was Eastern cottonwood. These reductions are detailed as follows:

- Common reed was found in 6.6% of samples in 2010 compared to 14.5% in 2009, a reduction of 55% in frequency of occurrence. Canopy cover was 2.1% in 2010 compared to 6.4% in 2009, a reduction of 67% in canopy cover.
- Purple loosestrife was found in 8.0% of samples in 2010 compared to 16.0% in 2009, a reduction of 50% in frequency of occurrence. Canopy cover was 1.6% in 2010 compared to 4.0% in 2009, a reduction of 60% in canopy cover.
- Eastern cottonwood was found in 1.4% of samples in 2010 compared to 3.6% in 2009, a reduction of 61% in frequency of occurrence. Canopy cover was 0.04% in 2010 compared to 0.2% in 2009, a reduction of 80% in canopy cover.

Modified Daubenmire Summary																							
Project Name: Platte River Recovery Implementation Program In-Channel Vegetation Monitoring									Date:	8/25/2010	Anchor Point:	1											
# of Quadrats:		247	Estimated Acreage:	32.0	Examiners	Dani McNeil and Nate Van Meter					Company: Olsson Associates - Lincoln, NE												
		Species																					
Cover Class	Mid Point	Cattail species		Common reed		Purple loosestrife		River bulrush		Eastern cottonwood <1.5m tall		False indigo - <1.5m tall		Peach leaf willow - <1.5m tall		Russian olive - <1.5m tall		Sandbar willow - <1.5m tall		Saltcedar - all heights		Reed Canary Grass	
1. 1-5%	2.5	1	2.5	3	7.5	7	17.5	10	25	3	7.5	1	2.5	0	0	0	0	1	2.5	0	0	1	2.5
2. 6-25%	15	0	0	8	120	7	105	2	30	0	0	8	120	1	15	0	0	2	30	0	0	2	30
3. 26-50%	37.5	1	37.5	1	37.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	112.5
4. 51-75%	62.5	0	0	7	437.5	0	0	1	62.5	0	0	0	0	0	0	0	0	0	0	0	0	1	62.5
5. 76-95%	85	0	0	0	0	0	0	1	85	0	0	0	0	0	0	0	0	0	0	0	0	7	595
6. 96-100%	97.5	0	0	3	292.5	0	0	2	195	0	0	0	0	0	0	0	0	0	0	0	0	7	682.5
Total Canopy			40.0		895.0		122.5		397.5		7.5		122.5		15.0		0.0		32.5		0.0		1485.0
Number of Samples			247		247		247		247		247		247		247		247		247		247		247
% Canopy Cover			0.162%		3.623%		0.496%		1.609%		0.030%		0.496%		0.061%		0.000%		0.132%		0.000%		6.012%
Species Composition			0.343%		7.664%		1.049%		3.404%		0.064%		1.049%		0.128%		0.000%		0.278%		0.000%		12.717%
Frequency			0.810%		8.907%		5.668%		6.478%		1.215%		3.644%		0.405%		0.000%		1.215%		0.000%		8.502%
Estimated Acreage			0.052		1.160		0.159		0.515		0.010		0.159		0.019		0.000		0.042		0.000		1.924
Total Canopy 11677.5																							

Figure 3.5. Modified Daubenmire sheet for anchor point AP-1.

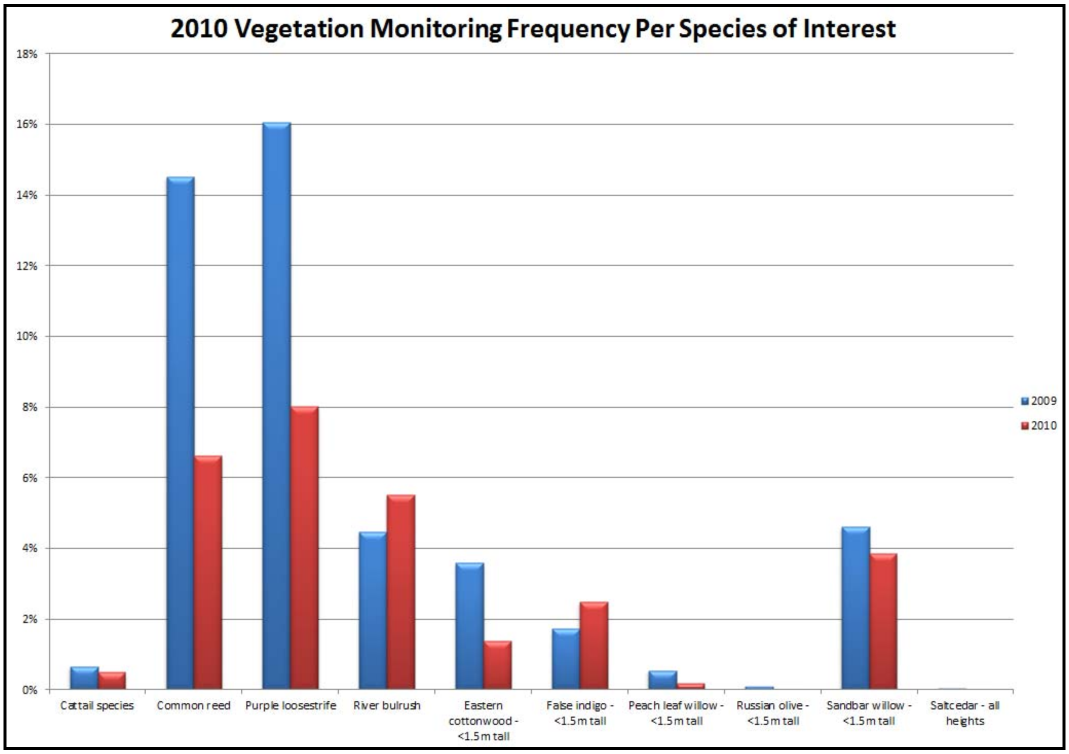

Figure 3.6. Frequency of occurrence for each Species of Interest across all 2010 sample locations, compared to 2009 frequencies.

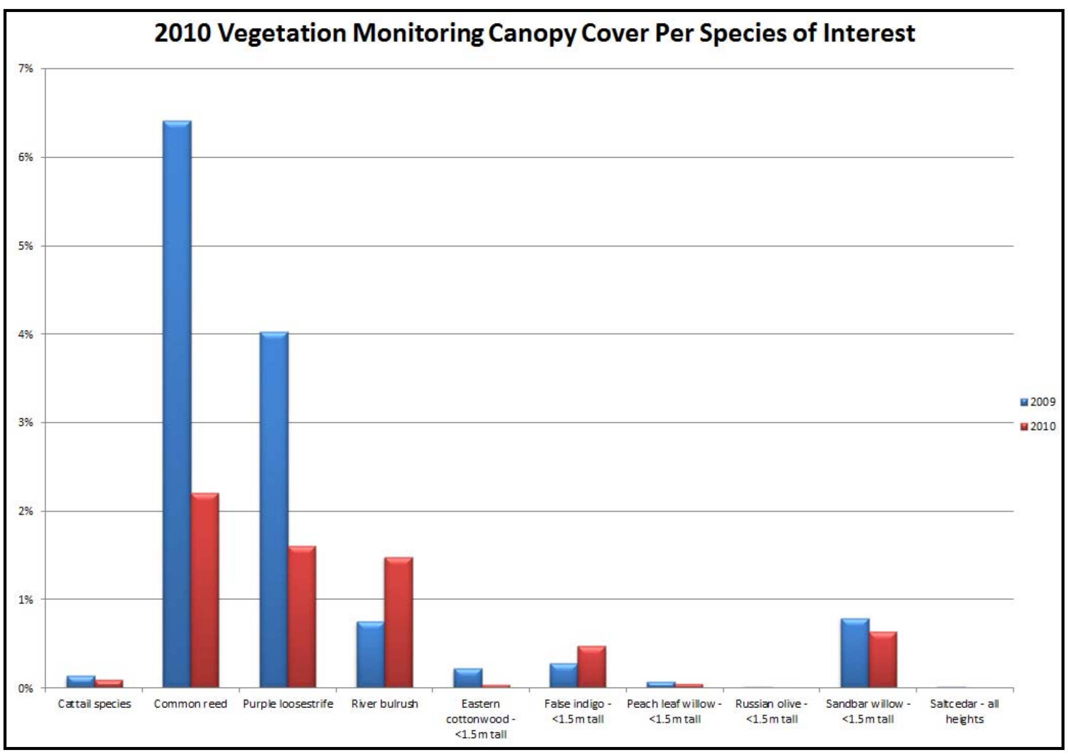

Figure 3.7. Percent canopy cover of each Species of Interest across all 2010 sample locations, compared to 2009 percent canopy cover.

Only river bulrush and false indigo increased in frequency or percent cover from 2009 to 2010. The increases are detailed as follows:

- River bulrush was found in 5.5% of samples in 2010 compared to 4.5% in 2009, an increase of 18% in frequency of occurrence. Canopy cover was 1.5% in 2010 compared to 0.8% in 2009, an increase of 88% in canopy cover.
- False indigo was found in 2.5% of samples in 2010 compared to 1.7% in 2009, an increase of 47% in frequency of occurrence. Canopy cover was 0.5% in 2010 compared to 0.3% in 2009, an increase of 67% in canopy cover.

Please note that despite the large number of samples, many of these percentages are relatively low, and thus the estimates of reductions or increases in occurrence or cover are just that – rough estimates of possible trends.

However, the reductions in common reed and purple loosestrife at least are large enough to show real changes. Extensive spraying of common reed was done in 2009 and 2010, and the high river flows of 2010 appear to have scoured many of the dead plants. The high flows also appear to have scoured or inundated the loosestrife and the cottonwood, resulting in far less coverage. Most of the cottonwoods in the VSZ are first-year seedlings or second-year saplings, and these appear to have been effectively removed by the high flows.

The increase in river bulrush occurrence and cover appears to be related to the creation of suitable habitat by the removal of common reed. River bulrush is a fast-growing species which is tolerant of a wide range of hydrologic regimes and soil types, and thus can rapidly colonize open areas in the river. It will be important to monitor the extent of this species, and if the trend continues it may be necessary to control this species in the future.

It is not clear why false indigo increased in frequency and cover. This species usually grows at higher locations at the margins of the VSZ. Even though this species is only of interest if it is less than 1.5 meters tall, these plants tend to be mature shrubs rather than seedlings or saplings. It is possible, since the increased river flows of 2010 widened the channel at some anchor points, that some false indigo, which was outside of the VSZ in 2009, was inside the VSZ in 2010, but this is just speculation.

The percent canopy cover for each species of interest also was used to estimate the acreage of cover for each species by multiplying the percent canopy cover by the total acreage of VSZs at all monitored anchor point belt transects. **Figure 3.8** shows the estimated acreage of each species of interest for 2009 and 2010 at the pure panel anchor points. Total acreage of VSZs monitored in 2010 was approximately 583 acres.

Other species that were not considered species of interest in 2009 or 2010 were not analyzed. There was some concern that reed canarygrass (*Phalaris arundinacea*) may be moving into the areas that have been opened by the removal of common reed. Many of the sand bars appeared to have a good growth of grass-like vegetation, but these were mainly species such as *Cyperus* spp. (nutsedge) and *Leersia oryzoides* (rice cutgrass). These species are not invasives and thus are unlikely to be considered species of interest. Observations indicate that reed canarygrass is found mostly at the beginning or end of transects. However, at these locations it is often present at a high cover class and like common reed it can spread rapidly by vegetative means. Although it is unlikely to spread to sand bars in high river flow years, it could take advantage of future low river flows to extend into the channel. Thus it may be advisable to add this to the list of species of interest.

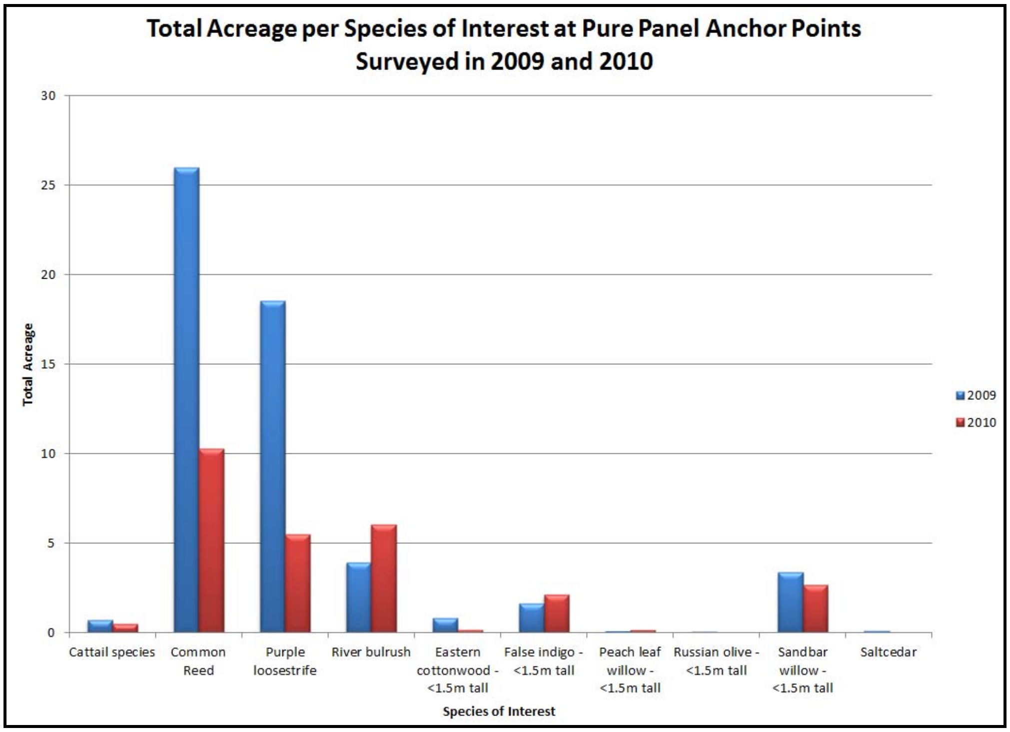

Figure 3.8. Estimated acreage of each Species of Interest in 2009 and 2010 at the pure panel anchor points that were survey both years. Note that in 2010 not all of the secondary channels at each pure panel anchor point were surveyed. This chart only summarizes acreages at locations sampled in both 2009 and 2010 for comparison purposes.

In contrast, two of the species of interest (Russian olive and saltcedar) were not identified in any of the samples taken in 2010, and were present in very low numbers in 2010.

Species of Interest Elevation Analysis

The presence or absence of each species of interest at each sample point location was entered into a second spreadsheet. This spreadsheet was created from the survey data recorded in the field and listed all vegetation sample locations surveyed and included GPS coordinates and elevation data. Columns for each species of interest were added to this spreadsheet and an "Yes" was entered for each location where a species of interest was found. This spreadsheet was then used to create a vegetation sample location point shapefile with all spreadsheet data in the attribute table. This spreadsheet and shapefile includes points that are coded as VEGSTRT and VEGEND. These points mark the start and stop locations of the VSZ. Other than the VEGSTRT location at the beginning of each transect (ID 00), these locations typically do not have vegetation data as they usually are not located at the 10-meter sampling intervals. This spreadsheet was also used to calculate the average elevation for each species of interest at each anchor point.

The average elevation per pure panel anchor point for each species of interest increased in 2010 compared to 2009. For the two most common species of interest, common reed and purple loosestrife, this increase averaged approximately 0.4 feet across all pure panel anchor points. This number is likely due to the combination of herbicide spraying and high flows that removed much of this vegetation. **Figures 3.9** and **3.10** depict the average change in elevation for common reed and purple loosestrife across all pure panel anchor points that had these species present.

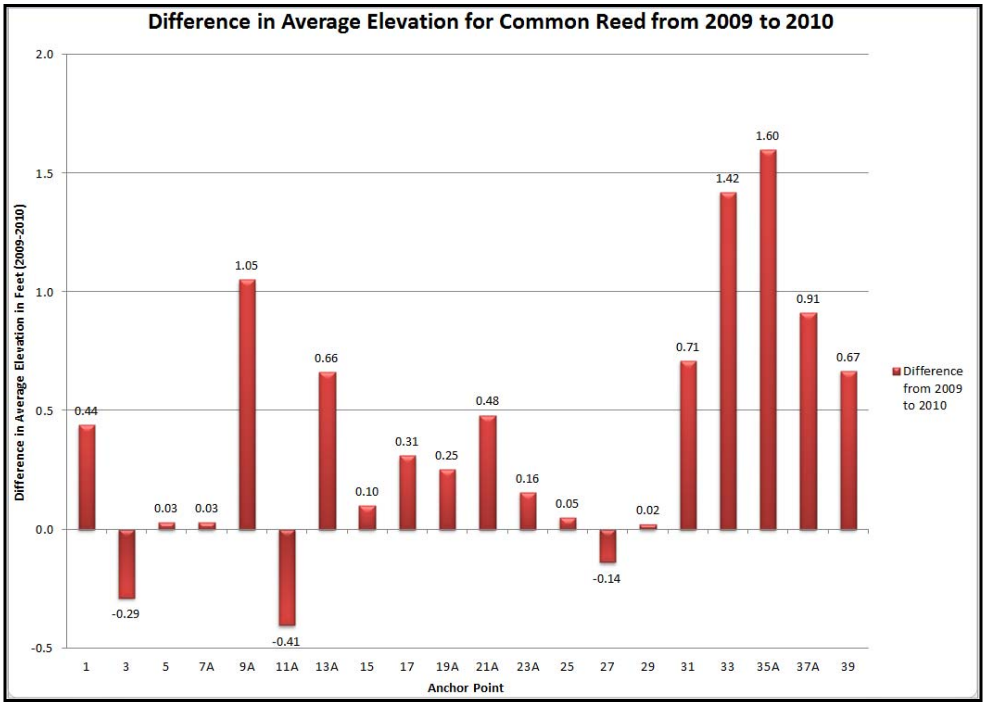

Figure 3.9. Average change in elevation of the vegetation sample points with common reed present in 2009 versus 2010 at the pure panel anchor points.

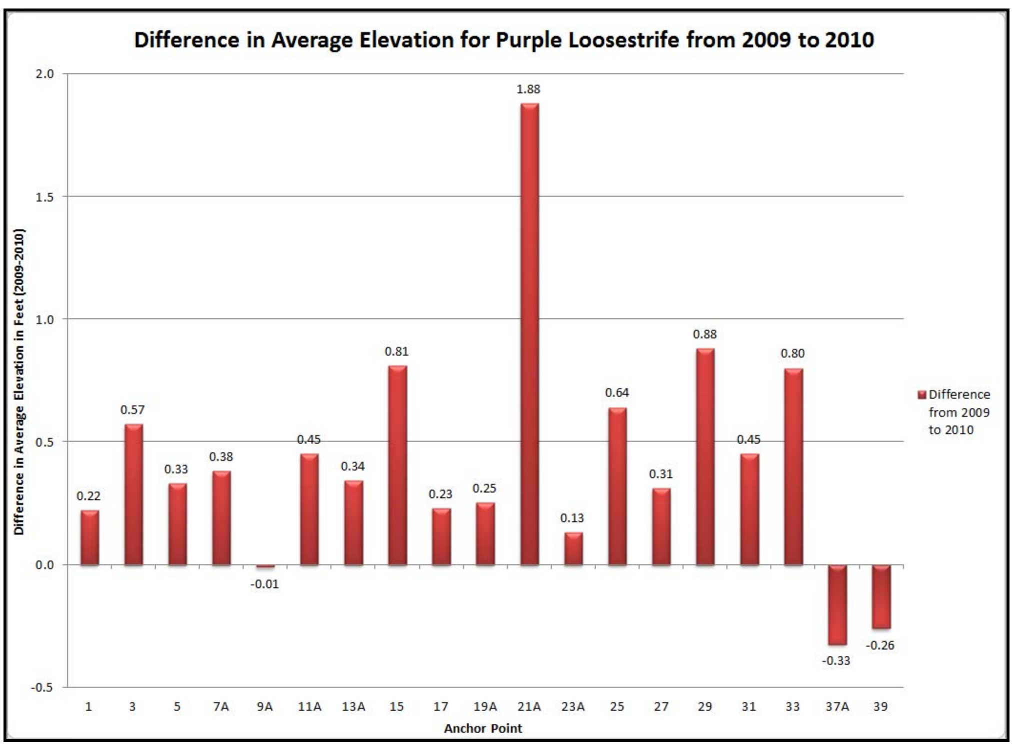

Figure 3.10. Average change in elevation of the vegetation sample points with purple loosestrife present in 2009 versus 2010 at the pure panel anchor points.

Another species that showed a noteworthy change in elevation between 2009 and 2010 was Eastern cottonwood. Eastern cottonwood increased an average of 0.9 feet in elevation across all pure panel anchor points between 2009 and 2010. Many of the cottonwood occurrences in 2009 were first year seedlings that were present on recently exposed sandbars. In 2010 this habitat type was greatly reduced due to higher water elevations during the growing season and therefore there were fewer sample locations with cottonwood seedlings.

One of the analyses that is defined in the monitoring protocol has not been completed at this point, which is weighted elevation above base flow. The weighted elevation above base flow calculation will be performed after a method to define base flow at each anchor point or transect has been established. The Program is developing a protocol for calculating the base flow elevation at each anchor point. Once base flow data is available the analysis can be completed.

Green Line Elevation Analysis

Another analysis that was conducted was a comparison of the average elevation of the green line in 2009 versus 2010. The green line elevation comparison was conducted on a per-transect basis for the pure panel anchor points. In 2010, three types of green lines were recorded: green line, high bar green line, and vertical bank green line, thus two calculations were made. Many of the vertical bank green lines were not collected in a comparable manner in 2009 and therefore we feel the most accurate way to comparing the 2009 versus the 2010 green line data is to keep the 2010 vertical bank green line elevations out of the equation. The green line elevation increased by approximately 1.1 feet per transect in 2010 compared to 2009 if the vertical bank green lines from 2010 are not included and by approximately 1.3 feet if they are included. **Figures 3.11**, **3.12**, and **3.13** depict the change in average green line elevation per transect at three sample anchor points AP-3, AP-29, and AP-33a, respectively. Note that AP-3 shows a lot less variability in elevation change (ranging from 0.8 to 1.2 feet of increase) compared to AP-29 (0.3 to 2.3 feet) or AP-33a (0.5 to 4 feet). This is consistent with greater changes in channel topography at AP-29 and AP-33a.

Throughout the analysis process, staff who had not been involved in data collection performed a QA/QC review of the data. The review process compared the spreadsheet of the vegetation survey location with the data on the field data sheets, among other items. Olsson and Ayres staff coordinated closely while compiling the survey data and the vegetation data and information.

3.4.3 Recommendations for Protocol Revisions

Possible changes to the 2011 list of species of interest:

- Add reed canarygrass
- Remove Russian olive and saltcedar

It is worth discussing with PRRIP staff whether reed canarygrass (*Phalaris arundinacea*) should be added to the list of species of interest for 2011. For all identified plants, including reed canarygrass, the same data is being collected but currently no analyses of frequency of occurrence or canopy cover are being done for non-species of interest. Thus, it is not as easy to identify trends for this species.

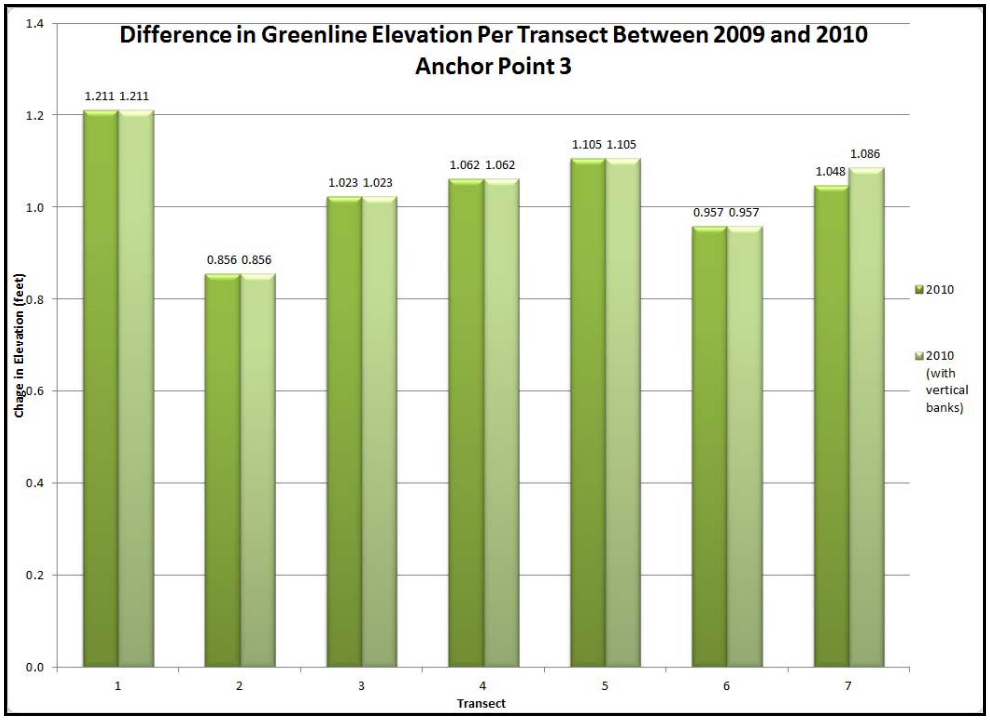

Figure 3.11. Change in 2010 compared to 2009 green line elevations at AP-3. Darker bars exclude vertical bank green lines and lighter bars include them.

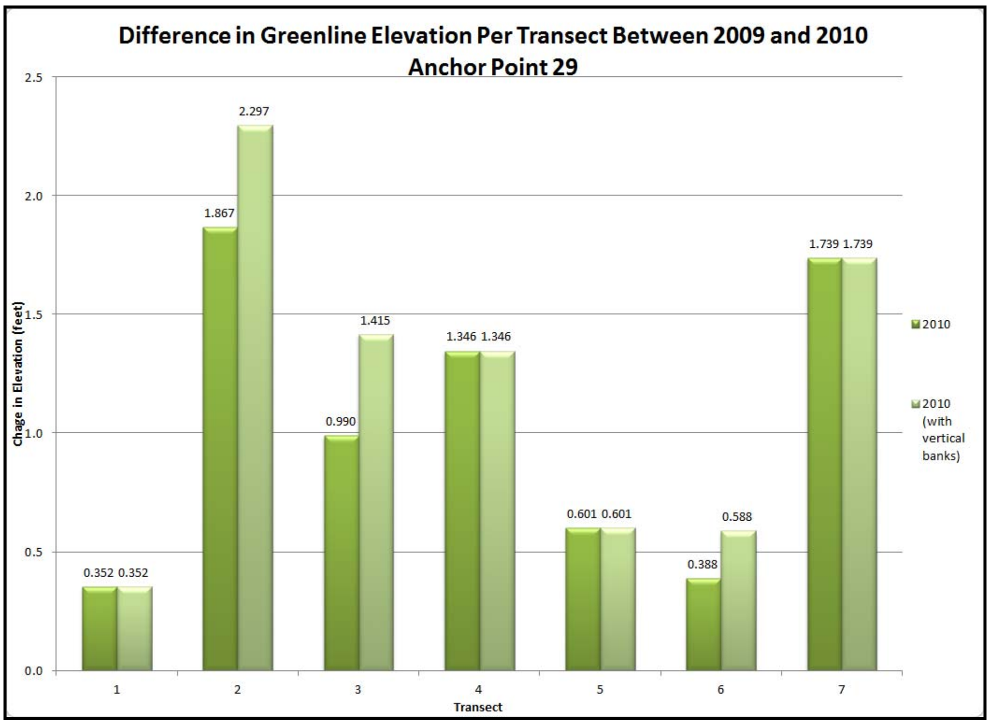

Figure 3.12. Change in 2010 compared to 2009 green line elevations at AP-29. Darker bars exclude vertical bank green lines and lighter bars include them.

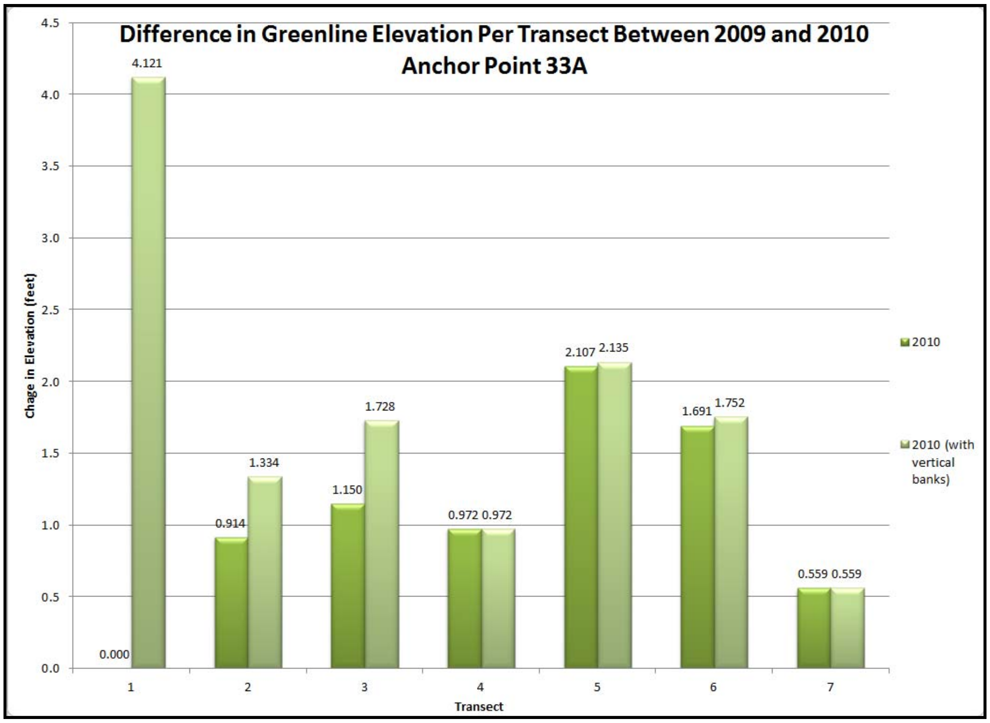

Figure 3.13. Change in 2010 compared to 2009 green line elevations at AP-33a. Darker bars exclude vertical bank green lines and lighter bars include them.

Similarly, it is worth discussing with PRRIP staff whether it makes sense to continue to analyze data for Russian olive or saltcedar. No sample included these in 2010, and they were very rare in 2009. Unless these species start appearing in much larger numbers, the analyses that currently are being done are not useful to the program. If they do start appearing in larger numbers, researchers will be able to go back to earlier data and conduct analyses at that time.

4. BED AND BAR MATERIAL SAMPLING

Bed and bar material samples were collected and analyzed per the methodology defined in Section III.D of the monitoring protocol. Per the protocol, the bed and bar material samples will be taken at locations along the geomorphology transects at each anchor point. Bed material samples will be used 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.

4.1 Bed and Bar Material Sampling

Bed and bar material are be documented using grain size distributions of samples collected during each successive annual topographic survey per Section III.D of the monitoring protocol. As many as 13 bed material samples and one bar material sample will be collected annually at each of the 25 surveyed anchor points. The bed and bar material samples will be collected as follows:

- Main and Secondary Channel Bed Samples - Three main channel samples were collected from each of the three geomorphology transects at each anchor point. Each transect was divided into three equally-spaced increments with one sample from the thalweg in the increment that contains the thalweg and a representative dry or wet bed sample from the other two increments. If additional smaller channels separate from the main channel were present on the Year 2 Rotating Panel anchor points, one sample was collected from the thalweg of the middle transect on the second largest channel at the anchor point. The locations of each of the samples were georeferenced using GPS.
- Sand Bars in Main Channel - Samples were collected from natural high flow sand bars. Natural bar sites were selected for sampling from anywhere in the main channel at the anchor point. One set of three samples representing materials found on the sampled sand bars was collected. The three individual samples were collected in close proximity to each other at the head of the bar and were representative of the materials that comprise the bar. The three samples were combined to form a composite sample. The central location of the composite sample was georeferenced. Any surface armor layer or coarse surface lag was noted and removed prior to sampling.

4.1.1 Methodology

Based on the protocol, bed sediment samples were to be collected using a steel cylinder core sampler. However, because of the coarseness of the material, it became evident during the 2009 sampling effort that using the steel cylinder core sampler defined in the protocol was both difficult and impractical. It was extremely difficult to push or drive the core sampler into the bed and bar material and often the amount of material retrieved was small, thus requiring the need to conduct multiple samplings at the sample site. Instead, a 6-inch diameter and 12-inch long piece of PVC pipe, beveled at one end and covered with a 200 micron mesh at the other end, would be more practical for collecting bed material samples and would likely provide the same results. The pipe dredge is shown in **Figure 4.1**. The pipe dredge was pushed 6 to 8 inches deep at an angle into the bed of the channel with the opening facing upstream. The mesh at the end of the pipe allowed the water in the pipe to pass through the pipe with minimal loss of the sample material. All bed samples collected from the main channel and any secondary channels were transferred to individual sample bags that were labeled with the sampled anchor point, transect ID, sample number, and the date the sample was taken per the protocol. All sample locations were georeferenced using the Trimble GeoXT handheld GPS unit.

Figure 4.1. Pipe dredge used to collect bed material samples.

Bar material samples were generally collected at the head of a high bar in the area where the coarsest material was deposited. Samples were taken at 3 different spots on the bar, generally in relatively close proximity to each other such that the zone that was being sampled was generally the same. The samples were collected with a shovel after noting and removing any armor or coarse lag. An approximately equal volume of bar materials was collected at each of the three sites. The composite bar material samples were transferred to sample bags that were labeled with the sampled anchor point, transect ID, sample number, and the date the sample was taken. A single georeferenced point was taken at a location that was central to all the samples using the Trimble GeoXT handheld GPS unit.

4.1.2 Results

A total of 243 bed and 27 bar material samples were collected at all Year 2 anchor points. Bed material samples were also collected at the 5 sampling bridges. All samples were transferred to the Olsson geotechnical lab and analyzed for grain size distributions using the same procedures, sieve sizes, and results reporting as described in the protocol. The 2010 grain size data and other information for the samples are provided in an Excel file on the attached DVD.

Figure 4.2 shows the D_{16}, D_{50}, and D_{84} distributions by river mile for the 2010 bar samples collected at each anchor point. Although the bar sample gradations are fairly variable, the figure shows minimal overall fining in the downstream direction.

The 2010 bed material sample data has been compiled as both individual data and as composited data for each anchor point. **Figure 4.3** shows the D_{16}, D_{50}, and D_{84} distributions by river mile for the composited bed material samples collected at each anchor point. A comparison with the bar material gradations shown in Figure 4.2 would suggest that there is little difference between the bed material and bar material. A comparison of the 2010 bed sample data with the 2009 bed sample data for all the pure panel anchor points shows little change, except for a slight fining in the upper third of the project reach. In addition, **Figure 4.4**, which is a comparison of the 2010 bed material sample data to the 1989 USBR bed material sample data, shows a general overall coarsening of the Central Platte River since 1989.

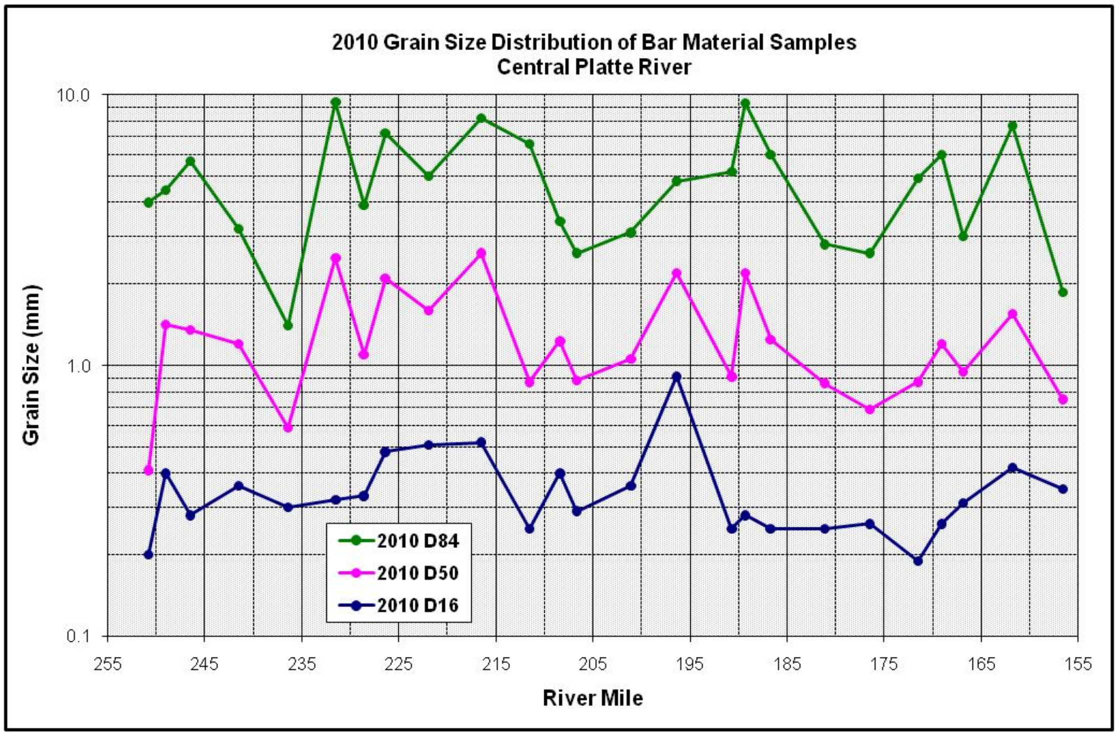

Figure 4.2. Grain size distribution of 2010 composite bar samples by river mile.

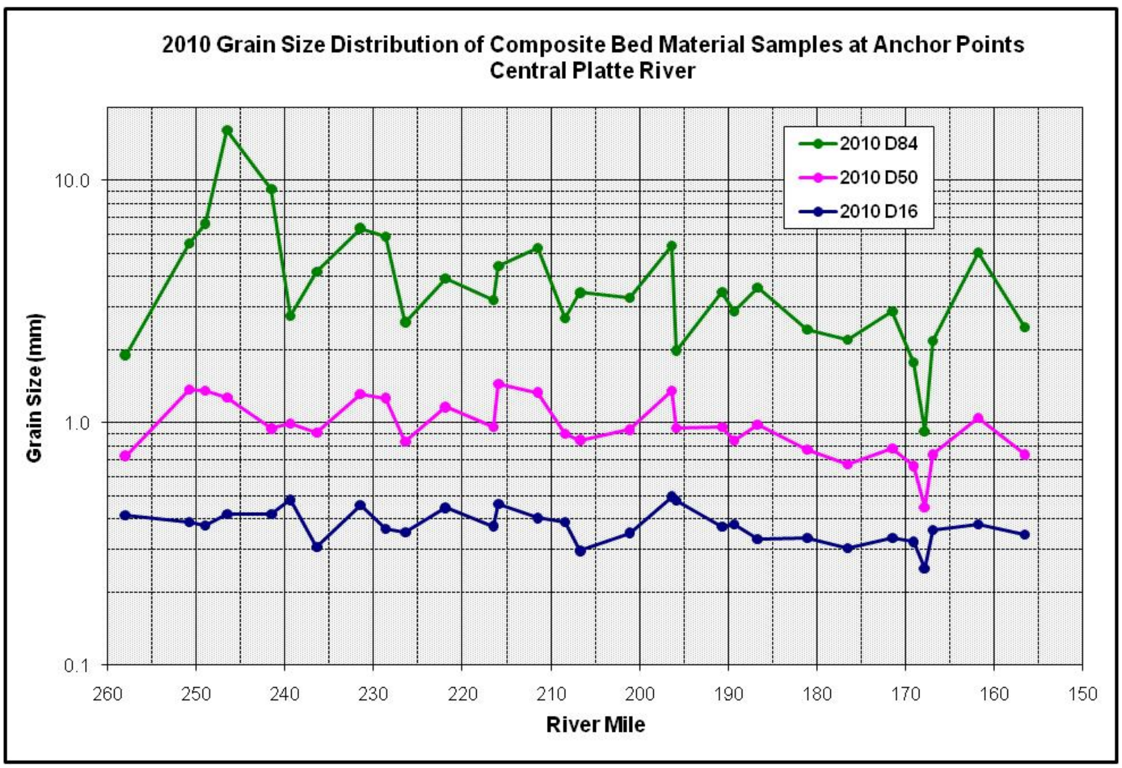

Figure 4.3. Grain size distribution of 2010 bed material samples by river mile.

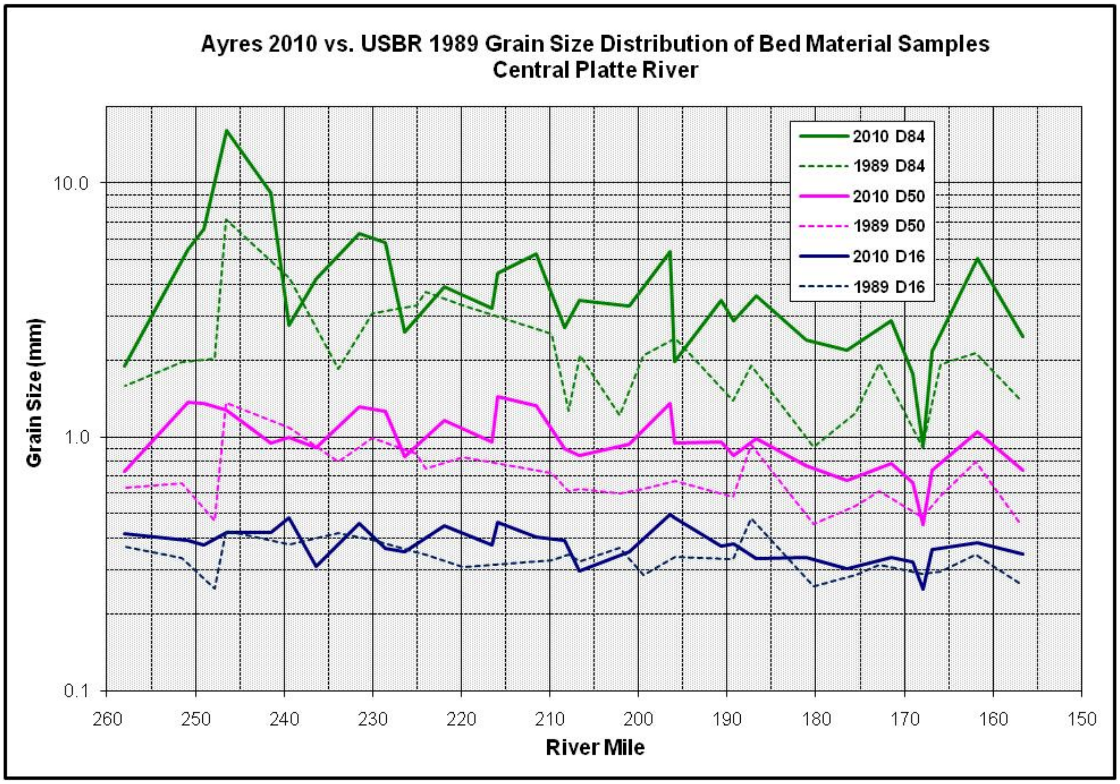

Figure 4.4. Comparison of the grain size distributions of the 2010 bed samples with the 1989 USBR bed samples by river mile.

A comparison of the 2009 and 2010 composited bed material sample gradations for the project reach suggests that the bed material collected in 2010 is slightly finer than the 2009 bed material, especially in the upper part of the reach. A comparison of the bar material sample data from 2009 and 2010 shows no definitive overall change in gradation along the project reach.

In addition, **Figure 4.5** provides a comparison of the grain size distributions for bed material in the J-2 Return (South) channel at river mile 246.5 (AP37b) and river mile 241.5 (AP35b). This figure suggests that the bed material in the J-2 Return channel, at least at river mile 246.5, has coarsened significantly since 1989, but like the main channel of the river, has fined slightly between 2009 and 2010.

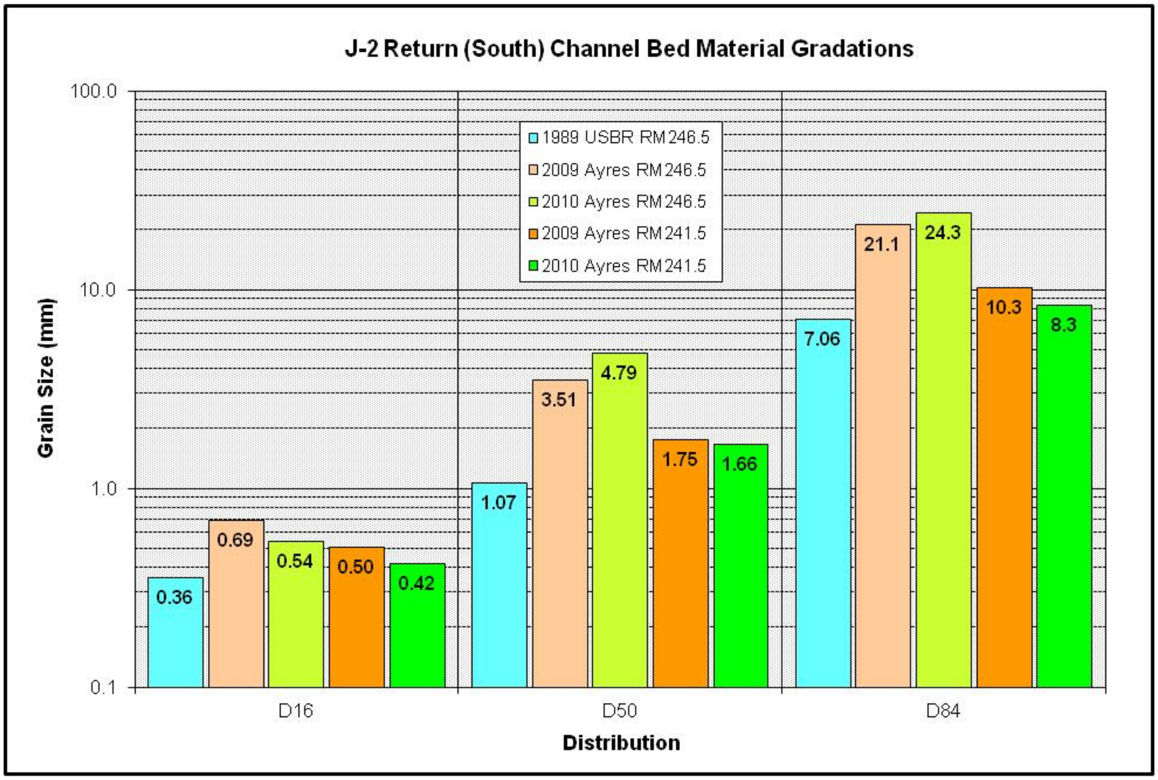

Figure 4.5. Comparison of grain size distribution for the USBR 1989 USBR, Ayres 2009, and Ayres 2010 composite bed material samples at river miles 246.5 and 241.5 on the J-2 Return (South) channel.

5. SEDIMENT TRANSPORT MEASUREMENTS

The total sediment load in a channel is the sum of the bedload and suspended load. Bedload is the material that moves (rolls, slides, or bounces) along the bed. Suspended load is that material in full suspension throughout its motion and can consist of materials that are found in the bed along with the finer materials (silts and clays) that are derived primarily from the watershed. The finer materials are often referred to as the wash load as they are easily transported by the river, even at low flows, and tend to "wash" through the system. Wash load is commonly defined as sediment finer than 0.0625 mm (division between sand and silt). Although measurement of suspended sediment is relatively easy, bedload measurements on an easily deformable bed like the Platte River make sampling difficult and can produce inaccurate results.

5.1 Bedload Sampling, Depth-Integrated Suspended Sediment Sampling, and Total Load Computations

Bedload and suspended sediment load is to be monitored throughout the 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). Bedload and suspended sediment is to be measured using procedures from Edwards and Glysson (1999) and Thomas and Lewis (1993) and analyzed by a certified geotechnical lab.

The protocol, which was revised last year, calls for 3 bedload samplings in the 1,000-3,000 cfs increment, 2 in the 3,000-5,000 cfs increment, and a single bedload sampling during a flow greater than 5,000 cfs. Suspended sediment sampling is only to be completed in conjunction with the bedload sampling for the flow event greater than 5,000 cfs. The protocol calls for using the standard U.S. Geological Survey (USGS) methodology for conducting both bedload and depth-integrated suspended sediment sampling based on equal width intervals at five gaged bridge sites for specific flow increments.

Although revisions to the protocol last year required that suspended sediment sampling is only to be completed for flows higher than 5,000 cfs, a single suspended sediment sample was also collected at the lower flow increment as a check with the previous year's data. It was noted that, at these low flow conditions, much of the suspended load was fine material (wash load) and, thus, it was concluded that a significant amount of bed material load during these events must be occurring in the near bed region as bedload. Therefore, it was determined that bedload sampling will be more valuable and useful at discharges below 5,000 cfs.

The protocol also calls for using a well-established calculation procedure, the Modified Einstein method, to provide another estimate total sediment load based on the suspended sediment measurements and the bed material size analysis. To complete this analysis, a bed sample is to be taken at the bridge locations once every year. This can be accomplished after the high flows during the transect surveys. The protocol calls for collecting this bed sample even if there is no suspended sediment sampling for the year.

At the low flow events (below 5,000 cfs) the total sediment load was assumed to be the bedload result. At the high flow events, the total sediment load was the sum of the bedload and suspended load, or alternatively, could be based on the Modified Einstein method. These results combined with volume of aggradation and degradation measured with topographic ground surveys provides the necessary information to monitor the sediment budget between Lexington and Chapman.

5.1.1 Methodology

Samples are to be collected using USGS standards for both a bedload and depth-integrated sampler at 20 equally spaced locations (verticals) in the river cross section along the bridge face. This will allow inclusion and comparison of historical bedload and suspended sediment measures from the USGS and others in the data set. Per the protocol, samples are to be collected at each site 6 times during the year. The sampling portion of the protocol calls for obtaining two bedload samples from the 1,000 to 3,000 cfs and 3,000 to 5,000 cfs flow increments each, and one bedload and one suspended sediment sampling (concurrently) of a flow greater than 5,000 cfs.

In general, flows exceeding 5,000 cfs are not very common; however this year was an exception. Mean daily flows during the spring and summer months often exceeded 2,000 cfs and the peak flow, which was well over 5,000 cfs throughout the project reach, was sustained for the last two and a half weeks of June.

Per the protocol, the bedload samples were collected at each bridge site during each of the flow increments at 20 equally spaced locations (verticals) along the bridge using a truck mounted, cable suspended, BL-84 Helley-Smith bedload sampler (**Figure 5.1**). A standard USGS B-56 sounding reel was used to suspend the Helley-Smith sampler. The sampler is lowered slowly onto the bed and kept in place for a predetermined amount of time. Because of rapid filling of the bag at some locations, the initial time used was reduced from 60 seconds to 30 seconds with two samplings being conducted at each vertical. Each bridge sampling consisted of 1 to 3 bags of sediment that were composited in the lab. Information for each sample site, including the date, begin and end time of the sampling, discharge, bridge name, and bag number, was recorded on each of the sample bags.

The 20 depth-integrated suspended sediment samples were collected at each bridge site during the >5,000 cfs flow increment using a truck mounted, cable suspended, US DH-76 sampler (**Figure 5.2**). The USGS B-56 sounding reel was again used to suspend the sampler. The samples were collected at a constant transit rate at each section. The DH-76 pint sampler bottles collected were combined into a larger container to make a single composite sample for that bridge site.

The composite bedload and suspended sediment samples were delivered to and analyzed by the Olsson geotechnical lab. The sediment samples were analyzed by dry sieving per the methodology defined in the protocol to determine their grain size distribution. The total load computation for larger events (greater than 5,000 cfs) was calculated using the modified Einstein method.

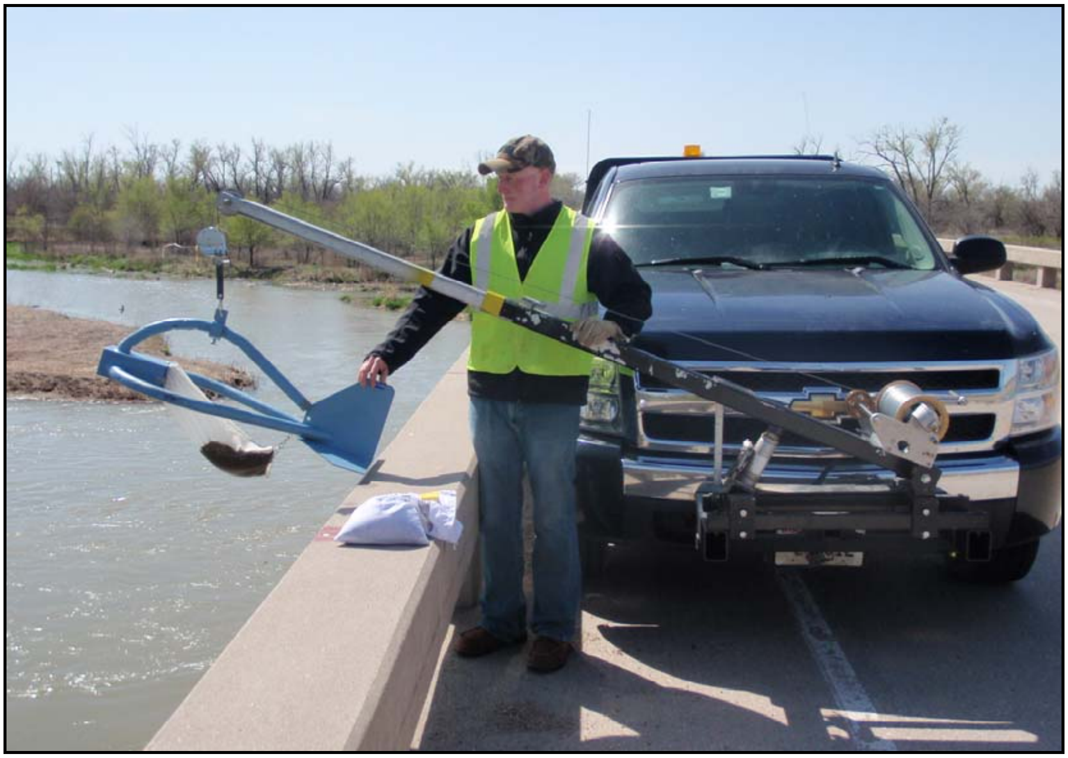

Figure 5.1. View of BL-84 Helley-Smith bedload sampler cable suspended with a B-56 sounding reel on a truck-mounted crane system.

Figure 5.2. View of US DH-76 suspended sediment sampler cable suspended with a B-56 sounding reel on a truck-mounted crane system.

5.1.2 Results

Bedload sediment sampling was completed on April 17-18, May 7-9, June 15-17, and June 30-July 1, 2010. The instantaneous flows in cubic feet per second (cfs) for each sample at each bridge (as obtained from gages at those bridges) along with the calculated concentrations are shown in **Table 5.1**. Depth-integrated suspended sediment sampling was completed on May 7-9, and June 15-17, 2010. The instantaneous flows in cubic feet per second (cfs) for each sample at each bridge (as obtained from gages at those bridges) along with the calculated concentration are shown in **Table 5.2**.

Table 5.1. Bedload Sampling Flows and Concentrations for Year 2 (2010).

Bridge		April 17-18	May 7-9	June 15-17	June 30-July 1
Darr	Flow (cfs)	1,206	---	5,350	1,504
	Concentration (ppm)	152	---	91	80
Overton	Flow (cfs)	2,180	3,040	6,850	3,395
	Concentration (ppm)	52	159	91	39
Kearney	Flow (cfs)	1,675	2,505	7,810	4,265
	Concentration (ppm)	105	98	66	149
Shelton	Flow (cfs)	1,536	2,588	7,013	4,078
	Concentration (ppm)	41	89	84	113
Grand Island	Flow (cfs)	1,595	2,750	6,780	4,960
	Concentration (ppm)	66	64	85	114

Table 5.2. Depth- Integrated Suspended Sediment Sampling Flows and Concentrations for Year 2 (2010).

Bridge		April 17-18	May 7-9	June 15-17	June 30-July 1
Darr	Flow (cfs)	---	1,209	5,301	---
	Concentration (ppm)	---	849	581	---
Overton	Flow (cfs)	---	2,935	6,855	---
	Concentration (ppm)	---	597	174	---
Kearney	Flow (cfs)	---	2,380	7,735	---
	Concentration (ppm)	---	440	326	---
Shelton	Flow (cfs)	---	2,645	7,708	---
	Concentration (ppm)	---	499	430	---
Grand Island	Flow (cfs)	---	2,735	6,780	---
	Concentration (ppm)	---	1141	313	---

A single bulk bed material sample was obtained at each bridge between August 16 and October 29, 2010. The bed material gradation at each bridge is shown in **Table 5.3**. The bed material samples were collected from the thalweg in the main channel downstream of the bridges. The bridge cross section was not resurveyed this year.

Table 5.3. Bed Material Gradation Analysis at the Bridges.

Bridge	Date	D_{16} (mm)	D_{50} (mm)	D_{84} (mm)	USCS Class
Darr	10/29/10	0.38	0.72	1.9	SP
Overton	10/28/10	0.47	0.98	2.6	SP
Kearney	8/26/10	0.34	1.00	3.6	SP
Shelton	8/16/10	0.32	0.62	1.4	SP
Grand Island	8/23/10	0.26	0.53	1.3	SP

The Modified Einstein (Holmquist-Johnson and Raff 2006) calculations were run on the high flow event since both suspended and bedload samples were obtained at that flow. The bedload gradation was used as the bed material gradation and SAMWin was used to run normal depth hydraulic calculations. This data and the hydraulic results were then input into the Bureau of Reclamation Automated Modified Einstein Program (BORAMEP). The total load results are display in **Table 5.4**. Overall, the results are quite good, with the sum of the bed load and suspended load approximately the same as the total load calculated with BORAMEP.

Table 5.4. Calculated Modified Einstein Results for June 15-17 Flow Event.

Bridge	Flow (cfs)	Measured Suspended Load (tons/day)	Measured Bedload (tons/day)	Modified Einstein Total Load (tons/day)
Darr	5,301	8,319	1,317	10,178
Overton	6,855	3,212	1,522	4,247
Kearney	7,735	6,806	1,382	8,000
Shelton	7,708	8,957	1,592	10,480
Grand Island	6,780	5,737	1,555	6,081

There was some concern that the high flow bedload sampling results look inconsistent with the lower events. Dr. Everett Richardson (Professor Emeritus, Civil Engineering, Colorado State University) provided QA/QC as part of the suspended and bedload sediment sampling and analysis. After examining the data, it is Dr. Richardson's opinion that the bedload concentrations for the high flow event are low and should be larger by a factor of at least two. At the high flow event, large boils were observed at the flow at the bridge, indicating more of a dune bedform, which does mean that significantly more sediment should be in suspension. One possible explanation for the discrepancy is that based on our 2010 experience, a larger Helley-Smith sampler may be necessary at the high flow events in order to get the sampler properly positioned on the bed. Given this concern, and the success of BORAMEP for high flow conditions, it may be expedient to only collect suspended sediment at the high flows and use the Modified Einstein method to calculate the total load.

5.1.3 Recommendations for Protocol Revisions

Based on the results from the 2010 field season, it seems appropriate to adjust the protocol. It is suggested that both bedload and suspended load data are necessary and should be collected to estimate total load below 5,000 cfs. Above 5,000 cfs, only suspended load needs to be measured as the total load can be estimated from the Modified Einstein method.

6. PHOTOGRAPHIC DOCUMENTATION

6.1 Channel, Bank, and Vegetation Features

Per Section III.F of the monitoring protocol, ground photography will be conducted on each transect survey to document and describe bank stability and composition, vegetation type and structure, and the location of the main channel.

6.1.1 Methodology

Ground photographs will be taken of the banks and main channel at each geomorphology transect at all anchor points. Photographs of the in-channel vegetation will be taken of the vegetation quadrat at each survey point and general photographs will be acquired of the overall vegetation along the banks at each anchor point as well. 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.

Ground photography stations on each bank adjacent to the topography survey point are be taken 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. Photographs were to be taken at a variety of locations along each transect for the main channel and additional photographs are to be acquired on secondary channel sections. Transect and point identification, photo number, and direction are to be recorded for each photograph. Photographs are to be cataloged after field work is completed and all data/photos will be stored in the Program database. The digital ground photography will be georeferenced for incorporation into the Program database.

6.1.2 Results

Ground photos taken along the geomorphology transects were obtained per the protocol. Pertinent information regarding the location and direction of each photo was recorded as well.

With regard to the vegetation surveys, ground photographs were taken at each vegetation sample location to document site conditions at the time of field survey. These photographs were generally oriented towards the ground to show the vegetation conditions within the 1 meter square quadrat. General landscape views at each vegetation transect were also obtained.

Separate cameras and handheld sub-meter GPS units were used in the field to allow each photo to be georeferenced. A shapefile containing the georeferenced locations of all geomorphology and vegetation survey photos is included on the attached DVD.

7. DELIVERABLES

Deliverables included with the Final Year 2 Report include any and all 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 the monitoring activities. Where appropriate, all data has been compiled in Excel spreadsheet format so that it can be incorporated into the Program database. Year 2 data is reported in accordance with guidelines outlined in the Program's AMP and the Program's Database.

7.1 Transect Survey and LiDAR Data

The following deliverables pertaining to the Year 2 (2010) channel geomorphology transect surveys are included on the submitted DVD:

- Shapefiles and ground survey data for all surveyed geomorphology and vegetation transects
- Shapefiles of cross sections for all anchor points compiled from transect survey data and LiDAR data

7.2 In-Channel Vegetation Data

The following deliverables pertaining to the in-channel vegetation surveys are included on the submitted DVD:

- Copies of original vegetation field data sheets on modified Daubenmire forms in PDF format.
- Excel spreadsheet listing each vegetation sample point surveyed in 2010. Spreadsheet includes photo numbers and documentation on which species of interest are located at each sample point.
- Shapefile with attribute table documenting the presence or absence of each species of interest at each vegetation sample location.
- Two excel workbooks containing species of interest elevation data. One workbook lists elevation data for each species of interest and a separate workbook includes charts displaying the elevation data.
- Excel workbook with the following data:
  - Daubenmire forms for each anchor point that include all vegetation data collected in 2010 (minus field sketches).
  - The above excel workbook includes Daubenmire summary sheets which document the frequency, percent cover, and acreage for each species of interest at each belt transect and anchor point.
  - The workbook also includes the frequency, percent cover, and acreage graphs and a sheet of summary data used to create the graphs.
- Folder directory with vegetation sample point photos organized by anchor point and transect.

7.3 Bed and Bar Sediment Sampling Data

The following deliverables pertaining to the Year 2 (2010) bed and bar material sampling, analysis, and documentation are included on the submitted DVD:

- Grain size analysis data for all bed and bar samples by anchor point
- Spreadsheets compiling all pertinent data relating to the samples
- Shapefiles containing the locations of all sediment sample collection points

7.4 Bedload Data, Suspended Sediment Data, and Sediment Transport Results

The following deliverables pertaining to the Year 2 (2010) bedload and suspended sediment sampling and analysis are included on the submitted DVD:

- Spreadsheets compiling the bedload and suspended sediment sample data
- Summary spreadsheets of suspended sediment concentrations
- Bedload and suspended sediment grain size analysis sheets
- Spreadsheets with bridge cross section survey data
- Total load calculation spreadsheets

7.5 Ground Photography

The following deliverables pertaining to the location of Year 2 (2010) ground photography are included on the submitted DVD:

- Shapefiles of all georeferenced ground photography
- All ground photos obtained during transect surveys and sediment sampling work

8. SUMMARY

This Final Year 2 Report represents a summary of the work that was conducted this year (2010) under the Channel Geomorphology and In-Channel Vegetation Monitoring protocol. Included with this report is a DVD with all the raw and processed survey and vegetation data, photos, sediment samples, and other information acquired during the survey and sampling effort.

We believe that the Year 2 (2010) survey and sampling effort went relatively smooth considering the extensive amount of data that were collected and the high flow conditions under which the data were collected. The bedload and suspended sediment sampling began early in the year. The start of these efforts was timed to coincide with the start of the spring runoff in April. The duration of the flow in June allowed for all the bedload samplings under the 3 flow increments and one suspended sediment sampling under the highest flow increment as defined in the Protocol.

The anchor point surveys and sampling work were conducted using a combination of 4-wheel drive trucks, ATVs, and airboat. The airboat allowed us to access most anchor points and move around much more quickly.

Although the transect surveys and bed and bar material sampling were to be conducted under low flows, spring runoff in the mountains in Colorado and Wyoming coupled with an extremely wet early summer resulted in inordinately high flows in June. This resulted in conducting the survey and sampling work in considerably deeper and faster flow conditions than defined in the protocol. Flows in the project reach remained between 1,800 and 2,500 cfs during the survey work and have persisted into the fall.

All of the data collected for this year's monitoring has been processed and compiled into the appropriate formats requested by the ED Office. The 2009 LiDAR has been used to compile the cross sections for the Year 2 rotating panel anchor points. All anchor point cross sections and all associated data and information are herein submitted to the ED Office for review.

Overall, the channel morphology and vegetation characteristics along the river appear to have changed as a result of the long duration, high flow and the sustained intermediate flows throughout the summer. Bar and bed forms have changed along many of the transects and some bank retreat has occurred. Vegetation that was present on lower surfaces has been removed in many places as a result of the high flows. Dead phragmites that have been sprayed with herbicide over the last 2 years have been knocked down or eroded away in many places by the high flows.

9. REFERENCES

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.

Thomas, R.B., and Lewis, J., 1993. An Evaluation of Flow-Stratified Sampling for Estimating Suspended Sediment Loads, Journal of Hydrology, No. 170, pp. 27-45.