PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
Final Statement on Lower Platte River Stage Change Study

On June 12, 2012 the Governance Committee (GC) unanimously approved the following motion:

The Governance Committee accepts the Technical Advisory Committee recommendation to accept the Lower Platte River Stage Change Study Peer Review and Lower Platte River Stage Change Study as final without revisions, with the understanding that the tool can be subsequently used to evaluate Program actions but is not a statement on Program policy implications for pallid sturgeon.

The Stage Change Study is now final. The Lower Platte River Stage Change Study Final Protocol Implementation Report ("Stage Change Study") is attached as **Exhibit A**. The results of the peer review of the Stage Change Study as well as Program responses to each peer review comment are attached as **Exhibit B**. The Stage Change Study peer review scope of work is attached as **Exhibit C**.

All questions regarding the Stage Change Study, its use, and the peer review should be directed to the Executive Director's Office (EDO).

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

EXHIBIT A

Final Stage Change Study

HDR Engineering, Inc.

In Conjunction With
Mussetter Engineering, Inc.
The Flatwater Group, Inc.
Dr. Mark Pegg, UNL

RECOVERY IMPLEMENTATION PROGRAM
PLATTE RIVER

Lower Platte River Stage Change Study
Final Protocol Implementation Report

Platte River Recovery Implementation Program
Kearney, Nebraska

Version 1.0

December, 2009

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Introduction

This Protocol Implementation Report details the study effort associated with the lower Platte River Stage Change Study (Study) for the Platte River Recovery Implementation Program (Program) Governance Committee (GC). For purposes of this Study, the lower Platte River is defined as the reach between the Elkhorn River confluence and the Missouri River confluence. The framework for the Protocol Implementation Report is outlined in the "Lower Platte River Stage Change Study, Final Protocol Development Report" (HDR, The Flatwater Group, Mussetter Engineering, and Dr. Mark Pegg, 2008a). The Study objective was to develop information needed to evaluate the potential effects of Program water management activities on water stage and how those stage changes might affect the physical characteristics of the lower Platte River. The following activities are included in this report:

- Data Collection and Field Work
- Hydrology
- Hydraulics and Geomorphology
- Interpretation and Analysis

Data Collection and Field Work

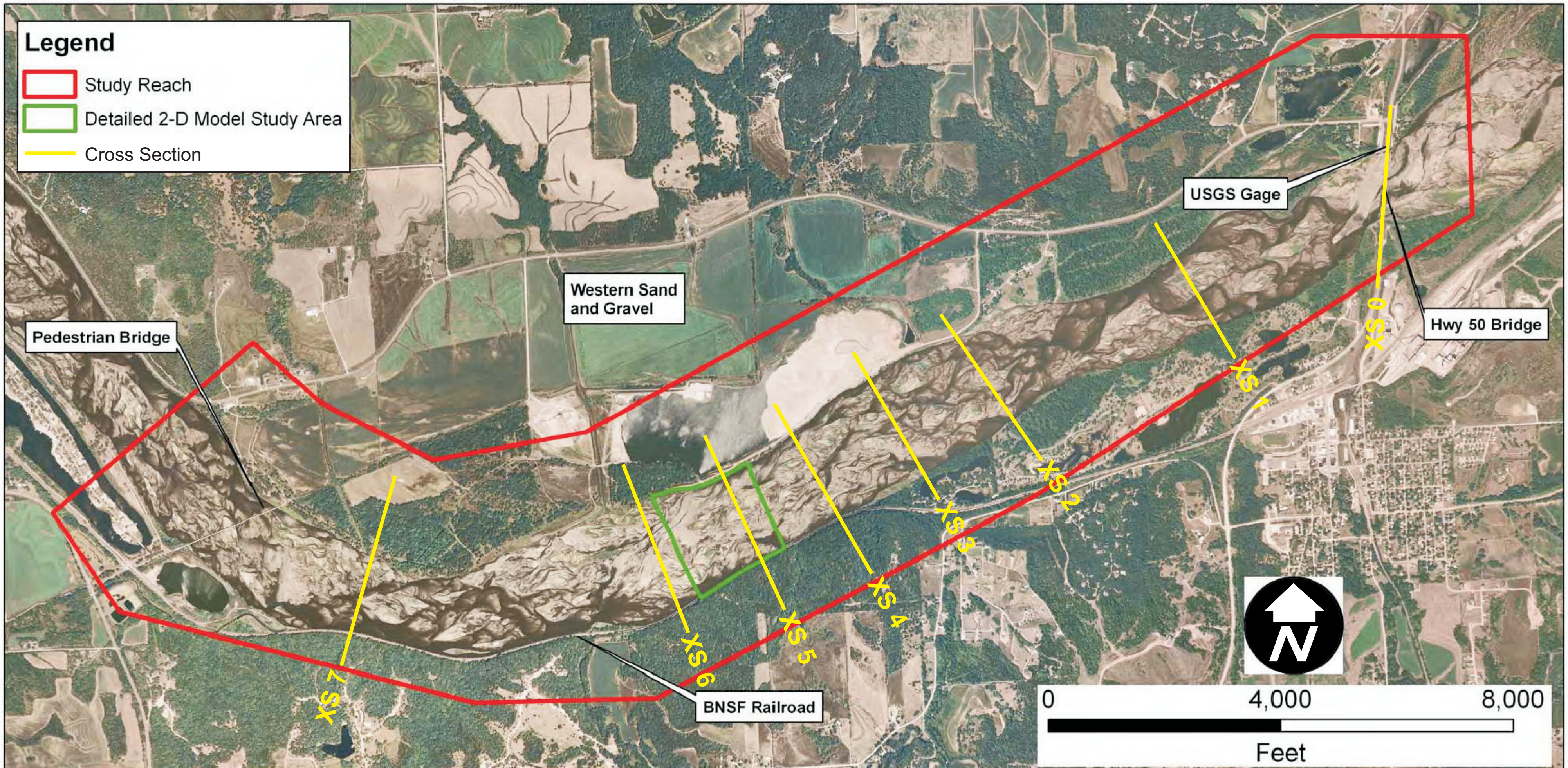
The lower Platte River reach chosen for the data collection effort is located between the Nebraska Highway 50 Bridge and the reclaimed Chicago Rock Island and Pacific Railroad (pedestrian) Bridge (Study Reach) as shown in Figure 1. The intent of the data collection effort was to obtain water surface and water quality information during the high, intermediate, and low flow conditions, and bed topography at low to intermediate flows, in the Study Reach. Details of the historic hydrograph are presented below in Hydrology – Study Flows.

Within the Study Reach, depth, velocity, turbidity, water temperature, dissolved oxygen, and conductivity measurements, as well as bed topography, were obtained during field data collection activities. The Study Reach cross section locations where data were collected are shown in Figure 1. Data were collected during the low flow period in September 2008 and the high flow period in May 2009. Limited data were also obtained in July 2008 during an additional high flow period. Data collection during intermediate flows was suspended for 2008 due to rain events, and these efforts have now been suspended indefinitely due to time and budget constraints. Water surface profiles were also obtained during 2 days in June 2008 on the recession limb of a flood event on the lower Platte River for use in model validation. The data collection effort is detailed in two reports: "Lower Platte River Stage Change Study Final First Progress Report – Field Work Activities" (HDR, The Flatwater Group, Mussetter Engineering, and Dr. Mark Pegg, 2008b) and "Lower Platte River Stage Change Study Final Second Progress Report – Field Work Activities" (HDR, The Flatwater Group, Mussetter Engineering, and Dr. Mark Pegg, 2009).

Hydrology

A hydrologic analysis was performed to analyze the lower Platte River flow regime for the following objectives of this Study:

- Determine the range of flows for the data collection and hydraulic modeling efforts;
- Determine if natural flows can be differentiated from Program activities;
- Evaluate hydrograph translation from Grand Island to Louisville, Nebraska.



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Study Reach

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Figure
1

Study Flows

The historic hydrograph for the U.S. Geologic Survey (USGS) Gage 06805500, Platte River at Louisville (Louisville gage), is shown in Figure 2. The gage is located on the Nebraska Highway 50 Bridge, at the downstream end of the Study Reach. Based on information shown in the plot, the flow ranges (in cubic feet per second [cfs]) listed in Table 1 were determined appropriate for the data collection effort.

Table 1. Historic Platte River Flows at USGS Louisville Gage

Historic Flow Condition	Time Period	Median Flow Range (cfs)
High	March - June	6,000 – 8,000
Intermediate	November - December	3,000 – 5,000
Low	August - September	2,000 – 3,000

Consistent with the Program's Adaptive Management Plan, a range of flows was selected to evaluate the effect of changes in river stage on a macro-, meso-, and micro-scale. Based on the period of record for the Louisville gage, the discharges that are of primary interest range from 5,000 to 39,000 cfs. The low end of this range roughly corresponds to the median mean daily discharge (that is, the discharge that is equaled or exceeded about half the time on an annual basis). The upper end of the range corresponds to approximately the 1 percent exceedence flow, which would be exceeded approximately 3.5 days per year, on average. The upper end of the range also has a recurrence interval of approximately 1.5 years on the annual peak flow series. The selected flows are believed to be appropriate for the hydraulic modeling efforts associated with this Study.

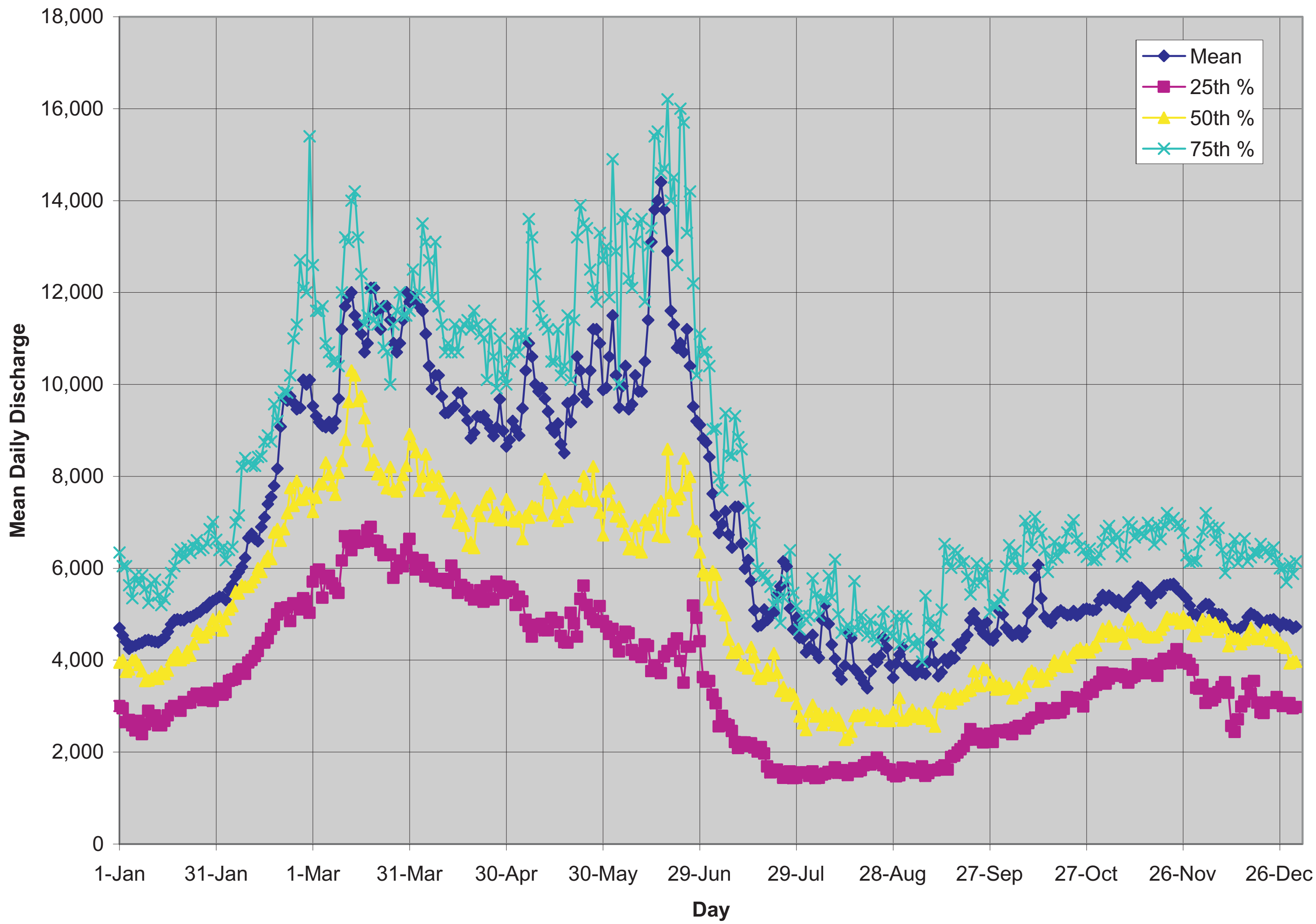
Natural Flows Versus Program Activities

The Program identified the evaluation of USGS gages to determine if Program-related activities are detectable outside the range of variability of the current hydrograph as an important task. The U.S. Fish and Wildlife Service (USFWS), Mountain-Prairie Region (Region 6), in conjunction with the Program's Water Management Committee, completed a preliminary analysis of how changes in central Platte River flow conditions due to proposed Program activities may affect the lower Platte River. The associated analyses are documented in a series of reports, including: "Estimated Historic Losses by Stream Reach in the Platte River Below Grand Island, Nebraska, and Implications for Program-Augmented Flows" (Draft Report) dated May 2002 (USFWS, 2002a) and "Summary Report on the Potential of Changes in Central Platte Flow Conditions to Affect Flows in the Lower Platte" (Draft Report) dated December 2002 (USFWS, 2002b). These two reports are included in this Study as Appendices A and B.

Two phases in the USFWS study that are applicable to this Study are: Estimate historic losses based on daily flow records below Grand Island; and Estimate the likely range of possible effects of Program water at Grand Island on flow in the lower Platte River. Those analyses were extended through Water Year 2008 for this Study, using the travel times estimated in the USFWS studies.

The USFWS analysis segmented the Platte River between Grand Island and Louisville into the following three stream reaches:

- Reach 20 – Platte River from Grand Island to Duncan, Nebraska
- Reach 21 – Platte River from Duncan to North Bend, Nebraska
- Reach 22 – Platte River from North Bend to Louisville, Nebraska



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Historic Hydrograph @ Platte River Louisville Gage

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Figure
2

Data Collection

Streamflow Data

USGS daily streamflow data for the lower Platte River system were compiled through Water Year 2008. The data were obtained to overlap the last water year in the USFWS analyses (1994 or 2000) at each location for data set verification. Table 2 summarizes the stream gage locations, USGS site number, stream reach, period of record for the USFWS study, and periods of record used to extend the analysis through 2008.

Table 2. Platte River Basin Gage Location Used for Historic Loss Analysis

Nebraska Gage Locations	USGS Site No.	Stream Reach	Period of USFWS Analysis	Period of Record for Extended Analysis
Platte River at Grand Island	06770500	Reach 20	1975-1994	1995-2008
Platte River at Duncan	06774000	Reach 20/21	1975-2000	2001-2008
Loup River at Genoa	06793000	Reach 21	1997-2000	1997-2000
Loup Power Canal at Genoa	06792500	Reach 21	1997-2000	1997-2000
Loup River at Columbus	06794000	Reach 21	1954-2000	2001-2008
Loup Power Plant Return	Estimated	Reach 21	1997-2000	1997-2000
Shell Creek near Columbus	06795500	Reach 21	1997-2000	1997-2000
Platte River at North Bend	06796000	Reach 21/22	1975-2000	2001-2008
Elkhorn River at Waterloo	06800500	Reach 22	1975-1994	1995-2008
Salt Creek at Greenwood	06803555	Reach 22	1975-1994	1995-2008
Platte River at Louisville	06805500	Reach 22	1975-1994	1995-2008

The Loup River gage at Columbus (USGS Gage 06794000) ceased operation in 1978. Monthly regression relationships between daily flows for the Loup River at Genoa (USGS Gage 06793000) and the Loup River at Columbus (USGS Gage 06794000) were developed for the time period during which both gages were in operation: Water Years 1954 through 1978 (USFWS, 2002a). USFWS used these monthly regression relationships for estimating streamflow for the Loup River at Columbus for the period between 1978 and 2000. The same methodology used by USFWS and described in the May 2002 Draft Report (USFWS, 2002a) was applied to determine streamflow values for this gage from 2000 through 2008.

The USFWS study (USFWS, 2002a) stated that the best estimate of daily flows from the Loup Power Plant Return was based on the amount of hydroelectric power generated at the "Columbus Hydroelectric Powerhouse" (Columbus Powerhouse) during that day. Because daily hydroelectric power generation estimates were compiled only from January 1997 through December 2000, the USFWS analysis at this location as well as the associated Platte River reach (Reach 21) was based on the period of January 1997 through December 2000, consistent with the USFWS analysis (2002a). These flow estimates were assumed equal to the return flows to the Platte River. Due to the limited availability of daily Columbus Powerhouse generation values after 2000, no additional data were obtained for this Study at the Loup Power Plant Return; therefore, the period of analysis for the Loup Power Plant Return and the associated Platte River reach (Reach 21) remained the same as the USFWS analysis: 1997 through 2000.

The Nebraska Department of Natural Resources installed a gage downstream of the Columbus Powerhouse in 2003. This gage would more accurately reflect the Loup Power Plant Return than the analysis described in the USFWS study. However, for consistency in comparing the results to the USFWS study (2002a), the gage data were not incorporated into the analysis.

Evaporation Data

The USFWS study incorporated evaporation data from two weather stations: Grand Island and Omaha. The Grand Island weather station discontinued recording evaporation data, so no evaporation data were available for Grand Island from 2001 through 2008. Therefore, historical monthly averages from the USFWS period of record (1954 through 2000) were used to estimate monthly evaporation values from 2001 through 2008 at Grand Island.

For purposes of this Study, monthly pan evaporation data measurements were collected from the Omaha weather station located in Valley, Nebraska, which is operated by the National Weather Service. Evaporation data at this location were available for May through September for 2001 through 2006. To estimate the Omaha evaporation values for the period of January through April and October through December from 2001 through 2006, historical monthly averages from the USFWS period of record (1954 through 2000) were used. The historical averages for the USFWS period of record (1954 through 2000) were also used in conjunction with monthly averages from the Omaha weather station at Valley (2001 through 2006) to estimate the monthly averages for 2007 and 2008 evaporation values at Omaha.

Methodology and Analysis

Accuracy Assessment of USGS Stream Gage Measurements

The USGS accuracy assessment was performed using the same methodology as described in the USFWS December 2002 Draft Report (USFWS, 2002b) and extending the analysis to include Water Year 2008. The accuracy of the USGS stream gage measurements limits the detectability of flow changes at Louisville. As noted by USFWS (2002b) “the effect of flow changes in the central Platte River for the magnitude currently envisioned under the Platte River Program are not likely to be detectable at Louisville, Nebraska” (USFWS, 2002b).

Data in the USFWS December 2002 Draft Report (USFWS, 2002b) covered Water Years 1975 through 1994 and included mean daily flow in the Platte River at Louisville expressed as a frequency of exceedence. This Study updated previous analyses to include Water Years 1975 through 2008. The uncertainties of USGS mean daily flow measurements in the Platte River at Louisville (cfs plus or minus), expressed at the 95 percent confidence level as frequency of exceedence, presented in the USFWS analysis were also updated to include Water Years 1975 through 2008.

Additional details regarding the methodology used for the accuracy assessment of USGS stream gage measurements are documented in Appendix B (USFWS, 2002b).

Effects on Flows in Lower Platte

The procedures and methodology used by USFWS (2002a) for estimating historic losses by stream reach for the Platte River below Grand Island were applied in this Study for the updated periods of record. A daily mass-balance evaluation (inflow versus outflow) was performed for each of the three stream reaches using USFWS’s daily flow tracking and accounting Microsoft Excel spreadsheet.

This spreadsheet calculated reach gains or losses of each reach from a daily-mass balance analysis as follows:

Net loss (-) or gain (+), if any = Outflow at the downstream end of the reach + Estimated daily evaporation and evapotranspiration losses - Lagged inflows at one or more locations

All parameters used in the USFWS analysis were adopted for this Study. They include travel time, evaporation and evapotranspiration methodology, open water surface area, and vegetated riparian areas. The only updated data were the addition of evaporation data for the period of 2001 through 2008, as described above. Based on these inputs, estimates were made for daily reach losses due to evaporation, evapotranspiration, and seepage by extending the Excel spreadsheet formulas.

Estimated conveyance losses or gains by river reach were calculated using the methodology described above and documented in the USFWS Draft Report (USFWS, 2002a). In addition, upper and lower envelopes, representing 25th and 75th percentile years, of estimated conveyance losses in the Platte River between Grand Island and Louisville as percentage of augmented flow were determined and plotted for 100 and 500 cfs of Program water at Grand Island.

Additional details regarding the methodology used for estimating conveyance losses by stream reach for the Platte River below Grand Island are documented in Appendix A (USFWS 2002a).

Water Quality Measures

Several parameters often used to assess water quality for fish habitat were measured during field data collection efforts in 2008 and 2009. Those parameters include water temperature (degrees Celsius [^{o}C]), dissolved oxygen (milligrams per liter [mg/l]), conductivity (micro Siemens per centimeter [µS/cm]), turbidity (Nephelometric Turbidity Units [NTU]), depth (feet), and water velocity (feet per second) and were measured along each cross section (Figure 1) during the data collection effort. The number of samples taken per transect varied but ranged from 2 to 10 sample points, depending on diversity of habitats present along the transect. Data collected from each phase of sampling were then used to conduct a power analysis to determine whether sample sizes were adequate to statistically determine differences between sample periods. This analysis provides insight on whether the water quality data can differentiate between flow conditions.

Results

Accuracy Assessment of USGS Stream Gage Measurements

Based on the updated period of record used in this Study, Table 3 illustrates the mean daily flow by month in the Platte River at Louisville for Water Years 1975 through 2008, expressed as frequency of exceedence. Table 4 displays the differences in mean daily flows between the USFWS December 2002 Draft Report (USFWS, 2002b) and the current Study.

As stated in the USFWS December 2002 Draft Repot (USFWS, 2002b), USGS describes the accuracy of the Platte River stream gage at Louisville as “good,” meaning approximately 95 percent of the reported daily discharges are within 10 percent of their true value. Consistent with the methodology outlined in USFWS 2002b, This accuracy description implies the approximate uncertainties illustrated in Table 5 for USGS mean daily flow measurements in the Platte River at Louisville (cfs plus or minus), expressed at the 95 percent confidence level as frequency of exceedence, Water Years 1975 through 2008. Table 6 displays the differences of the uncertainties in mean daily flows between the USFWS December 2002 Draft Report (USFWS, 2002b) and the current Study.

Table 3. Mean Daily Flow at Louisville - WY 1975-2008 (cfs)												
Percent days exceeding	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
90%	2400	3600	5283	5049	3963	2942	1420	1243	1440	2340	3359	2600
50%	5020	7000	9075	8360	8195	8000	4535	3545	4045	4530	5280	5205
10%	8817	13500	18800	19700	22440	25110	14370	9707	9131	9574	9470	9115

Table 4. Difference in Mean Daily Flow at Louisville - WY 1975-2008 minus WY 1975-1994 (cfs)												
Percent days exceeding	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
90%	-200	0	-342	136	114	372	52	186	-39	210	180	164
50%	320	400	-1125	260	475	1045	400	0	-295	360	445	205
10%	215	-1120	-4060	-2220	630	1790	-1960	487	-1369	-526	-24	-61

Table 5. Uncertainty in Daily Flow at Louisville - WY 1975-2008 (plus-or-minus cfs)												
Percent days exceeding	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
90%	240	360	528	505	396	294	142	124	144	234	336	260
50%	502	700	908	836	820	800	454	355	405	453	528	521
10%	882	1350	1880	1970	2244	2511	1437	971	913	957	947	912

Table 6. Difference in Uncertainty in Daily Flow at Louisville - Uncertainty WY 1975-2008 minus Uncertainty WY 1975-1994 (plus-or-minus cfs)												
Percent days exceeding	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
90%	-20	0	-34	14	11	37	5	19	-4	21	18	16
50%	32	40	-113	26	48	105	40	0	-30	36	45	21
10%	22	-112	-406	-222	63	179	-196	49	-137	-53	-2	-6

Effects on Flows in Lower Platte

As documented by USFWS (USFWS, 2002a), daily evaporation and seepage losses were added together to estimate total Program water loss within each of the three reaches from Grand Island to Louisville. These total daily losses were then summarized for each month in terms of the average daily Program water loss occurring that month.

To estimate cumulative Program water effects from Grand Island to Louisville, Program-augmented flows were "routed" through the three reaches, with the corresponding percent loss subtracted from the flow in each reach. However, this routing could not be done for each month of the period of record because the period of record used for Reach 21 did not overlap with the period of record used for Reaches 20 and 22. Instead, the monthly loss percentages associated with the median, the 75th percentile, and the 25th percentile years were used to route and evaluate "normal," "high-loss," and "low-loss" scenarios, respectively.

The results, assuming 100, 500, and 1,000 cfs of additional Program water at Grand Island, are summarized in Figures 3, 4, and 4a, respectively. As illustrated in Figure 3, the estimated proportion of 100 cfs of Program water that ultimately reaches Louisville ranges from approximately 10 percent (in July and August of the worst years) to over 90 percent (in December, January, March, and April of the best years). From October to June in median years, between 70 and 90 percent of the Program water reaches Louisville. In July to September, this percentage falls to 45 to 55 percent.

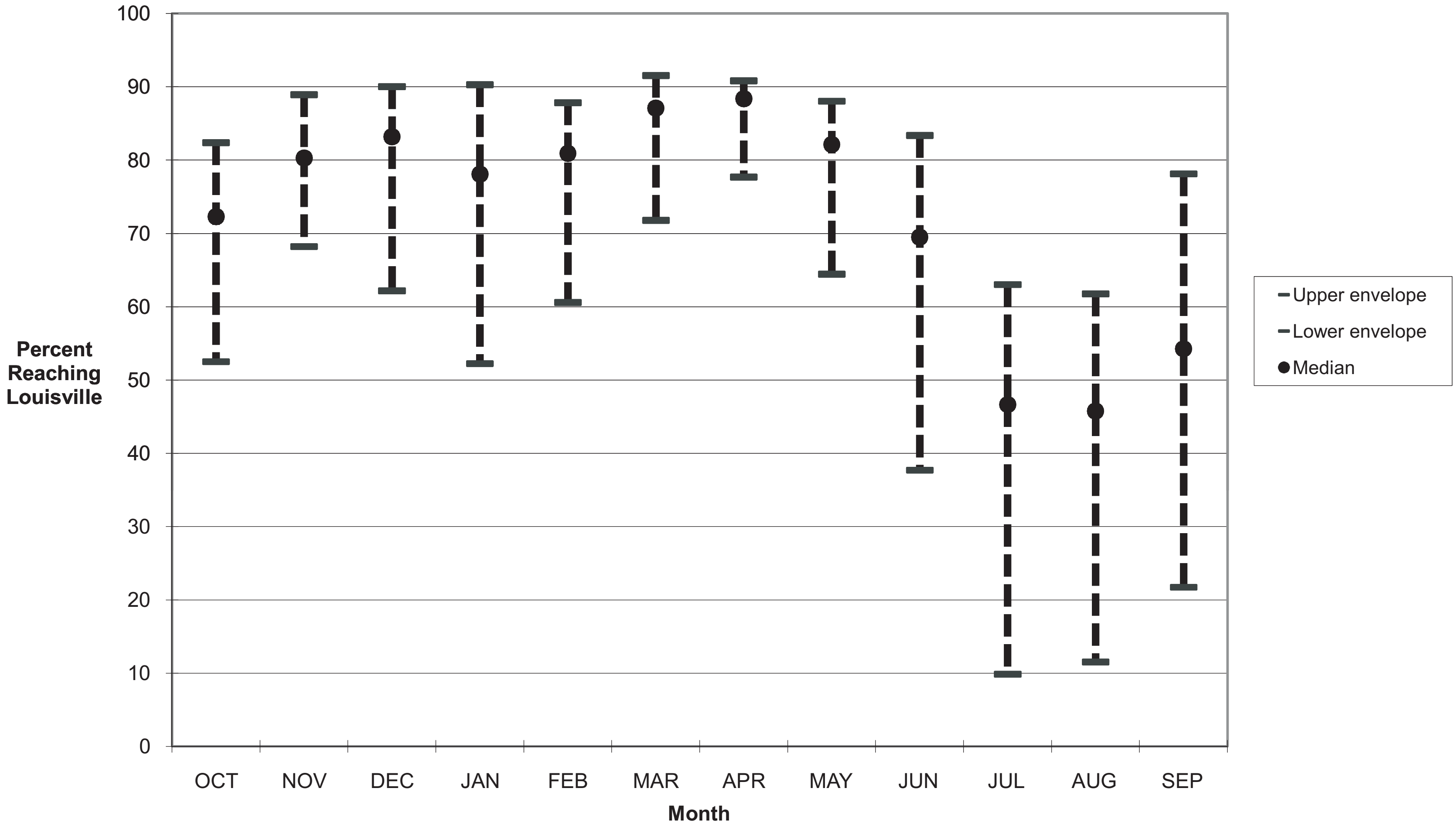
Patterns similar to the 100 cfs of additional Program water are illustrated in Figure 4 for the scenario with 500 cfs of additional Program water at Grand Island. However, relative to the 100 cfs analysis, an additional 1 to 6 percent of Program-augmented flow in October through June of the median year is estimated to reach Louisville, and an additional 9 to 15 percent of Program-augmented flow in July through September of the median year is estimated to reach Louisville.

As noted by USFWS (USFWS, 2002a), this relative increase in percentage of Program-augmented flow reaching Louisville demonstrates that the percentage of Program-augmented flow lost to evaporation will decrease as the amount of Program-augmented flow is increased. It is noted that although the total volume lost would increase with additional Program-augmented flow, the percentage of flow lost would decrease. Furthermore, the percentage of Program-augmented flow lost to evaporation is expected to increase as the amount of Program-augmented flow is decreased.

Comparison with USFWS Analysis

Comparing the results of the extended analysis for the 100 cfs of additional Program water with the USFWS Draft Report (USFWS, 2002b), the lower envelope (25th percentile) values have lowered. From October to May, the lower envelope is about 5 percent lower than the USFWS analysis. A significant drop in the lower envelope values is noticed from June to September, changing from a low of 40 percent reaching Louisville down to only 10 percent. The difference for nearly all of the upper envelope (75th percentile) values is typically less than a few percent.

When comparing the results for 500 cfs of additional Program water, patterns similar to the 100 cfs of additional Program water are evident. Overall the lower envelope (25th percentile) values have decreased for the extended analysis, and the most significant drop occurs from July to September. As with the 100 cfs scenario, the upper envelope (75th percentile) values remain nearly the same for the extended analysis period.



Estimated Percent of 100 cfs Program Water at Grand Island Reaching Louisville after Evaporation and Seepage Losses

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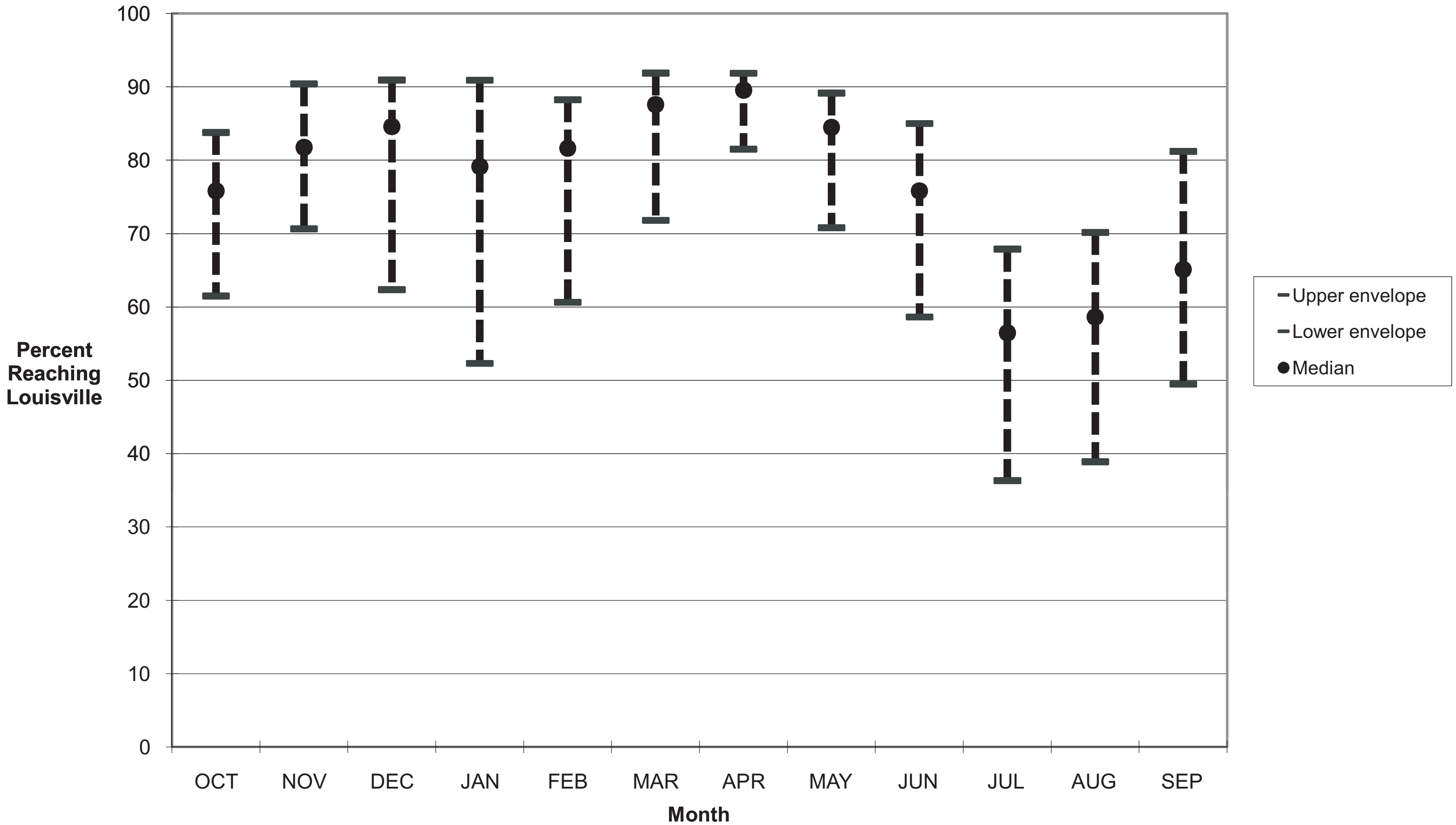
Figure
3



Estimated Percent of 500 cfs Program Water at Grand Island Reaching Louisville after Evaporation and Seepage Losses

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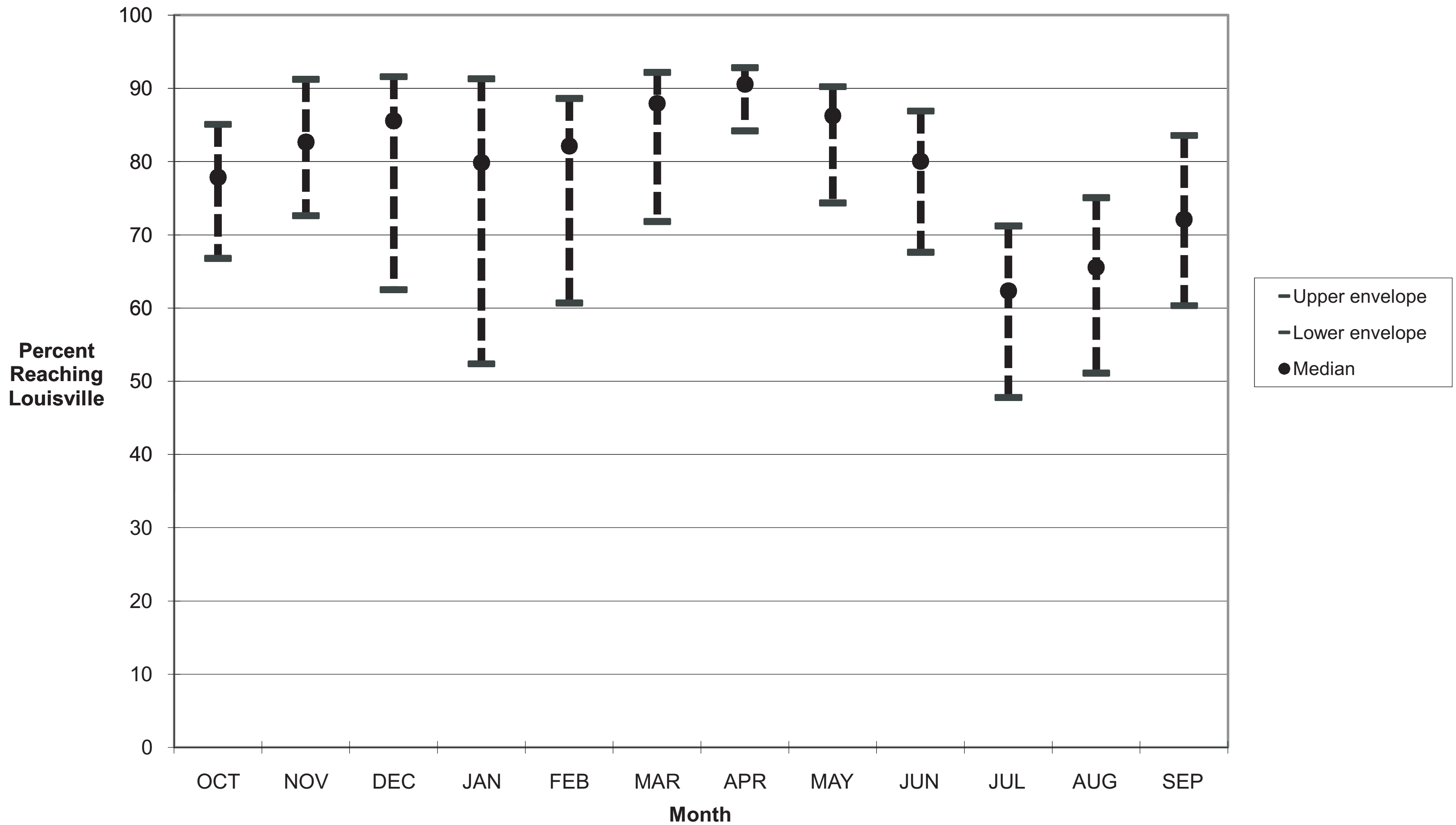
Figure: 4



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Estimated Percent of 1000 cfs Program Water at Grand Island Reaching Louisville after Evaporation and Seepage Losses

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Figure
4a

Hydrograph Translation from Grand Island to Louisville

The Program initiated a test of environmental account (EA) flows in late April 2009. This test afforded the opportunity to evaluate the translation of a pulse flow to the lower section of the Platte River and, in particular, the Louisville gage. For the analysis, the provisional real-time data was obtained from USGS (2009). Program staff also provided some preliminary information evaluating the pulse flow event to the Grand Island gage.

In general, little precipitation occurred during the time of the pulse flow; therefore, the recorded hydrographs should be reasonably representative of baseflow conditions. There were some minor precipitation events in the lower section of the river that may have affected flow as it moved downstream. The Salt Creek gage at Greenwood (USGS Gage 06803555) recorded a runoff event starting on April 25 and peaking on April 27. While small, this event increased the flow being recorded by approximately 200 cfs. As shown in Figure 5 and explained below, this corresponds with the apparent peak flow at Louisville on April 26, as represented in the mean daily flow.

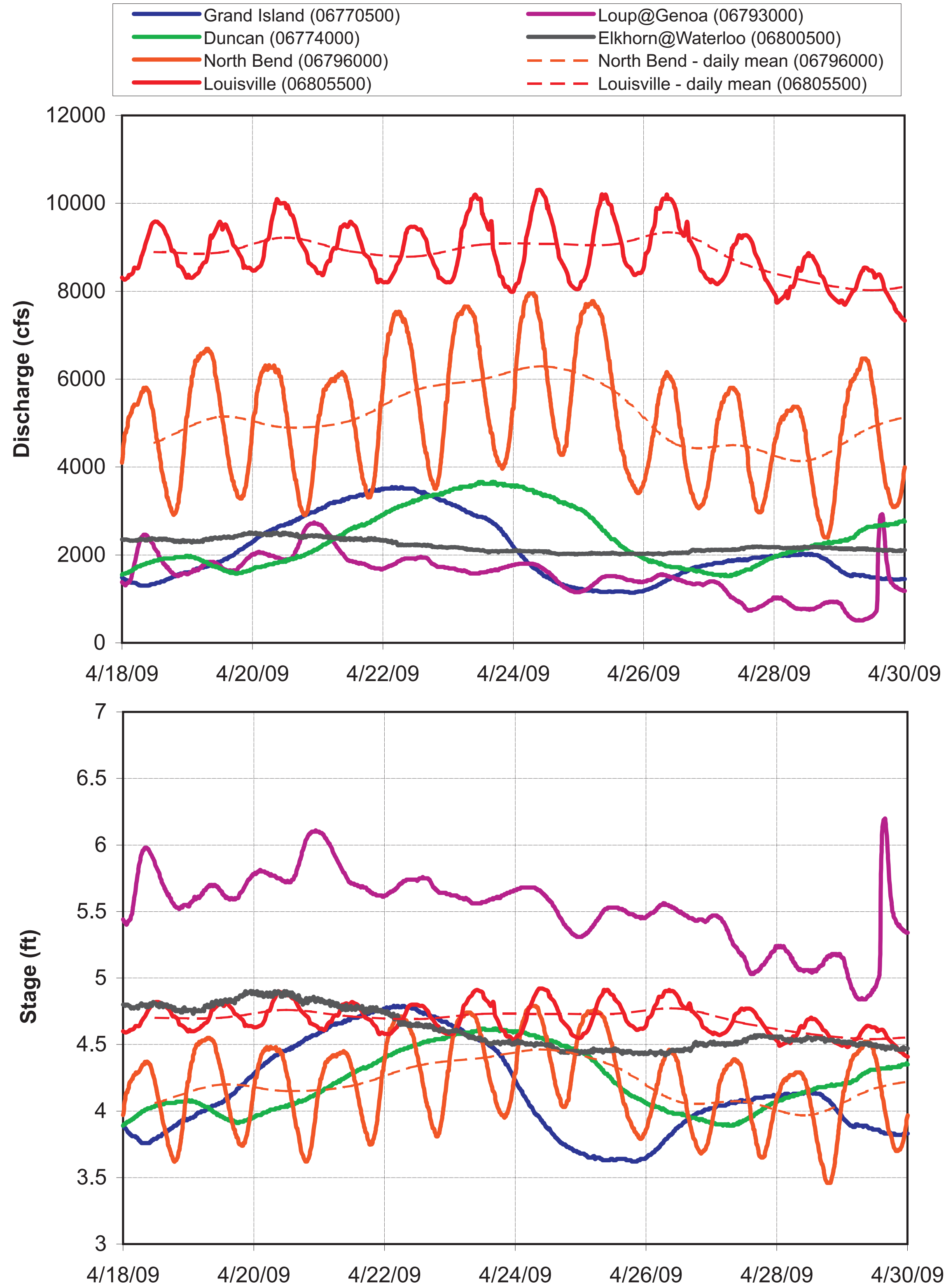
Figure 5 represents the real-time provisional data for six gage locations on the Platte River. These include Grand Island, Duncan, North Bend, and Louisville. Also included are the major tributaries of the Loup River and Elkhorn River. The Ashland gage was omitted from the analysis as key data from April 25 through April 27 was not available from USGS. Plotted data are for the time period of April 18 though April 30. For reference, the flows for April at Louisville and North Bend were at or above the median daily flow statistic for those stations, while Duncan and Grand Island were below (approximately half) the median flow for the time in April leading up to the pulse flow event.

The pulse flow is clearly represented at Grand Island for approximately April 18 through April 25. The peak of the EA flow at Duncan is estimated to be approximately 2,000 cfs above base flows. Based on review of the record, the approximate time of travel of the peak from Grand Island to Duncan is estimated at 35.5 hours. Travel times between gages have been estimated by a number of sources, including USFWS (2002b). In that report, travel time for April was estimated to be 1.7 days, or approximately 40 hours.

In reviewing Figure 5, the most obvious influence to the hydrographs at North Bend and Louisville is the intraday flow variation. For perspective, the intraday flow variation at North Bend for the period of interest is approximately 4,000 cfs. To visually smooth out the daily swings, the daily mean flow for the period was plotted for North Bend and Louisville. Using this information, a small peak can be indentified on April 24 at North Bend and on April 26 at Louisville. This peak may be representing the pulse flow as it moves through the system.

Travel time of the peak from Duncan to North Bend is estimated at 18 hours and from North Bend to Louisville is approximately 46.5 hours. The USFWS report estimates travel times of 26 and 31 hours, respectively for those locations. One observation of the total travel time from Grand Island to Louisville is that the estimated time is 100 hours as compared to the USFWS reported time of 97 hours.

Using the graphed mean data, a slight "bump" of the hydrograph at Louisville in the range of 300 to 500 cfs could be estimated. This additional flow is 15 to 25 percent of the estimated peak passing Duncan. Visual interpretation of the pulse flow hydrograph suggests an attenuating effect from Grand Island to Duncan of perhaps 0.5 days. The effect is not clearly seen as the apparent



Discharge and Stage Curves for the Platte River and Tributaries

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peak of the hydrograph moves downstream and is influenced by inputs from the Loup and Elkhorn systems.

The results of the hydrograph translation are summarized as follows:

- The amount and timing of this pulse flow is difficult to track with a high level of confidence.
- The small runoff event from Salt Creek could have dampened the effect of the pulse flow.
- Draft review of the data for the pulse flow suggests that approximately 13,000 acre-ft of EA pulse flow passed the Grand Island gage from April 18-25. During the time frame of interest, nearly 19k AF passed the Louisville gage every day.
- While a small peak may be represented within the "noise" of stage and discharge changes at the Louisville gage, this peak is likely within the accuracy of the gage readings.

Hydraulics and Geomorphology

A hydraulic and geomorphologic analysis was performed to assess the river hydraulics within the Study Reach with the objective of evaluating the change in depth and velocity with changes in stage. The analysis was carried out using both one-and two-dimensional (1D and 2D) models. For purposes of this Study, the following definitions were used:

- Macro-scale – Features that represent the reach-scale characteristics of the river, including the planform (i.e., sinuosity and alignment), channel width, gradient, reach-averaged hydraulic conditions (i.e., depth and velocity), and general substrate type (i.e., sand-bed for the lower Platte River). The planform dimensions over which the reach-scale characteristics apply are typically on the order of a one to several channel widths, and their height generally scales with the depth a high discharges.

- Meso-scale – Features that represent the subreach-scale characteristics of the Study Reach, including sandbars, distribution of depths and velocities, variability in substrate, and the individual habitat units. The planform dimensions over which these features apply is typically a fraction of the channel width, and their height typically scales with the flow depth at which they are formed.

- Micro-scale – Local characteristics, including local depths and velocities within individual habitat units, bedforms (i.e., ripples, dunes, antidunes), and local changes in substrate, that are quantified using detailed field measurements and 2D modeling results.

Macro-scale Hydraulic Model

A 1D macro-scale model encompassing the Study Reach was developed to provide reach-scale hydraulic characteristics of the lower Platte River to be used primarily to establish boundary conditions for the 2D meso- and micro-scale model. The U.S. Army Corps of Engineers-Omaha District (USACE-OD) performed a hydraulic analysis of the lower Platte River to update the current flood insurance study (USACE-OD, 2002) using the 1D HEC-2 model. Cross section data from the mid-1970s through 2001 were used for the Study, with the more recent data (1997 through 2001) in the portion of the reach upstream of Interstate 80.

A review of the USGS Platte River gages at Ashland and Louisville shows a relatively stable aggradation/degradation trend over this period. At Ashland, there has been a slight increase in stages of approximately 0.5 foot over the last 20 years at lower flows (approximately 3,000 cfs), suggesting a slight aggradation trend. The gage data shows essentially no change for flows of approximately 10,000 cfs over the same period, indicating that the aggradation is not affecting stages at higher flows. The Louisville gage has shown a mild degradational trend of approximately 1 foot for flows in the range of 3,000 cfs over the past 20 years. The degradational trend is slightly less, 0.5 foot, for flows in the range of 10,000 cfs for the same time period. Based on this information, the use of the USACE-OD model is reasonable as a data source for the macro-scale analysis.

1D Model Setup

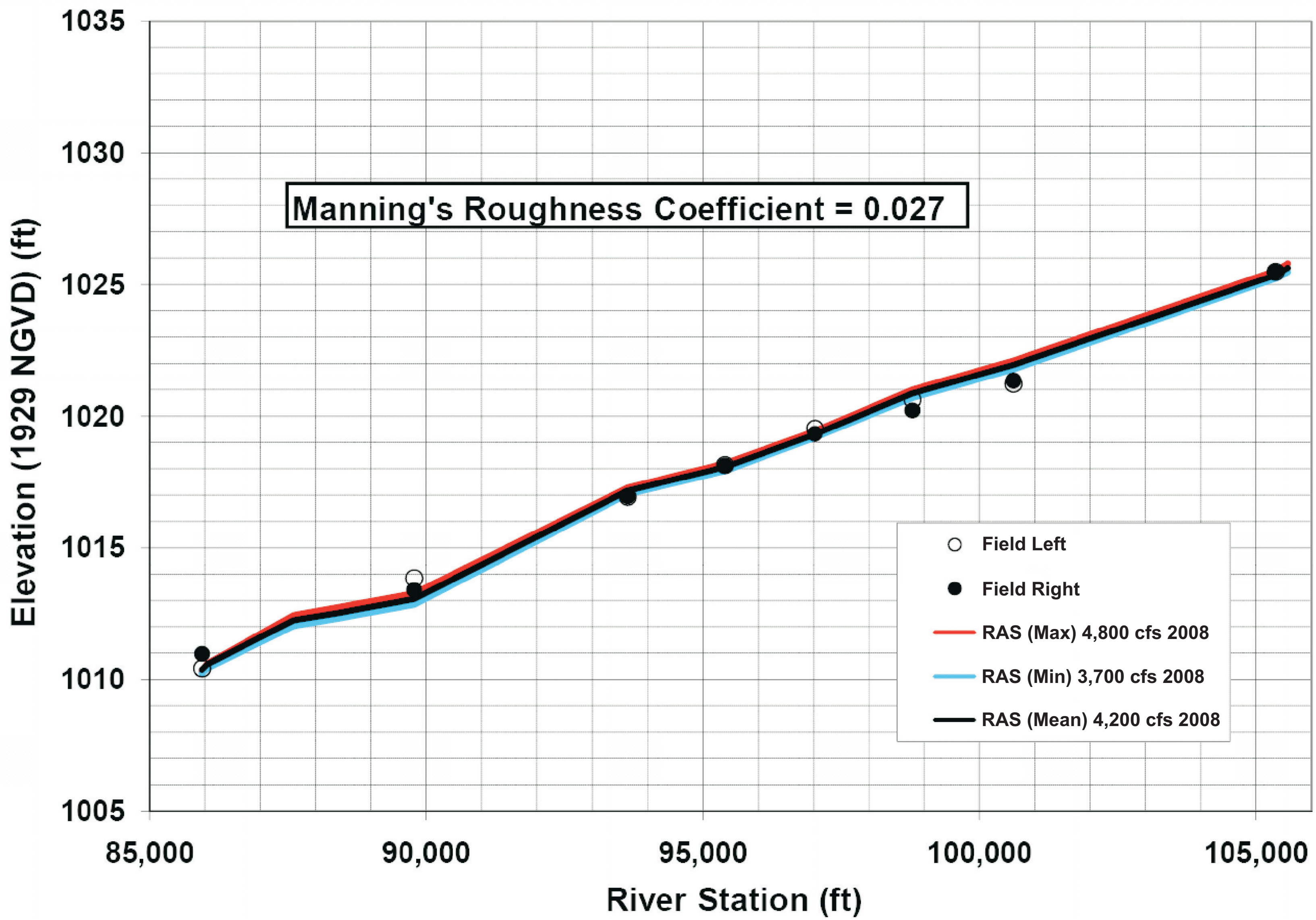
The HEC-2 model was converted to the more current HEC-RAS format (USACE, 2008). HEC-RAS is designed to perform 1D hydraulic calculations for steady and unsteady, gradually varied flow and is the appropriate tool to develop boundary conditions for the meso-scale analysis. For purposes of this Study, the model was only executed in steady mode. The 10-year model run was executed in HEC-RAS and compared to HEC-2 output to confirm proper translation of the model data. The maximum difference occurred at the Nebraska Highway 50 Bridge (-0.56 foot), which is attributed to the difference in bridge algorithms between HEC-2 and HEC-RAS. For all other sections, the maximum difference between the two models was less than ± 0.05 foot between the two models. Therefore, the model was adopted as the data source for the macro-scale analysis and will be referred to as the USACE-OD HEC-RAS model.

1D Model Validation

Topographic and water surface information obtained during the data collection effort were used for model validation purposes. Cross sections in the USACE-OD HEC-RAS model within the Study Reach were replaced with the surveyed cross section information. The surveyed cross section locations are shown in Figure 1. Water surface elevations were obtained at the left and right banks of each respective cross section. Two hydraulic models were developed, one incorporating cross sections from September 2008 and one incorporating cross sections from May 2009. The same Manning's "n" values, contraction and expansion coefficients, and channel stations were used in both version of the model. For the range of flow selected for the Study, all flows are contained within the channel.

Historic Low and High Flow

The September 2008 and May 2009 models were compared to the respective field data. Three water-surface profiles were computed for each model: the average maximum, minimum, and mean discharges at the Louisville gage during the respective data collection period, as shown in Table 7. The resulting predicted water surface profiles were below the measured water surface elevations. The Manning's roughness coefficient in the USACE-OD HEC-RAS model was 0.017 for the channel, which was calibrated for Platte River flows between 160,000 cfs (10-year) and 405,000 cfs (500-year). As described in more detail below under Bedform Analysis, it has been well-documented that the effective Manning's roughness coefficient varies with depth of flow (Chow, 1959). Due to the braided nature of the lower Platte River, it is reasonable to increase the Manning's roughness coefficient upward with decreasing depth of flow. After several iterations, a channel Manning's "n" value of 0.027 provided the best visual fit to the observed data for the September 2008 and May 2009 models for the range of modeled water surface profiles (maximum, minimum, and mean) (Figures 6 and 7). An exact fit to data taken at the banks using a 1D model for relatively low flows is unlikely based on the braided nature and daily flow variability of the lower Platte River and the inherent water-surface elevation difference within a given cross section. Based on these results, a reasonable channel Manning's "n" value for the range of flows sampled is 0.027.



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1D Model Validation September 2008

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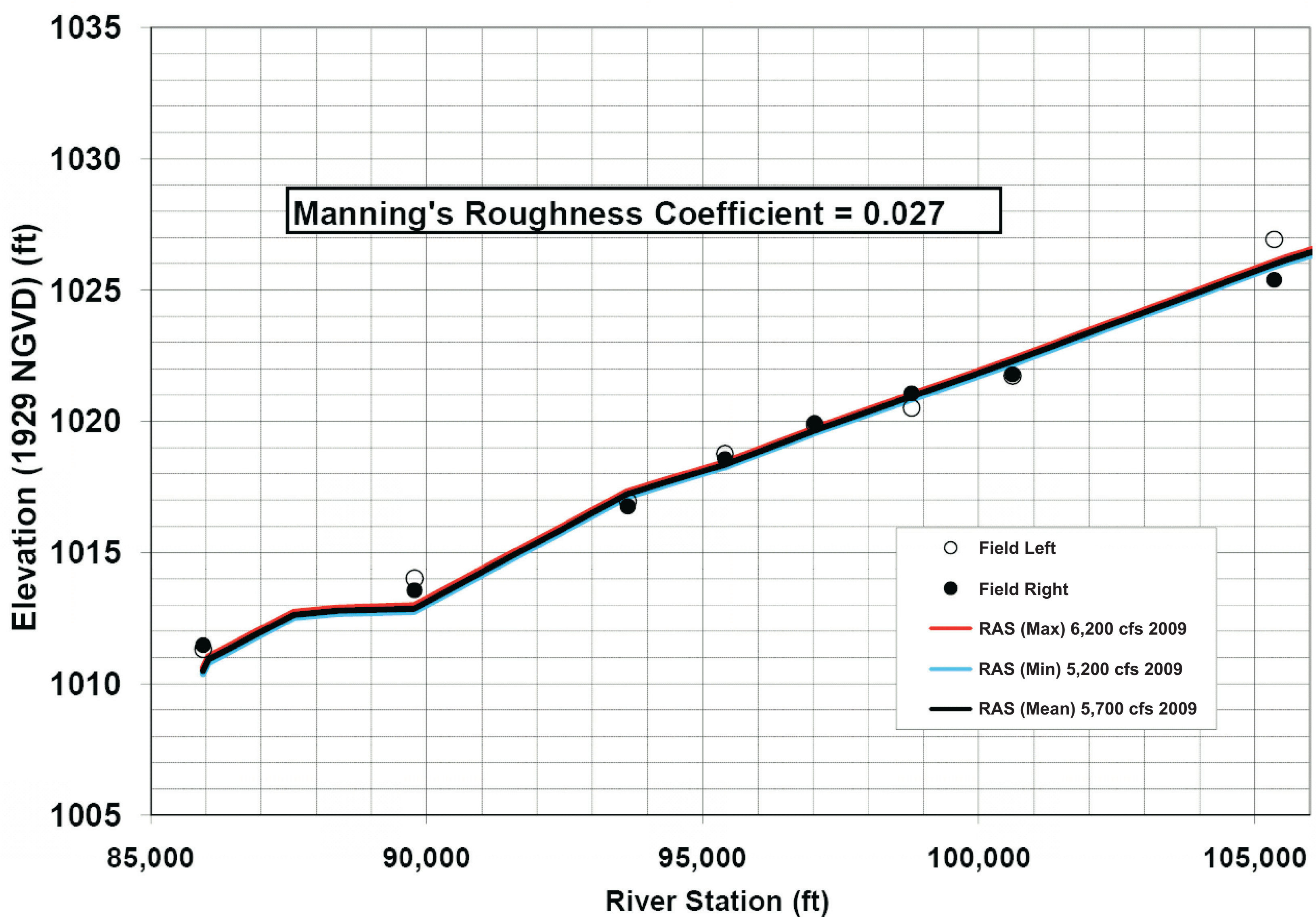

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Table 7. Average Maximum, Minimum, and Mean Discharge, September 2008 and May 2009

Data Collection Effort	Average Maximum Discharge (cfs)	Average Minimum Discharge (cfs)	Average Mean Discharge (cfs)
September 2008	4,790	3,670	4,200
May 2009	6,200	5,200	5,720

June 2008 Flood Event

The September 2008 and May 2009 models were then executed for the maximum, minimum, and mean discharges at the Louisville gage on June 16, 2008, as shown in Table 8, and compared to measured water surfaces. The model consistently predicted water surface elevations above the measured values using the channel Manning's "n" value of 0.027. After several iterations, a channel Manning's "n" value of 0.025 provided the best visual fit to the observed data (Figure 8). The September 2008 model predicted slightly higher water surface elevations than the May 2009 model. This is discussed below under Cross Section Comparison.

Table 8. Maximum, Minimum, and Mean Discharge, June 13 and June 16, 2008, at Louisville Gage

Data Collection Effort	Maximum Discharge (cfs)	Minimum Discharge (cfs)	Mean Discharge (cfs)
June 13, 2008	45,300	31,600	37,400
June 16, 2008	27,200	21,600	24,700

Finally, the September 2008 and May 2009 models were executed for the maximum, minimum, and mean discharges on June 13, 2008, as shown in Table 8, and compared to water surface profiles measured in the field. After several iterations, a channel Manning's "n" value of 0.021 provided the best visual fit to the observed data (Figure 9). Again, the September 2008 model predicted slightly higher water surface elevations than the May 2009 model. This is discussed below under Cross Section Comparison.

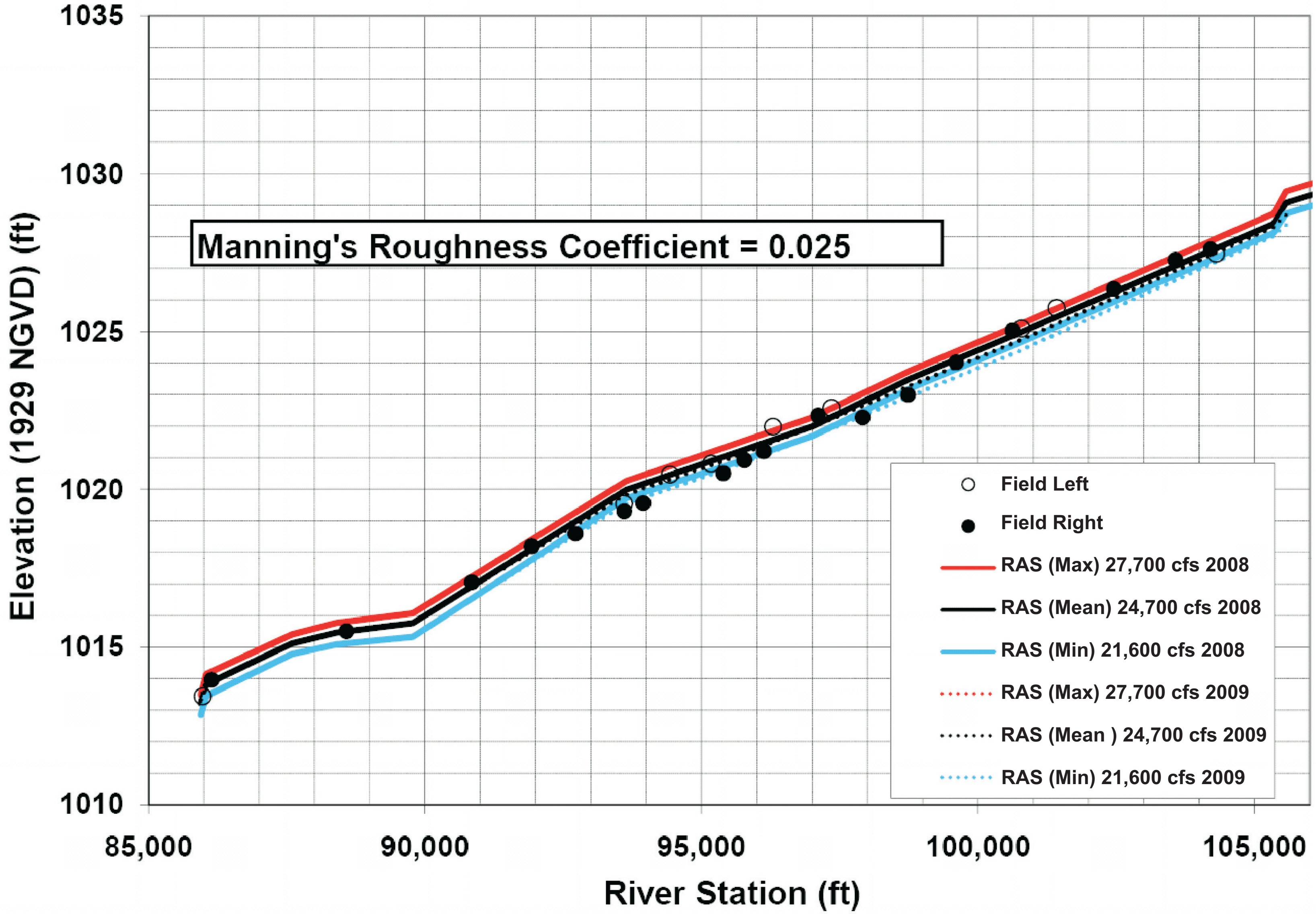
Based on the 1D model validation, the channel Manning's "n" values are reasonable values for the target flows listed in Table 9.

Table 9. Manning's Roughness Coefficient for 2008 and 2009 Discharge Events

Date	Mean Flow at Louisville Gage (cfs)	Manning's Roughness Coefficient in Channel
June 13, 2008	37,400	0.021
June 16, 2008	24,700	0.025
September 22-29, 2008	4,200	0.027
May 20-21, 2009	5,700	0.027

Cross Section Comparison

Cross sections were compared between the data collection efforts listed above, as well as topographic information obtained in October 2009 (Figures 10 through 17). These comparisons indicate that the low-flow channel or channels tended to deepen during the high spring flow events and tended to become shallower in response to periods of low flow. This is most pronounced in Figures 10, 11, 12, 14, and 16. At each of these cross sections, there appears to be a deeper, wider low-flow channel, and higher mid-channel features, suggesting flow



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1D Model Validation June 16, 2008

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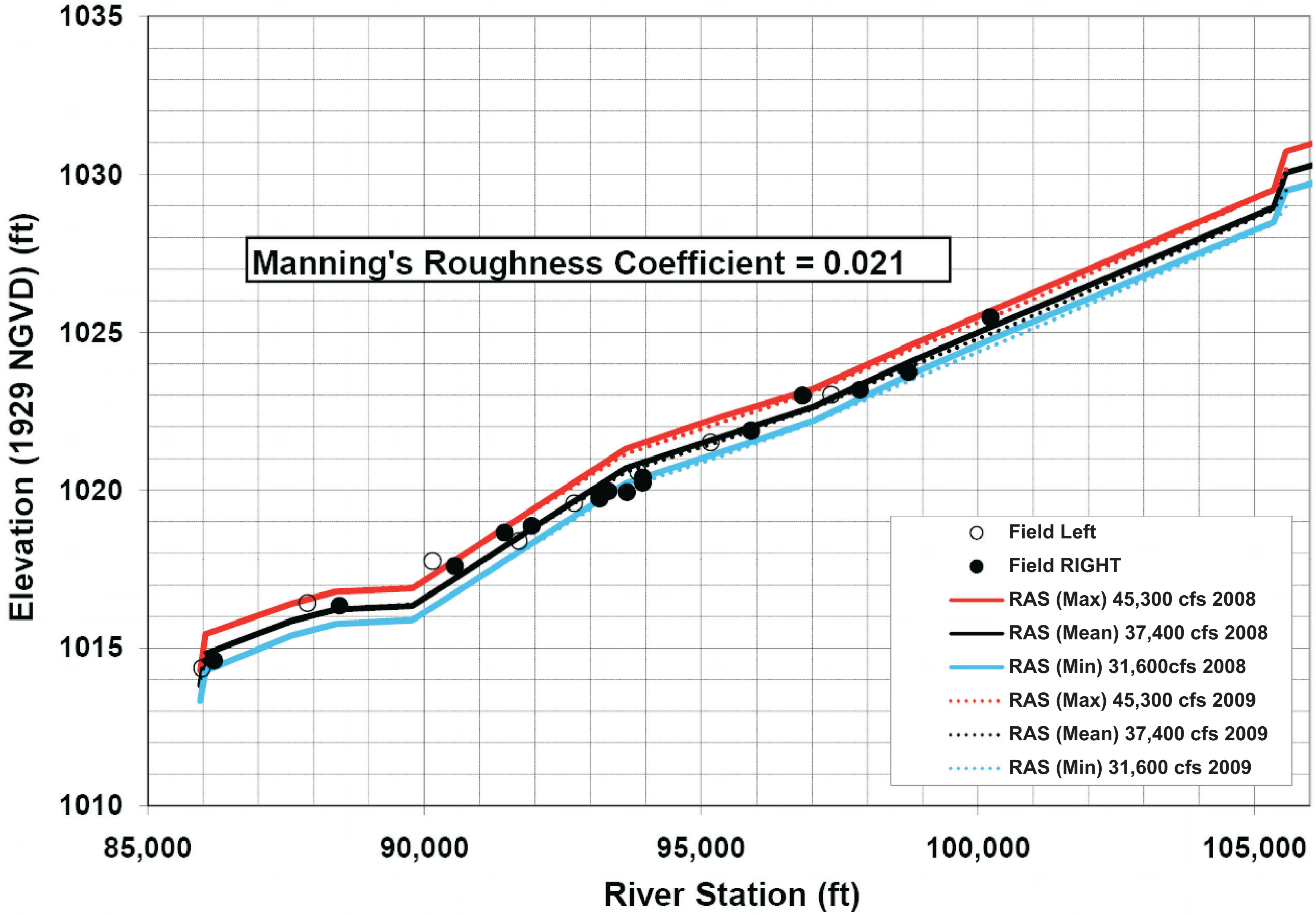

1D Model Validation June 13, 2008

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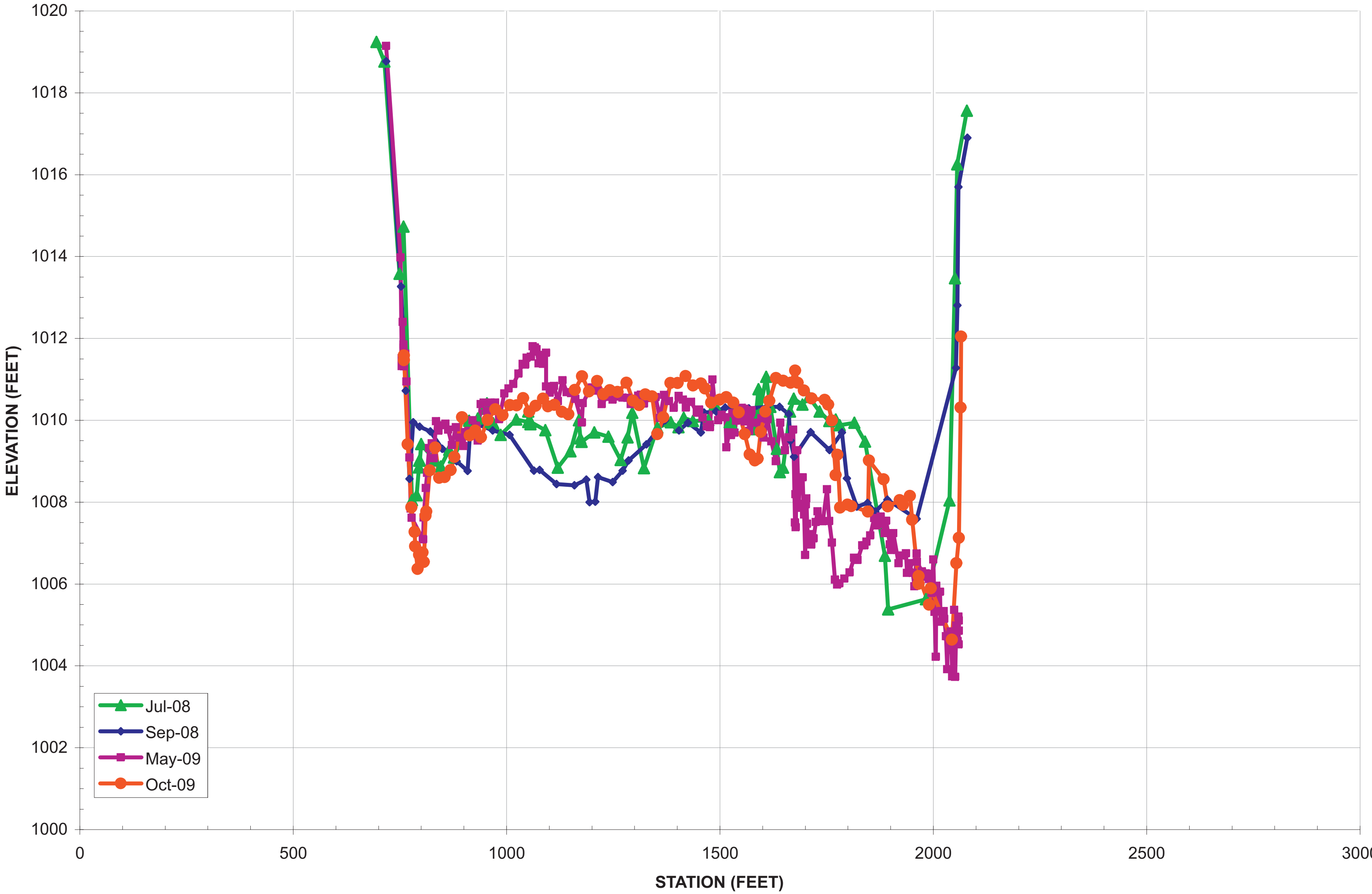

Cross Section 0

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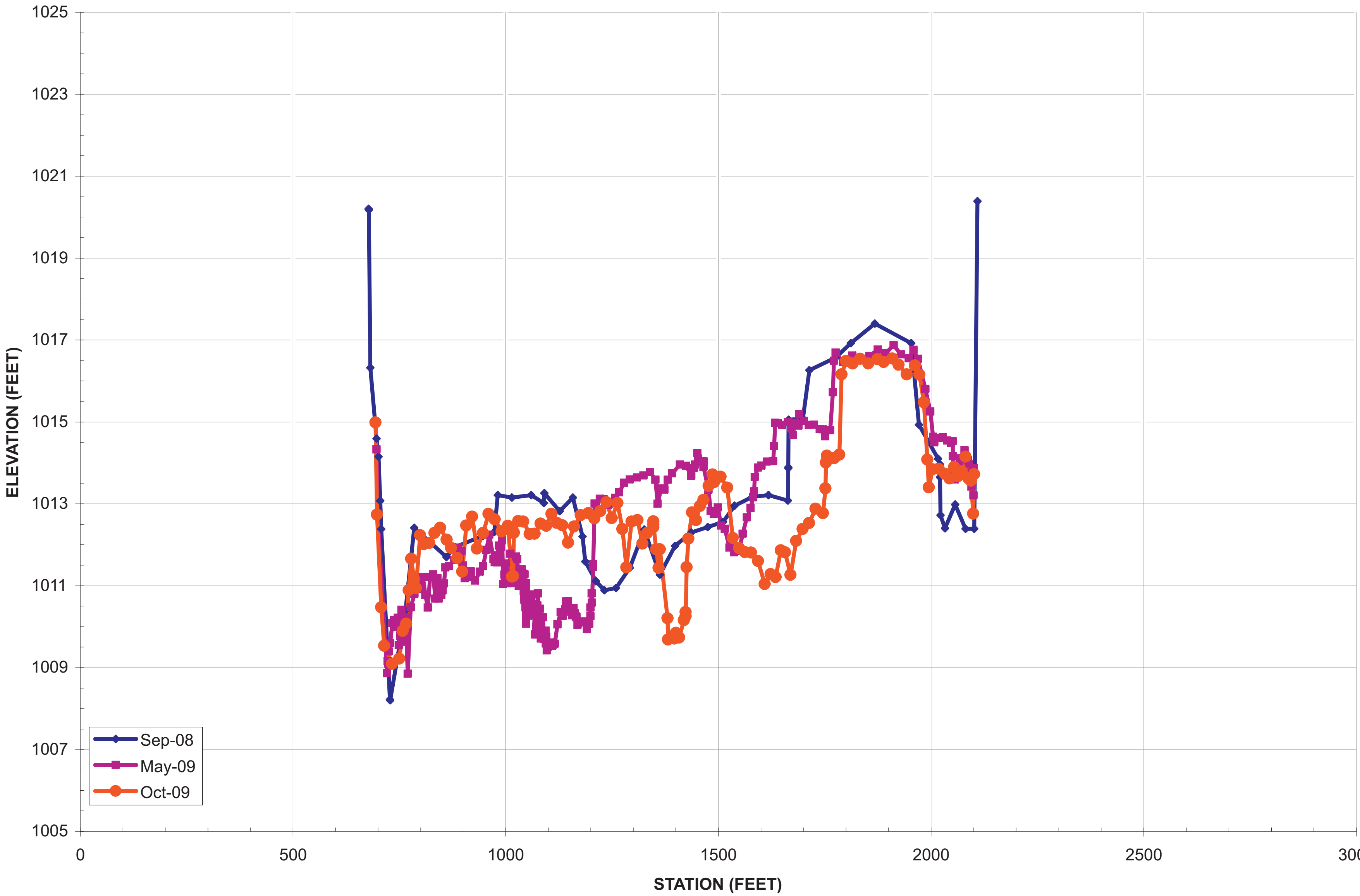

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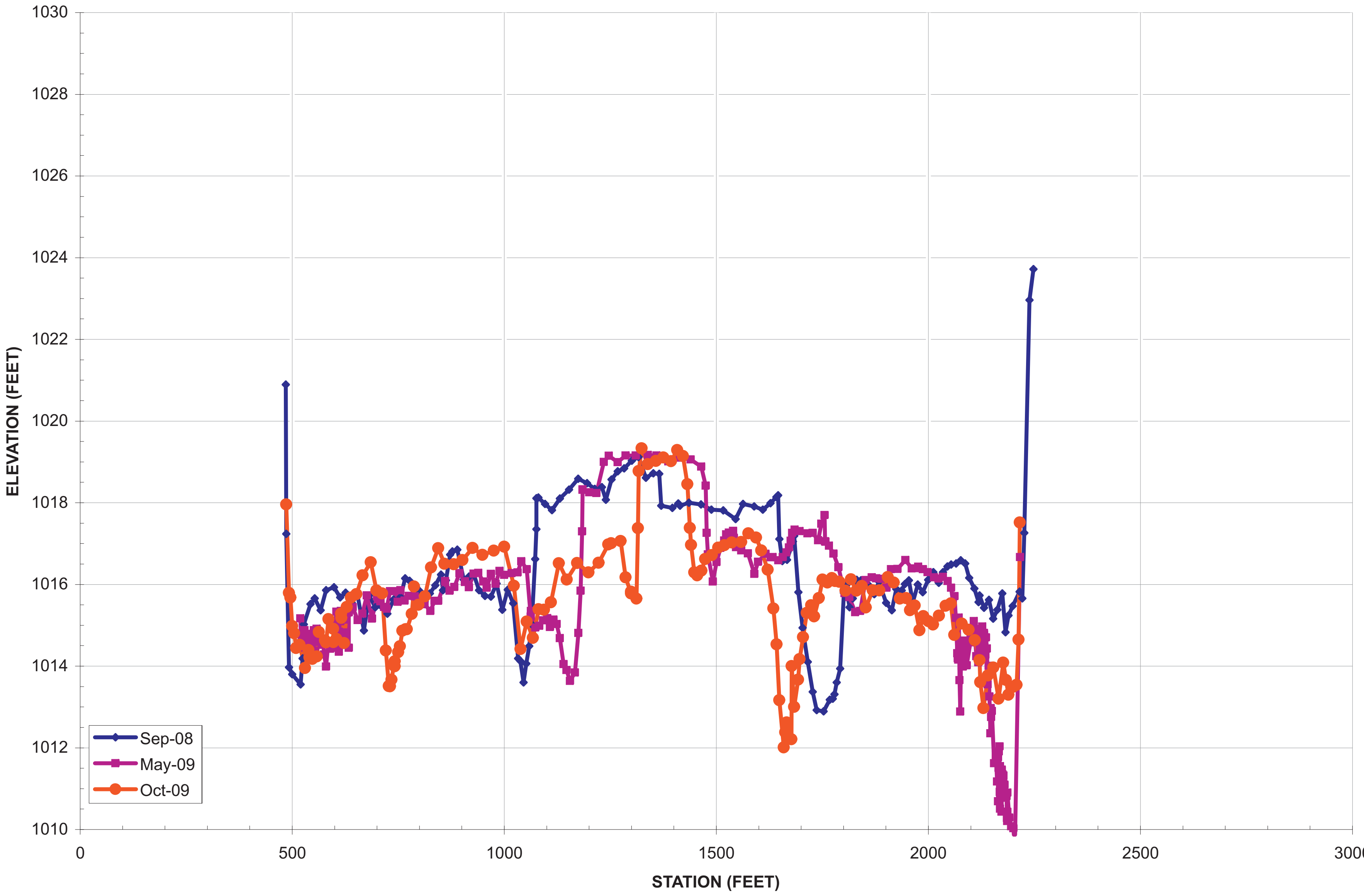

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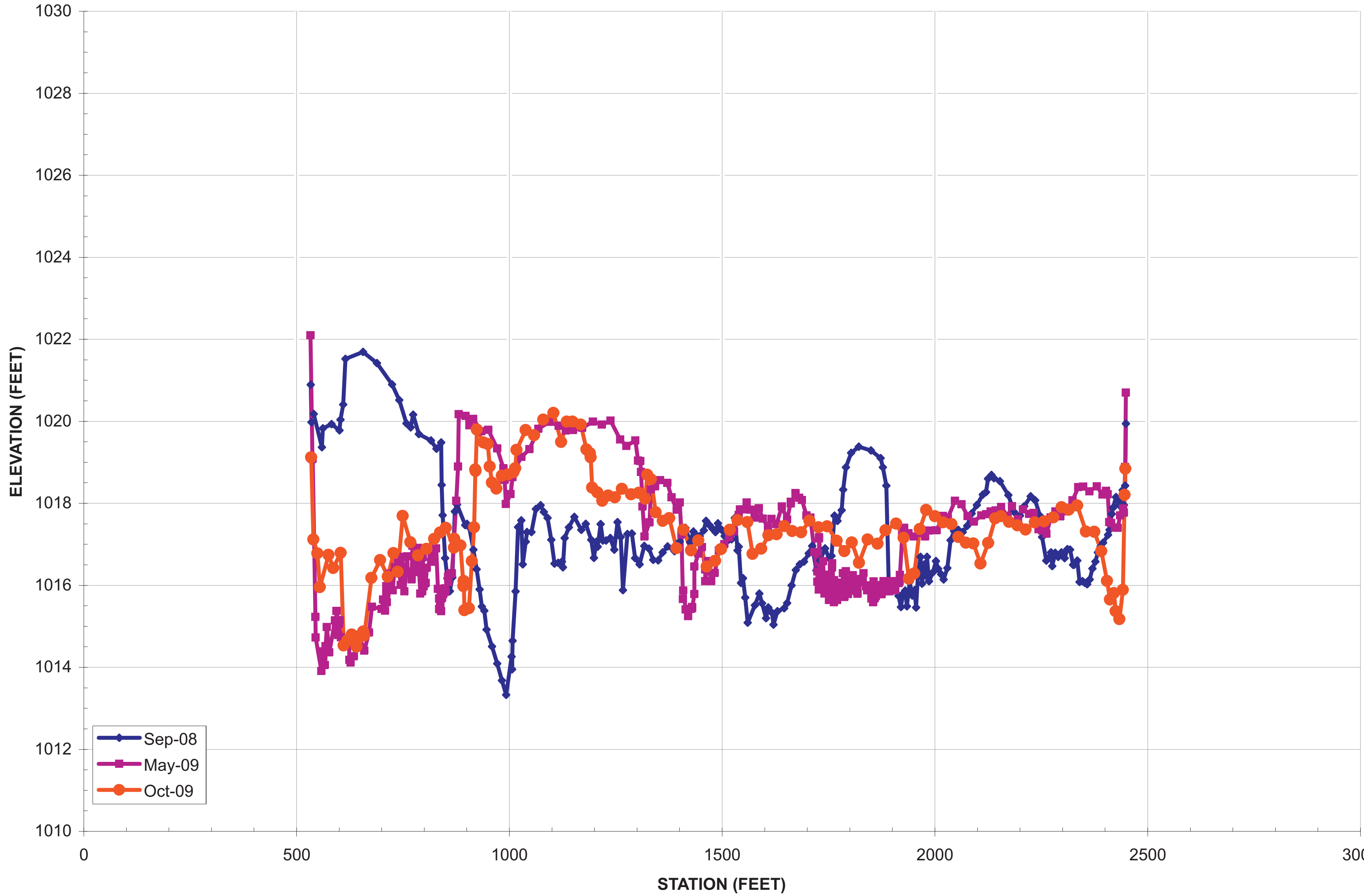

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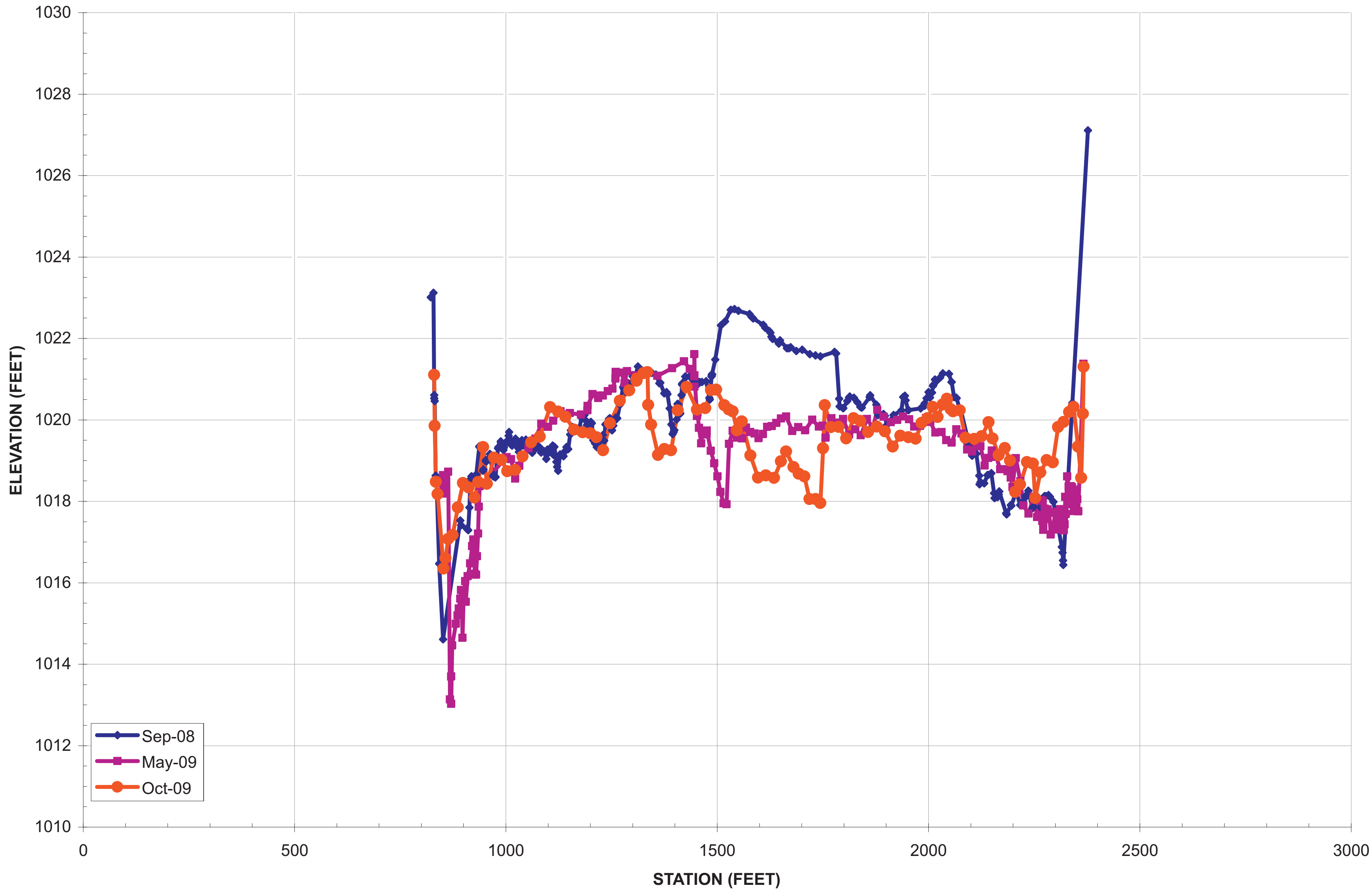

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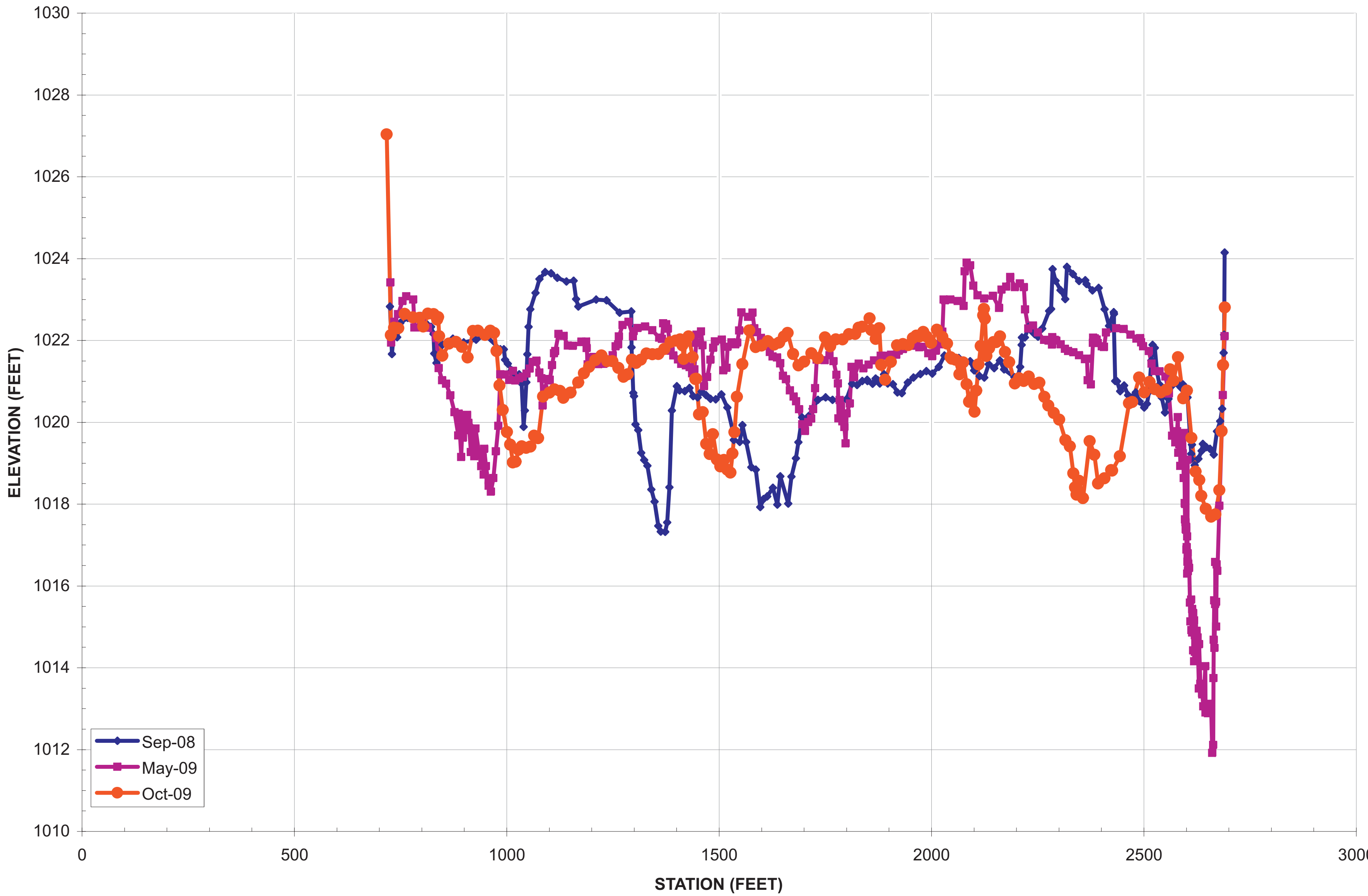

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concentration for the post high-flow surveys (July 2008 and May 2009). However, for the post low-flow surveys (September 2008 and October 2009) at those sections, there appears to be a shallower low-flow channel or channels, and lower mid-channel features suggesting greater flow distribution across the section. This is reflected in the validation modeling in that the September 2008 model predicted slightly higher water (within 0.2 foot) surface elevations than the May 2009 model.

Meso-scale Hydraulic Model

2D Hydraulic Model

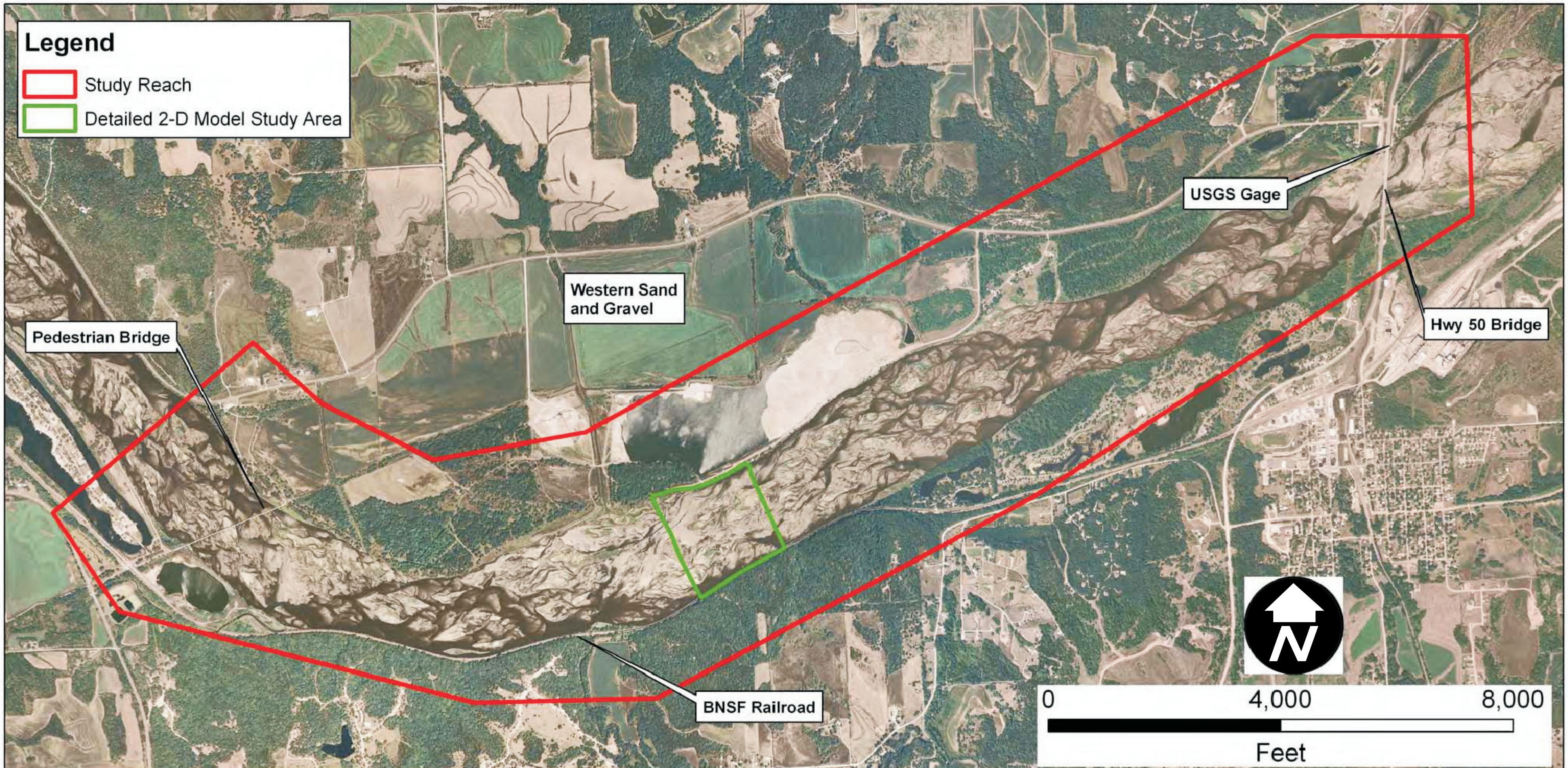
A 2D hydraulic model was developed within the Study Reach to facilitate a meso-scale evaluation of the hydraulic effects associated with variations in stage and discharge (Figure 18). Results from the model runs were used to determine how depth and velocity changes throughout the site over a range of discharges.

2D Model Development

The 2D modeling was carried out using the Bureau of Reclamation's SRH-2D version 2 model (Bureau of Reclamation, 2008) with Aquaveo's Surface Water Modeling System (SMS) Version 10.0 graphical user interface. SRH-2D is a depth-averaged, finite-volume, hydrodynamic model that computes water-surface elevations and horizontal velocity components for sub- and supercritical free-surface flows in 2D flow fields. SRH-2D was selected for this Study because it is a well-tested 2D model that provides a more accurate prediction of the complex flow patterns and hydraulic parameters along the Study Reach than can be obtained from the more simplified 1D models. The model uses a mesh composed of triangular and quadrilateral elements with corner nodes that represent the geometry of the modeled reach, with the channel topography represented by bed elevations assigned to each node in the mesh.

The SRH-2D mesh was established to represent the planform geometry and topography of the Study Reach that was developed from the field work. The modeled reach is approximately 1,700 feet long, and the grid resolution of the model is approximately 10 feet (Figure 19). A high mesh density was selected to represent the complex topography of the river as accurately as possible, resulting in a mesh that contains 29,793 elements.

As discussed in the data collection section, detailed topographic and bathymetric data of the river were derived from surveys conducted by HDR, The Flatwater Group, and Mussetter Engineering on September 23 through 26, 2008, when the discharge ranged from approximately 3,700 to 4,800 cfs (average discharge of the mean daily flows during this time period is approximately 4,200 cfs). Energy losses in the model are described by Manning's n-values that define the boundary friction losses and by kinetic eddy viscosity values that define internal energy losses associated with turbulent exchange. Because roughness values do not account for all of the computed energy loss in most 2D models, Manning's n-values are typically lower than those used in 1D models of the same reach. Due to the complexity of the topography and variation in existing channel bedforms, Manning's n-values at discharges less than about 8,000 cfs ranged from 0.023 in areas with limited bedforms to 0.027 in areas generally characterized by more significant features such as large dunes (Figure 20). To improve calibration at the highest surveyed discharges of 24,700 and 37,400 cfs, Manning's n roughness values in the model were reduced to a constant value of 0.013. Given that the detailed topography in the 2D model that was collected at a flow of about 4,200 cfs, the lower n-value also helps account for topographic changes that occur at the higher discharges. The n-value of 0.013 was derived from empirical relationships developed by Brownlie (1983) and later rearranged by the USACE Waterways



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Limits of the SRH-2D Model within the Study Reach

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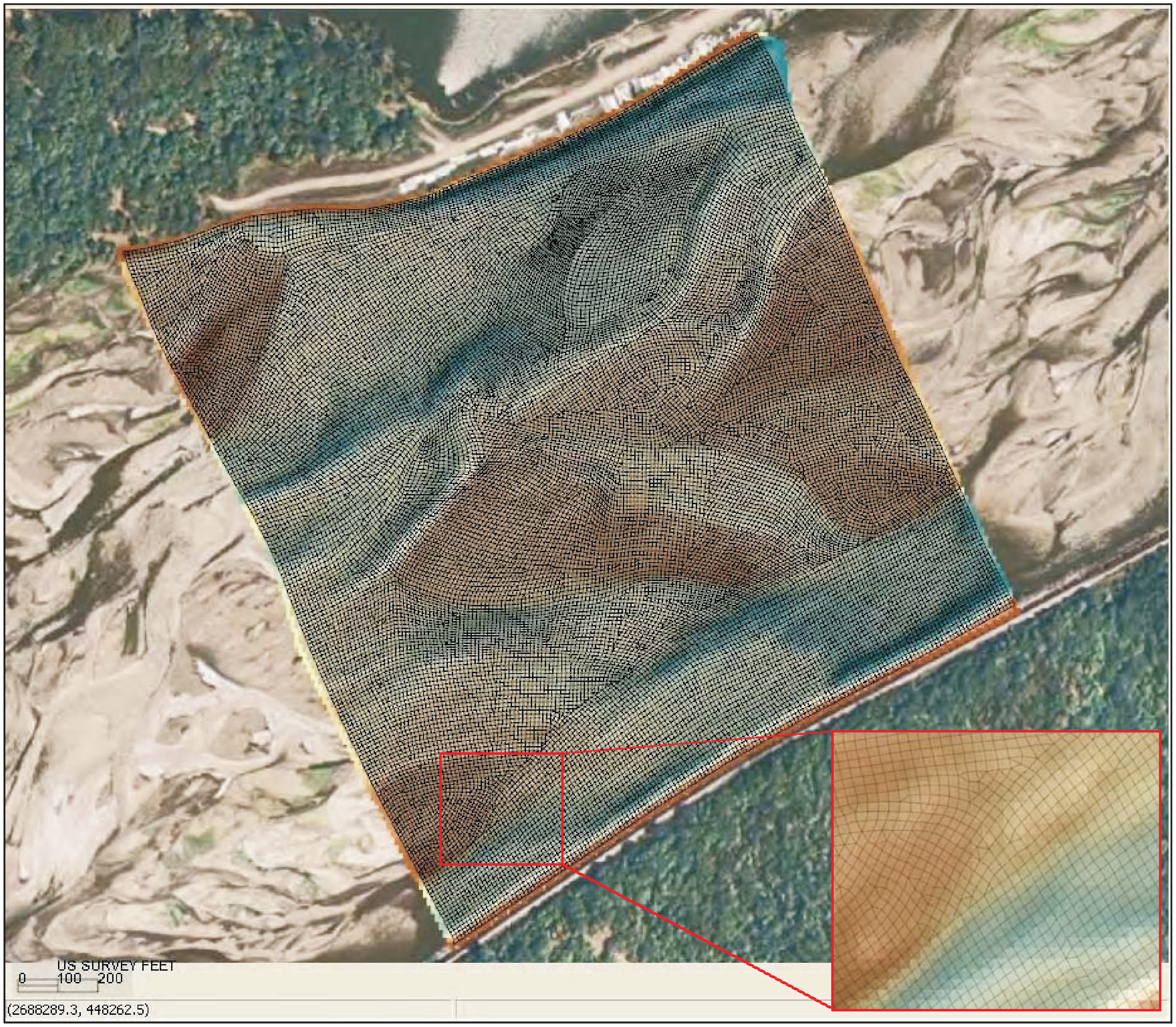

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SRH-2D Model Grid in the Detailed Study Reach on the Platte River

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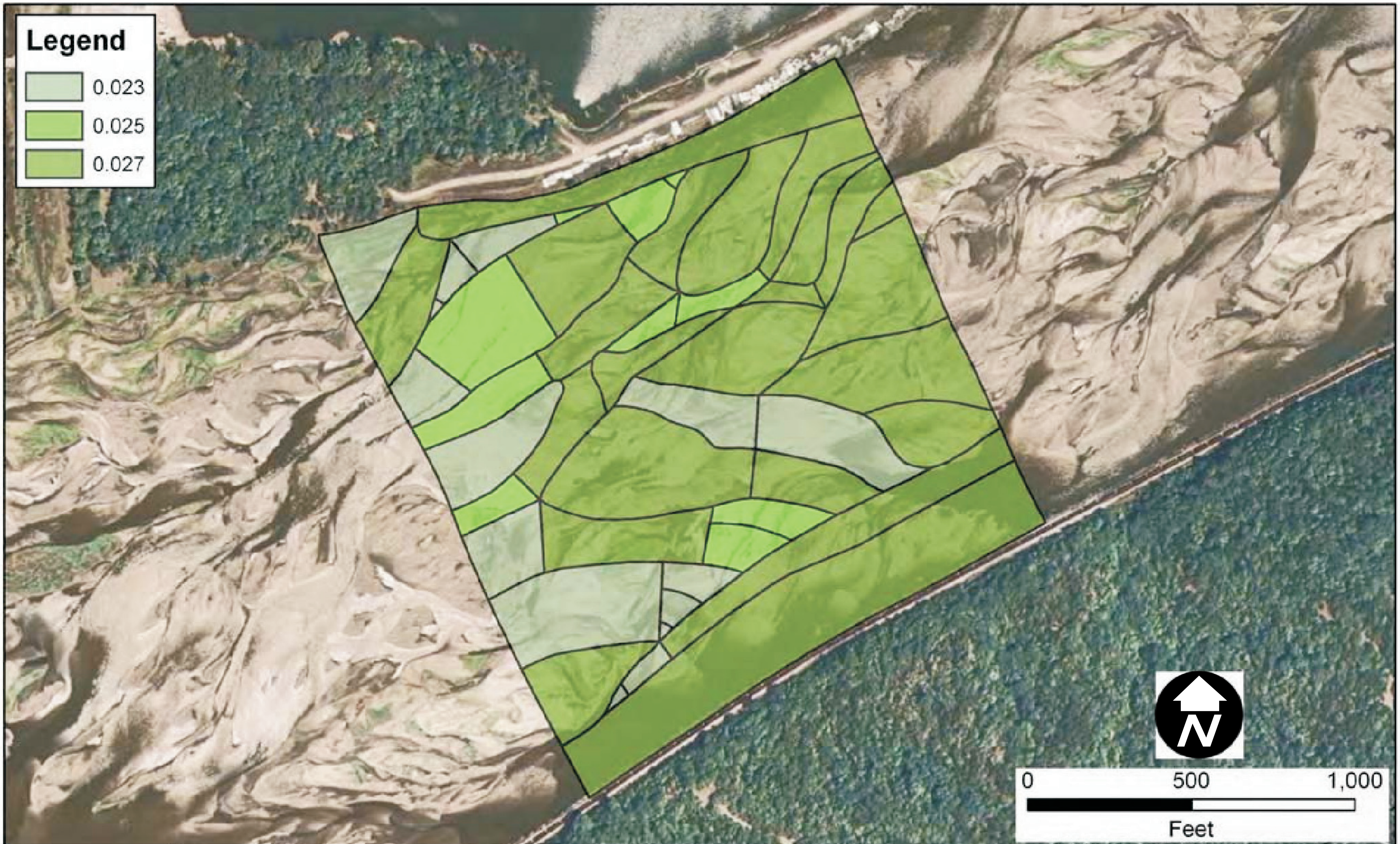

Manning's n Roughness Values used in SRH-2D Model

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Experiment Station (WES) (USACE, 1991) that relate hydraulic conditions and bed material characteristics to Manning's n-values. Model n-values at flows between approximately 8,000 and 24,700 cfs were interpolated from the bounding values. In addition to the roughness values, the k-ε turbulence model was applied to compute energy losses due to turbulence (Bureau of Reclamation, 2008).

The downstream boundary condition for the 2D model consists of a specified water-surface elevation for the particular discharge that is being modeled. A rating curve for the downstream end of the model was developed from the calibrated 1D HEC-RAS model described in the previous section at model station 98,387 (Figure 21). The upstream boundary condition consists of the total discharge entering the model. Exposed sandbars occur along the upstream model boundary that divide the flow at low to intermediate discharges As a result, it was necessary to divide the total discharge among three separate flow paths. The percentage of flow assigned to each flow path was determined based on the conveyance-weighted discharge in each flow path at an interpolated section in the September 2008 model (Figure 22). At discharges greater than approximately 12,000 cfs, a single discharge was applied to the entire upstream boundary of the model.

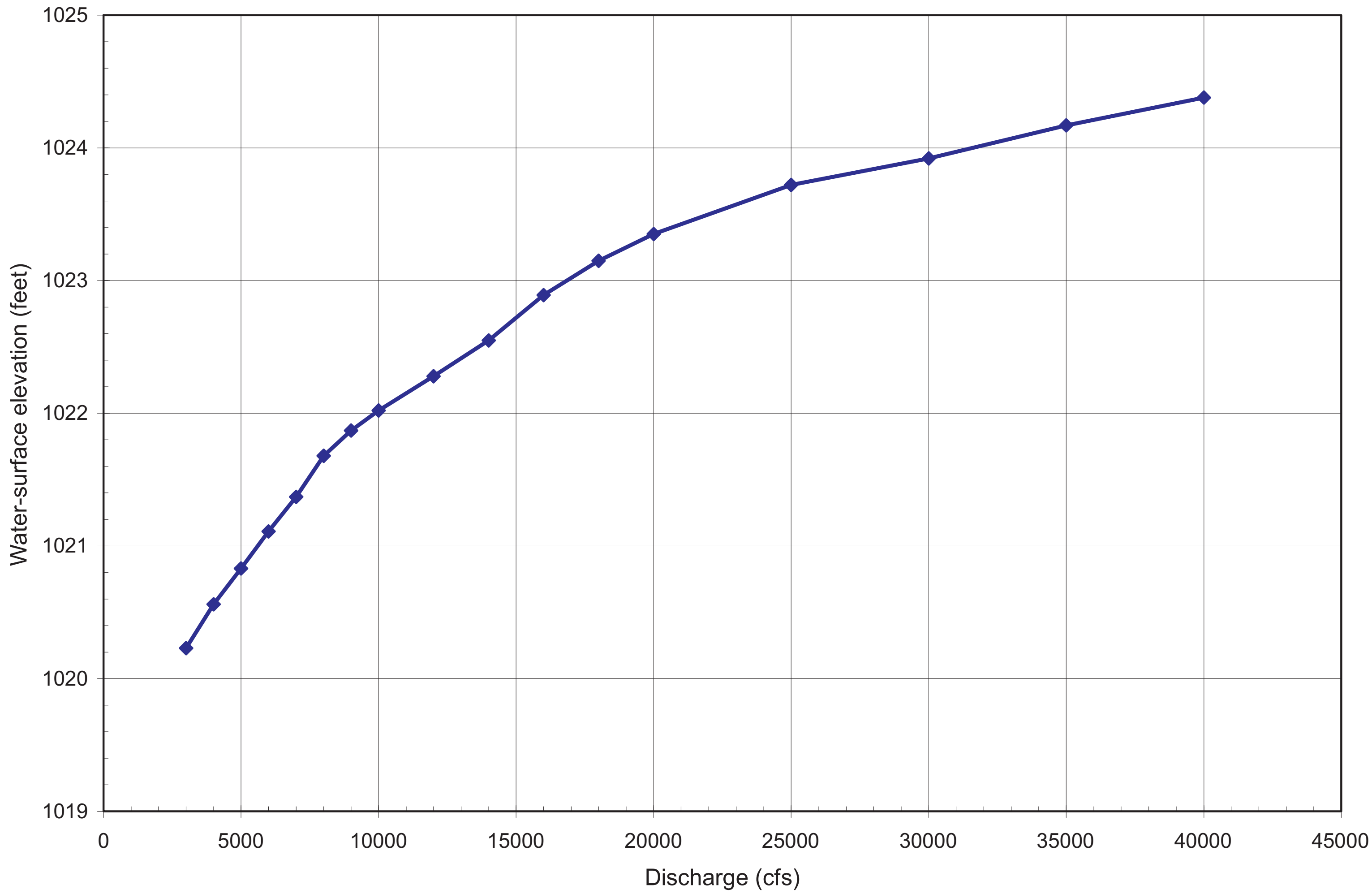
2D Model Calibration

The SRH-2D hydraulic model was calibrated to surveyed water-surface elevations at varying discharges and locations throughout the Study Reach (Figure 23). The model was also validated by comparing modeled and field-measured velocities at specific locations with the mesh. Calibration was achieved by refining Manning's n-values within physically reasonable limits throughout the Study Reach based on the change of roughness due to complex topography and bedforms. To improve calibration, the boundary conditions were refined to more accurately reflect the distribution of flow at the upstream end and the variation in water-surface elevations between the north and south flow paths at the downstream end.

Predicted water-surface elevations for a range of flows from approximately 3,700 to 4,800 cfs are in good agreement with measured values that were collected in conjunction with the topographic data on which the hydraulic model is based (Figure 24). Approximately 98 percent of the computed results are within +/- 0.5 foot of the measured values, and the standard deviation of the residuals is approximately 0.24 foot. Model results at higher discharges also compare well to water-surface elevations that were surveyed during the June 2008 and May 2009 field visits (Figure 25). In addition to evaluating computed water-surface elevations, the model was further validated by comparing the predicted velocities to field measurements collected at the time of the detailed survey (Figure 26).

2D Hydraulic Analysis

Results from the model were used to evaluate the change in hydraulic conditions and bedform characteristics over a range of discharges, and to aid in identifying habitat types based on the local hydraulic characteristics. The range of discharges analyzed corresponds with the average minimum and maximum observed during the data collection effort. In general, the hydraulic results indicate that at lower discharges in the range of 3,700 cfs, channel velocities vary significantly throughout the detailed Study Reach from stagnant flow in backwater areas up to about 5 feet per second (fps) (Appendix C). Channel depths at 3,700 cfs typically range up to 3 feet, but depths of more than 6 feet also occur in localized areas (Appendix D). As expected, flow characteristics within this detailed study reach become more uniform as the discharge increases. At 40,000 cfs, predicted channel velocities range from 2.8 to 9.8 fps, with the majority of the velocities greater than about 4 fps (Appendix C). Predicted depths at this discharge range



Stage-Discharge Rating Curve used as Downstream Boundary Condition in the 2-D Model

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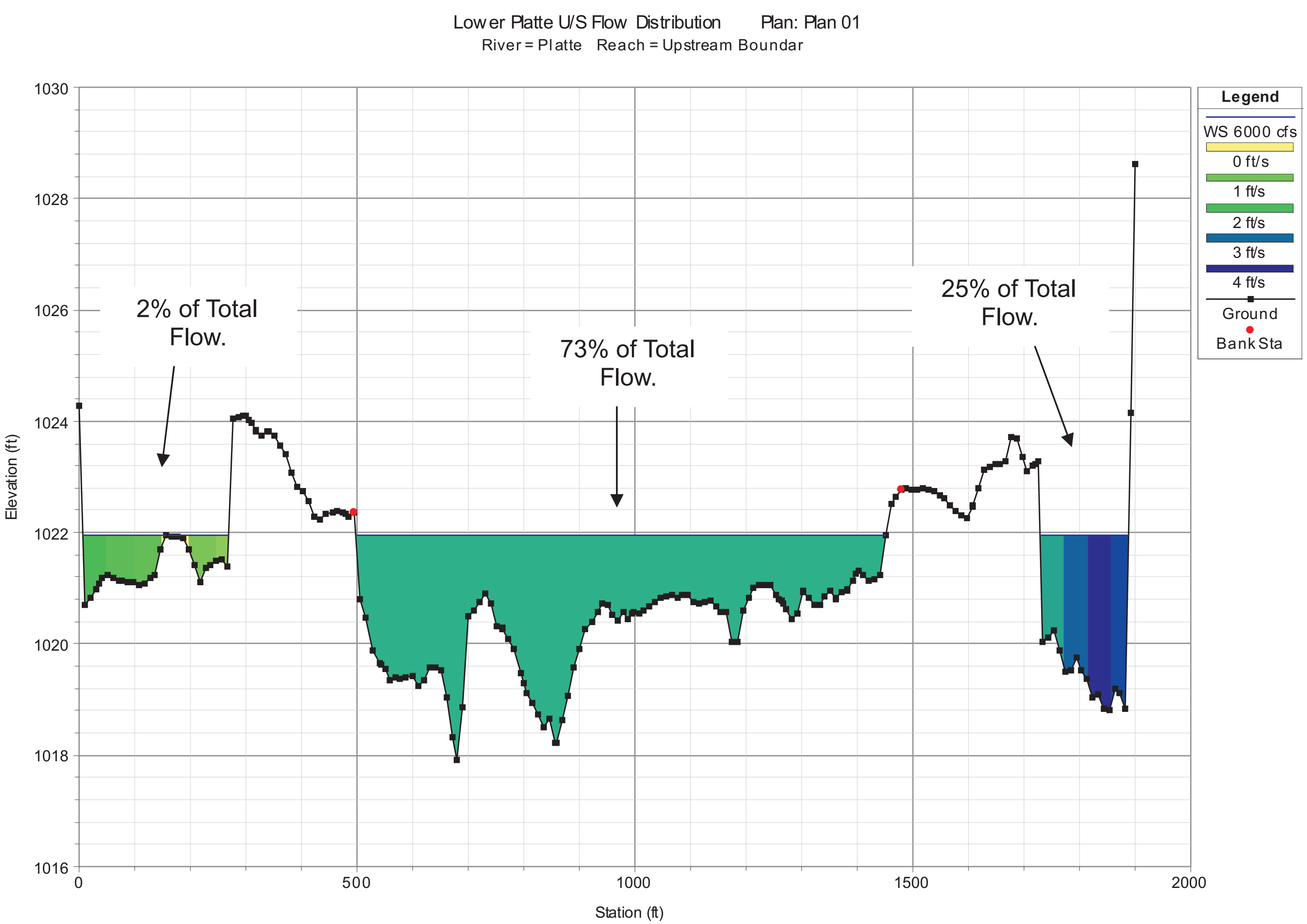

Approximate Flow Distribution at the Upstream End of the 2-D Model Study Area

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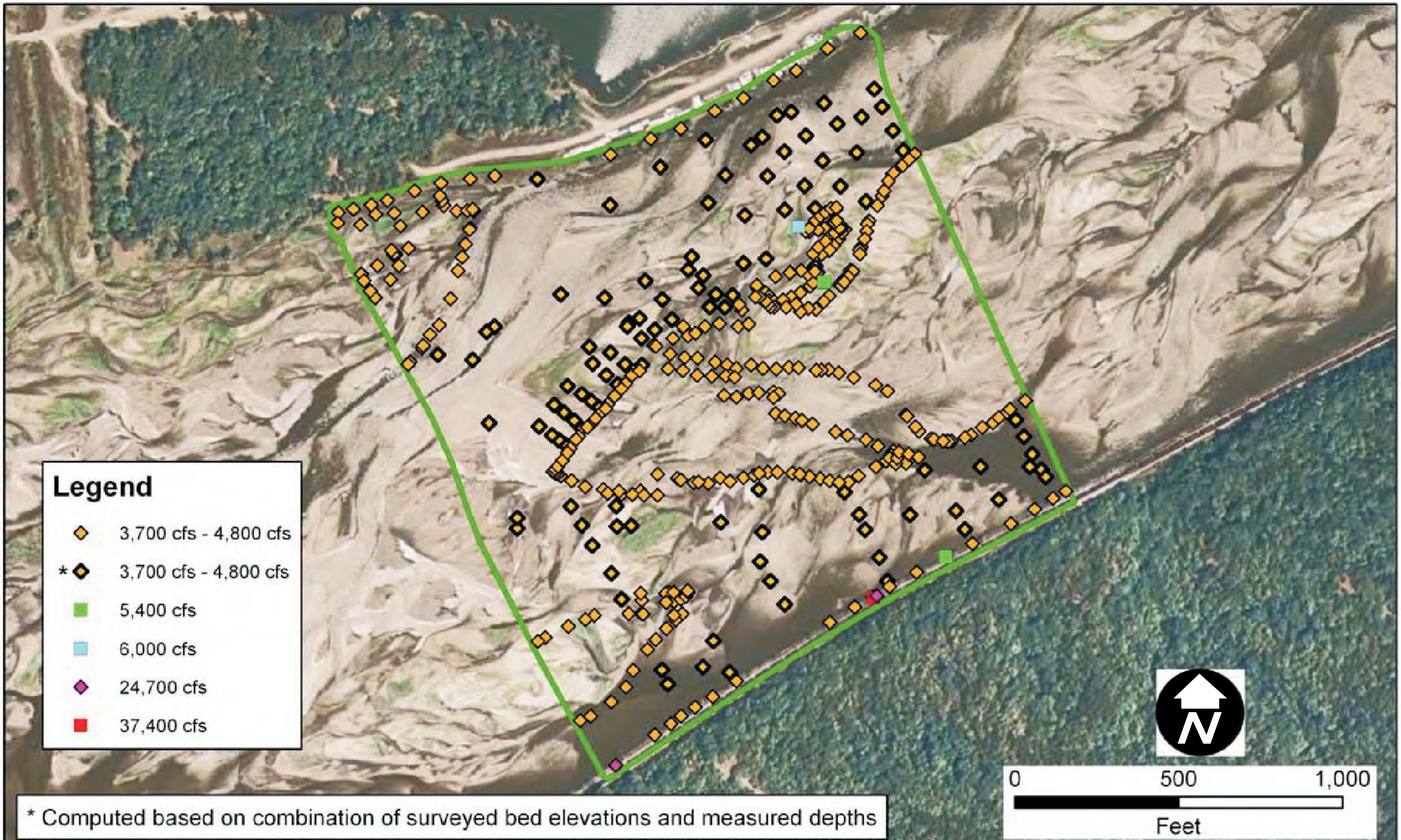

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Surveyed Water-surface Elevations Used for Model Calibration.

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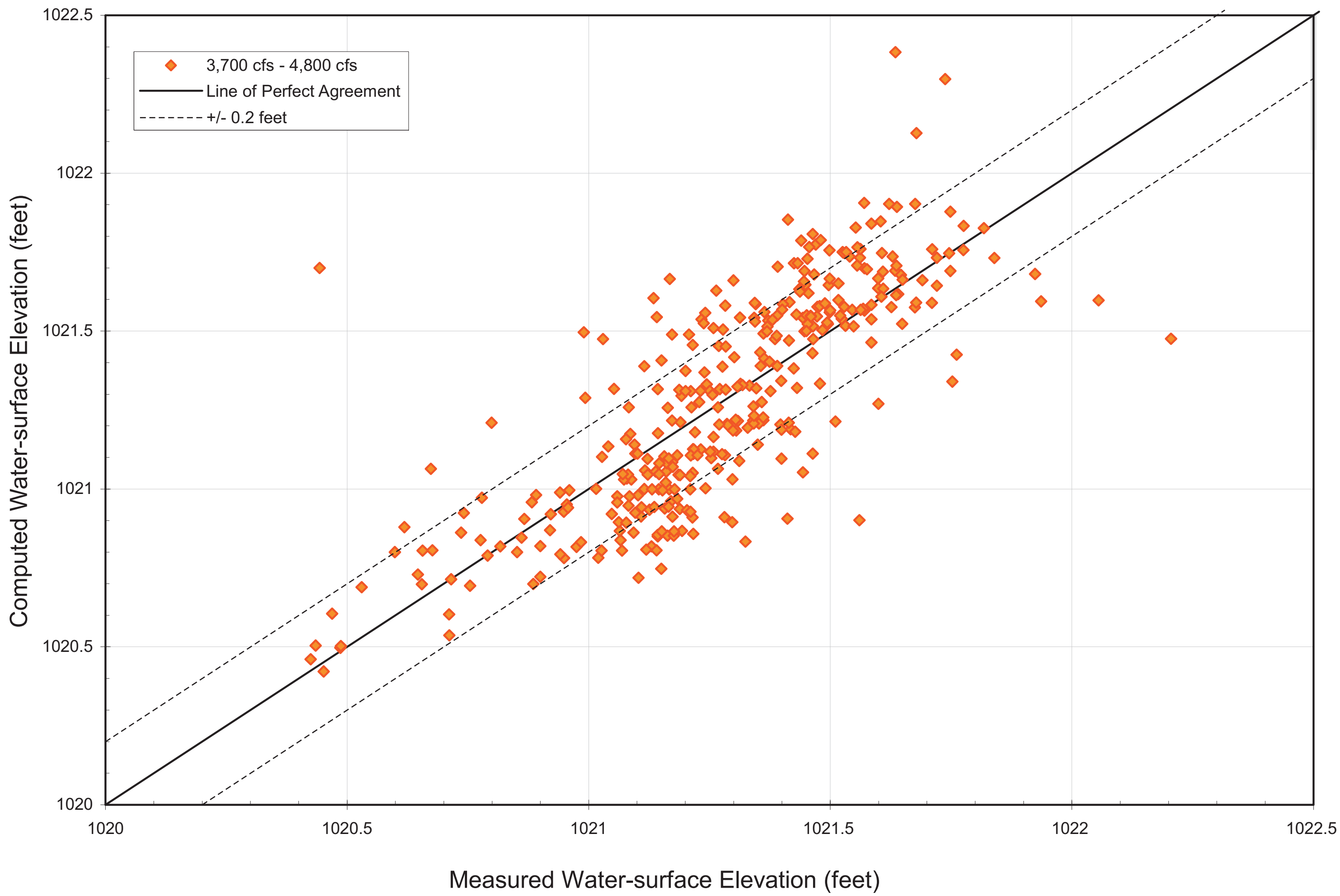

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SRH-2D Predicted Water-Surface Elevations vs. September 2008 Measured Values

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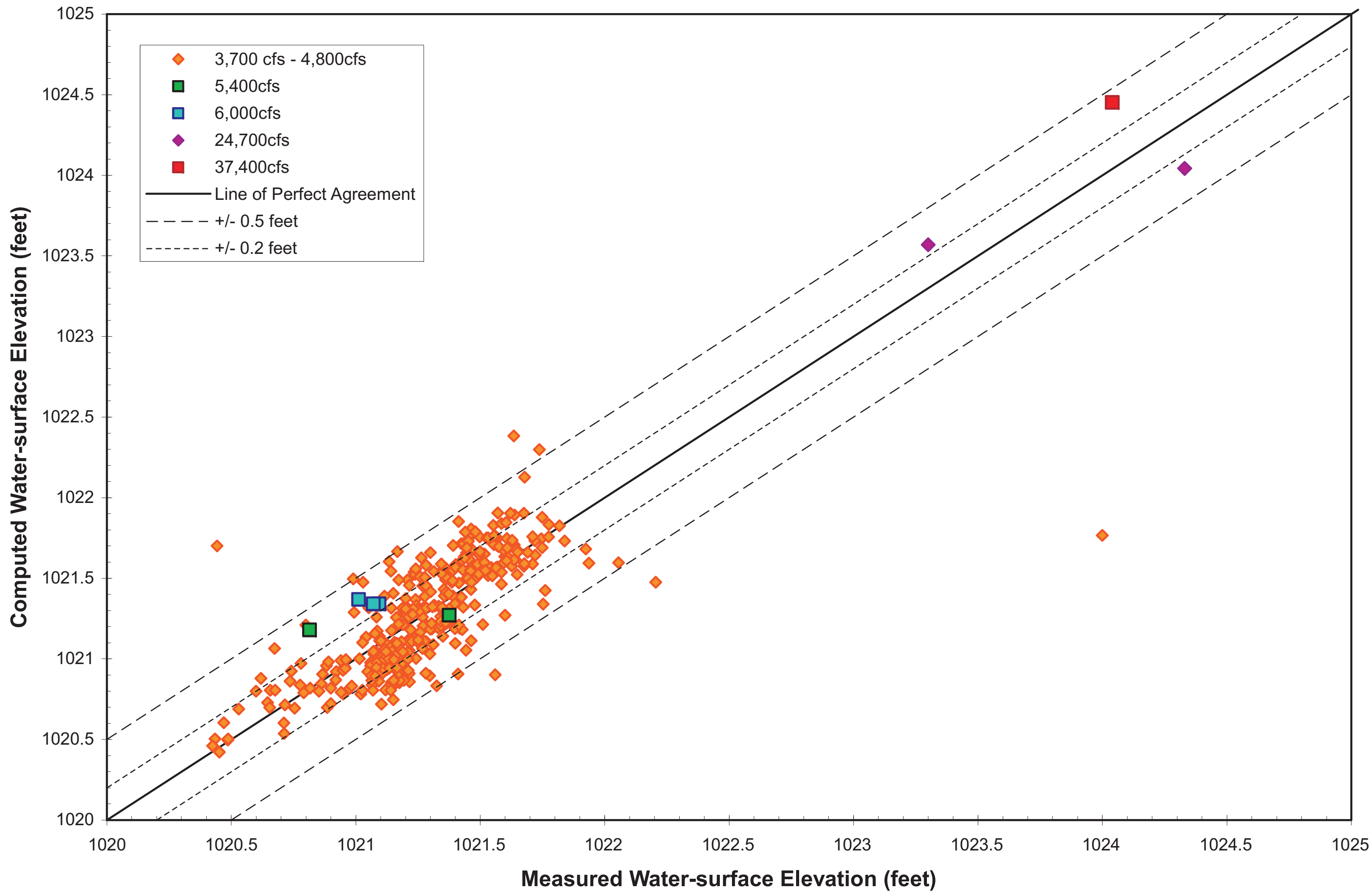

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SRH-2D Predicted Water-Surface Elevations vs. June 2008, September 2008, and May 2009 Measured Values

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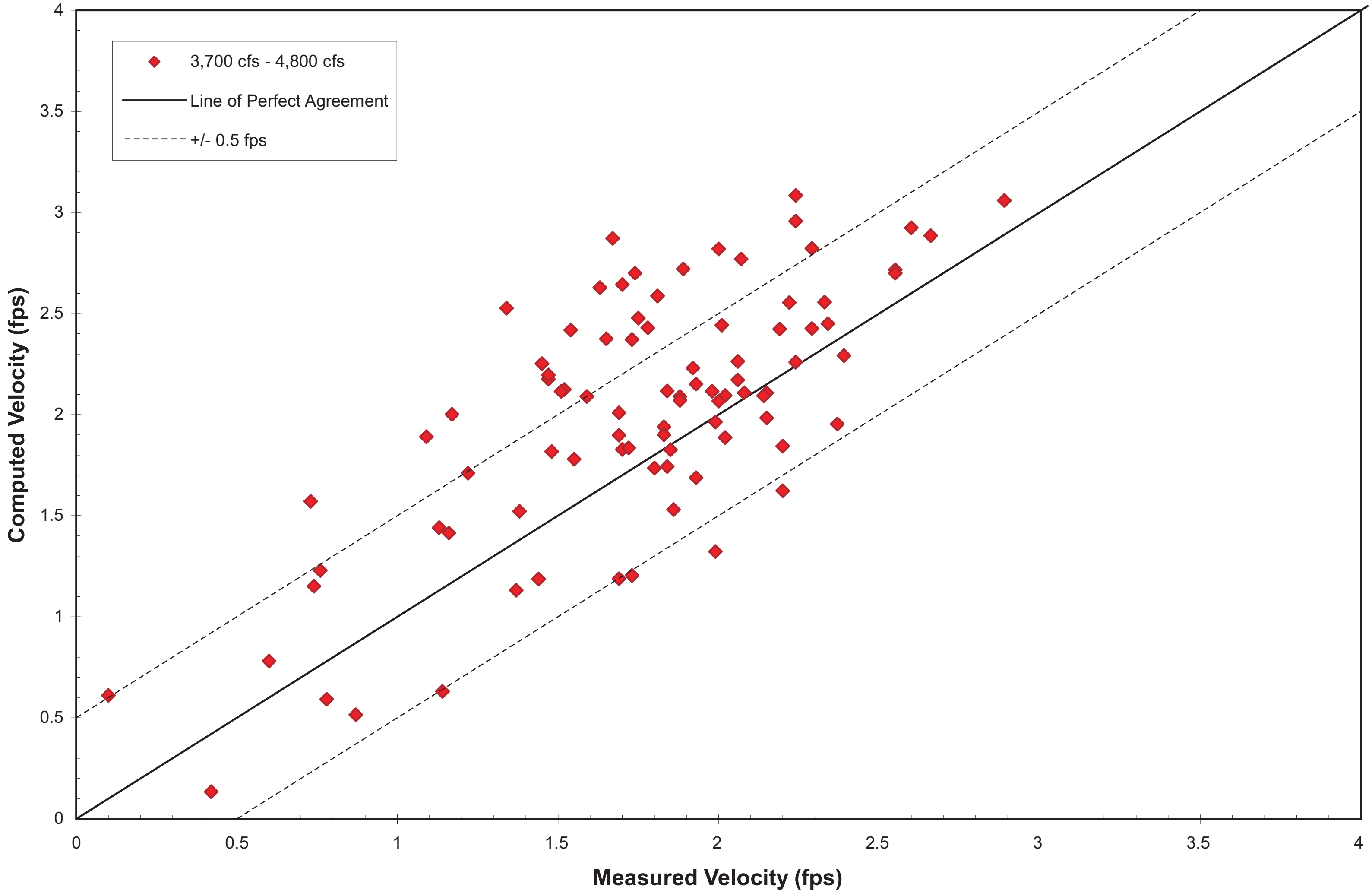

SRH-2D Predicted Velocity vs. September 2008 Measured

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from about 1 to 11.5 feet, but most are between about 3 and 7 feet (Appendix D). It should also be noted that the topography used in the model represents data collected at a flow of about 4,300 cfs, and because the micro-scale topography of the channel is likely to adjust at higher discharges, resultant depths and velocities could be somewhat different than those predicted by the model.

Bedform Analysis

Overview

Flow over alluvial sediment creates bedforms and bed configurations at a variety of scales that affect the hydraulic and sediment transport characteristics of the flow through their impact on flow resistance, depth and velocity patterns, and the rates at which the sediment is entrained and transported downstream. These bedforms and bed configurations, in turn, affect in stream habitat by creating a mosaic of physical features that are important to the species that are present in the river (Hawkins et al., 1993; Vadas and Orth, 1998; Polivka, 1999; Kehmeier, et al, 2007). Consistent with a hierarchy that was originally introduced by Jackson (1975) and subsequently modified and successfully applied to the sand-bedded Pecos River in New Mexico by Mussetter Engineering, Inc, (2004), three scales of bed configurations are present in the Study Reach. These scales are macro-, meso-, and micro-, as previously defined.

Based on the current knowledge of habitat requirements for the pallid sturgeon (*Scaphirhynchus albus*), diversity in flow depth and velocity associated with meso-scale bedforms (i.e., sand bars) and pockets of deeper and slower flow caused by local scour are the key hydraulic features that determine habitat. In this context, sand bars are defined as bedforms having lengths of the same order as the channel width or greater, and heights comparable to the mean depth of the generating flow (Task Force on Bedforms, 1966). Subaerially exposed mid-channel bars are a necessary feature of braided river patterns, and because of the implicit importance of bars in braided rivers such as the lower Platte River, bar types and the processes of bar development have been the focus of much research. Unfortunately, much of the research has generated confusion regarding processes of bar formation because of the proliferation of bar terminology (Smith, 1978).

In an attempt to classify bedforms into a unified hierarchy, Jackson (1975)[1] introduced the terms macroforms (bars), mesoforms (dunes), and microforms (ripples). He concluded that unlike mesoforms and microforms, macroforms are not directly related to the fluid flow regimes. Crowley (1983) and Blodgett and Stanley (1980) concurred with Jackson's differentiation of the bedforms and clearly characterized linguoid or lobate bars as macroforms. However, actively migrating linguoid bars frequently have actively migrating microforms (ripples) on their stoss sides, and dunes are often present in the channels along the margins of the linguoid bars (Crowley, 1983; Germanoski, 1989).

Smith (1974) and Church and Jones (1982) classified bars into four main types: (1) longitudinal, (2) transverse, (3) point, and (4) diagonal. Longitudinal bars are diamond-shaped, elongate parallel-to-flow features that develop by grain-by-grain accretion of the coarser fraction of the sediment load (Leopold and Wolman, 1957). Transverse bars have a crest that is essentially perpendicular to flow direction, most commonly lobate in shape, and flow diverges radially over them. The lobate bars have also been referred to as linguoid bars (Allen, 1968; Collinson, 1970; Blodgett and Stanley, 1980). Point bars form on the insides of bends and are most often

[1] Note that, although Jackson (1975) defined dunes as a meso-scale form, all the forms associated with the progression from ripples to dunes to upper regime flow are defined as micro-forms for purposes of this study.

associated with meandering rivers, but they are also common in braided rivers (Miall, 1977). Diagonal bars have their crests oriented at high angles to flow and commonly form riffles in gravel-bed rivers (Church, 1972; Church and Jones, 1982).

Germanoski (1989) has suggested that in the context of braided rivers, most bars can be classified as either linguoid or braid bars, while recognizing that both point and riffle-forming bars are also present. Linguoid bars are submerged, actively migrating, parabolic- or lobate-shaped positive bed elements that are bounded by an avalanche face along the downstream margin (Figure 27). The bars can occur at both the macro-scale (i.e., spanning the channel width) or at the meso-scale (i.e., spanning the width of individual chute channels between braid bars). The avalanche faces are frequently steeper and have greater overall height on one side of the bar than the other, which may in some cases grade into the channel bed. Although the parabolic or lobate shape is most common, many bars have sinuous or multi-lobed margins that form in response to local variations in the intensity and direction of the main flow paths. Linguoid bars occur in zones of high bed-load transport. The highest velocities over lobate bars typically occur along the centerline of the bar (Figure 27), and flows diverge radially across the bar crest, which promotes deposition on the downstream portion of the bar. Continual scour on the upstream portion and deposition on the downstream portion of the bar allows the bar to retain its overall shape while migrating downstream.

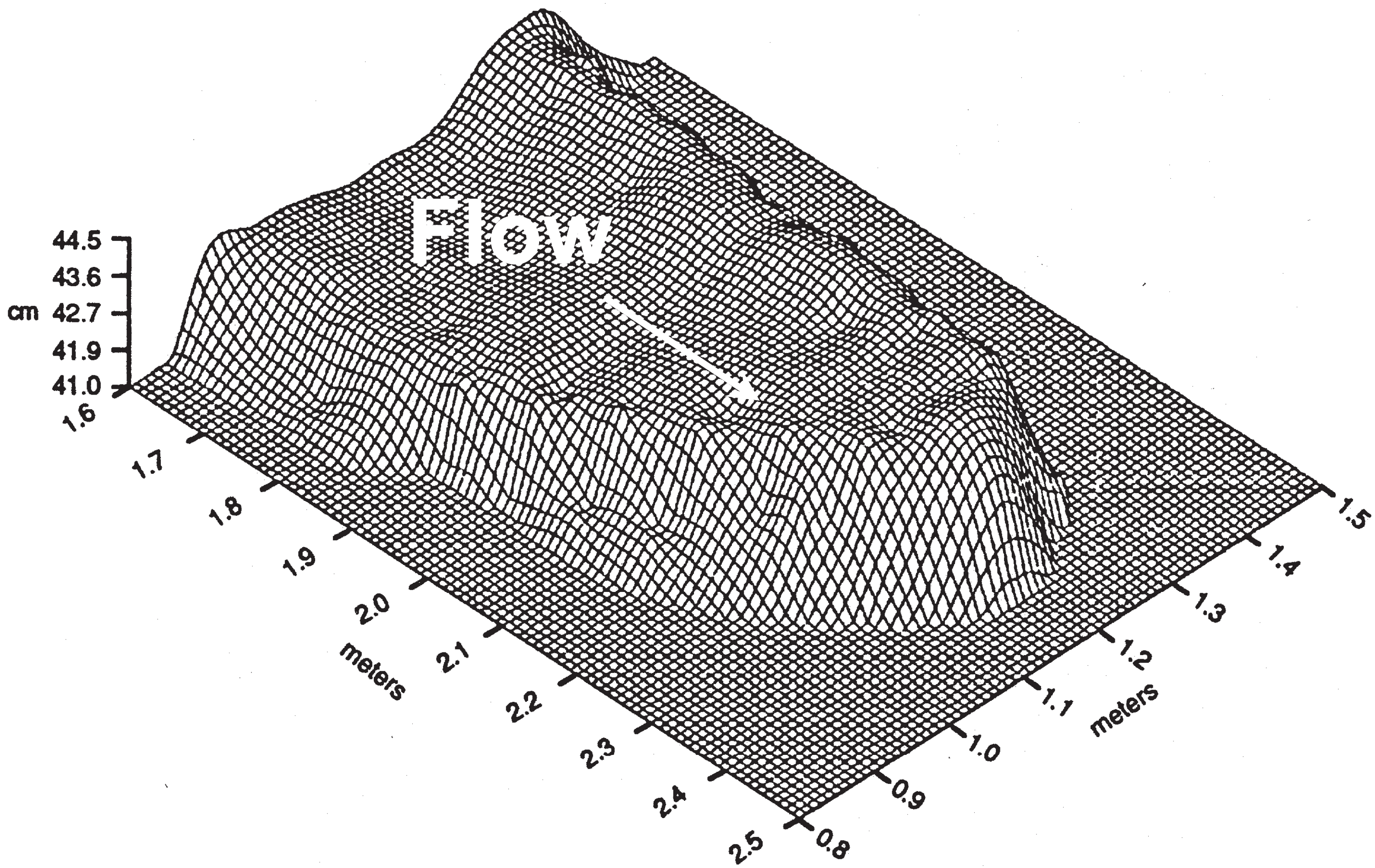
Flume experiments by Germanoski (1989) indicate that there is a direct relationship between sediment supply and linguoid bar development in sand-bed channels. These experiments also showed that the number of bars is a function of sediment supply, which indicates that bar development is supply limited. During high discharges in large, sandy, braided rivers such as the lower Platte River, almost the entire bed is a mobile complex of linguoid bars stacked en-echelon and side by side (Brice, 1964; Blodgett and Stanley, 1980).

Braid bars are stationary, subaerially exposed bars that represent the remnants of the linguoid bars that form at high flows, and they are, therefore, sites of sediment storage at low to intermediate flows. These bars are typically elongate features that are oriented parallel or sub-parallel to the flow, and they separate flows into distinct channels that are often occupied by migrating linguoid bars. Braid bars are formed primarily by dissection of stalled linguoid bars, a dynamic process that results from the interaction between the flow and bar shape that continuously exert a mutual influence on each other. Once the braid bars are formed, they grow by grain-by-grain accretion and accretion of parts of other stalled bars. Once subaerially exposed, braid bars are sculpted by marginal flows into more streamlined, longitudinal forms (Komar, 1983 and 1984). Braid bars are, therefore, sediment storage zones that are formed by both depositional and erosional processes.

The coexistence of the various scales of bedforms indicates that the local flow and velocity distributions created by the presence of the macroform features has a significant effect on the presence and character of the meso- and microforms. At a given discharge, the presence or absence of the meso- and microforms is controlled by the hydrodynamic effects of the macroform. Thus, under low-flow conditions in a sand-bed channel, actively migrating ripples and dunes may be present in some localized reaches and not in others, depending on the location of the actively migrating linguoid bars.

Bedforms

The characteristics of the micro-scale bedforms follow a predictable pattern from low energy to high energy conditions that is directly related to the size of the bed sediment and the hydraulic characteristics of the flow (Figure 28). As a result, the type of bedform that is present at any



Note the scour channel on the stoss (upstream) side and the steep slip face on the lee (downstream) side.

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Three-dimensional Plot of an Ideal Linguoid Bar

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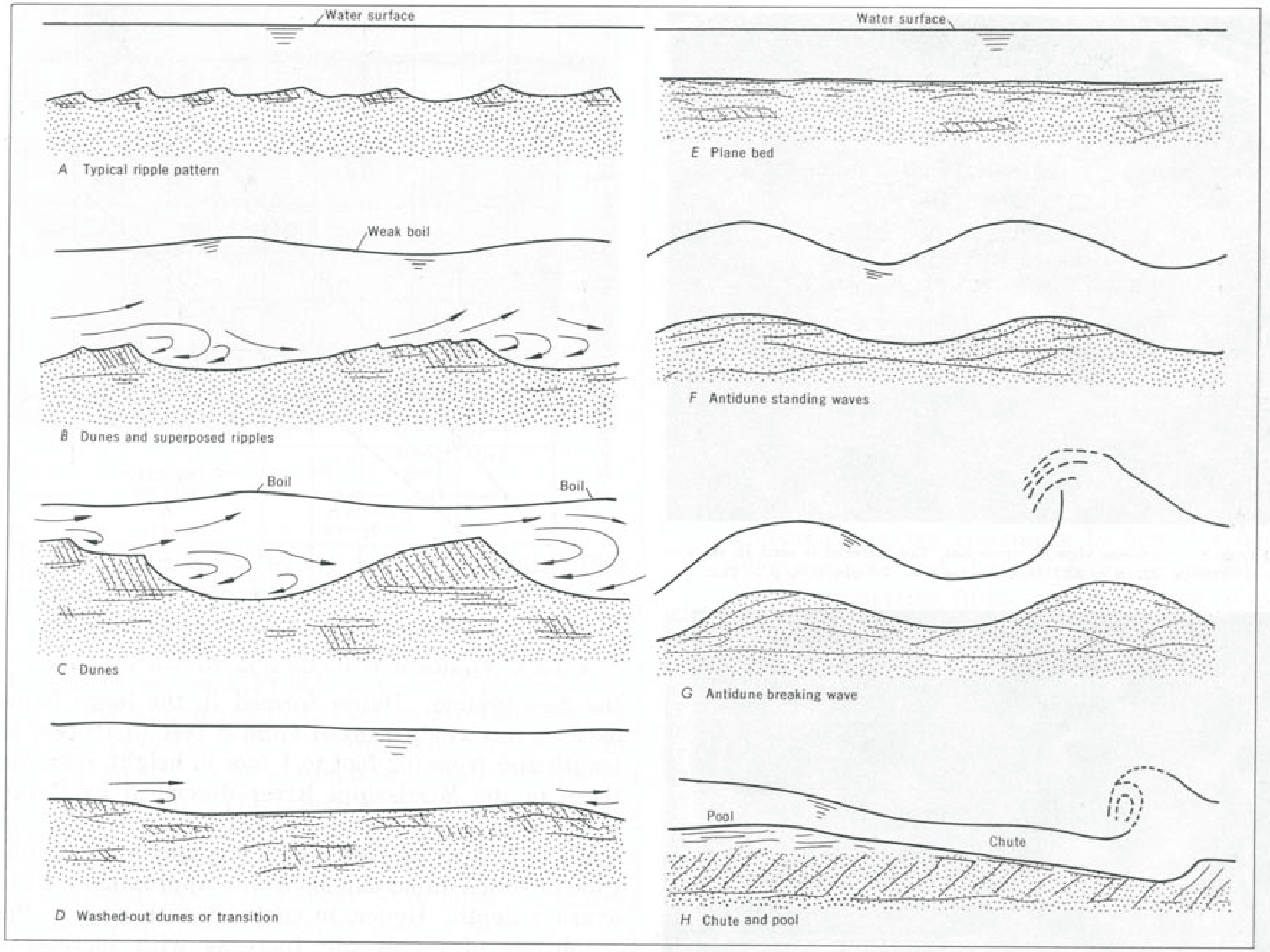

from Simons and Richardson, 1966

Forms of Bed Roughness in an Alluvial Channel

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Figure
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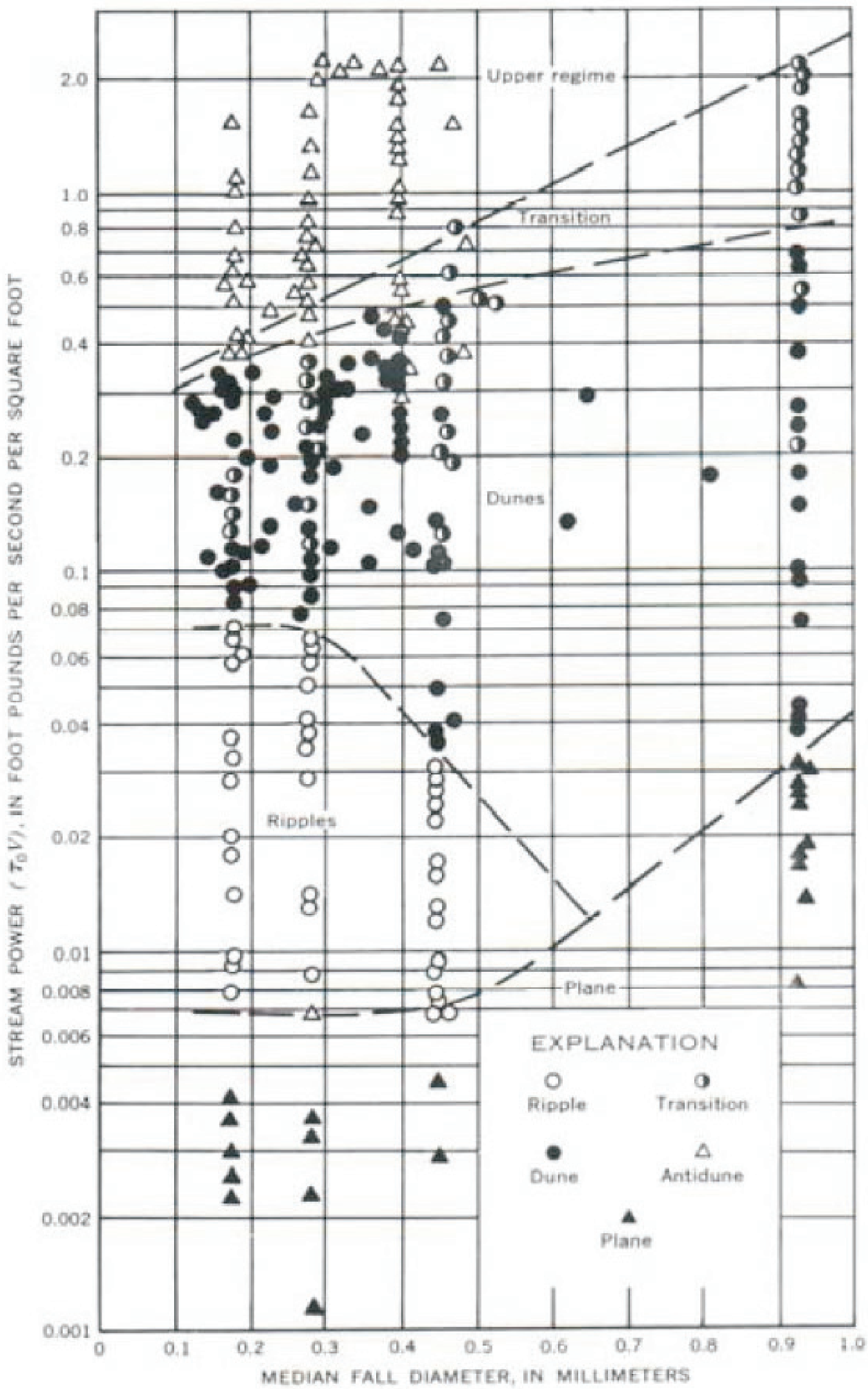
given location varies with time as the discharge changes. The presence and type of bedforms are important to this Study because their effect on hydraulic resistance to flow and, thus, channel stage varies significantly over the continuum of bedform types (Nordin, 1964; Simons and Richardson, 1961: Middleton and Southard, 1984; Bennett, 1995). In addition, bedform type is indicative of the type of meso-scale habitat that is present at any particular location, and the individual bedforms (particularly dunes) can affect habitat by creating hydraulic diversity at the micro-scale.

Numerous methods for predicting bedform type have been presented in the literature based on both laboratory and field data and analytical techniques. One of the most commonly used methods was originally presented by Simons and Richardson (1966) as a phase diagram that relates bedform type to the median fall diameter of the bed sediment and the stream power (Figure 29). The data on which Figure 29 is based were derived from a combination of laboratory and field data from the Elkhorn and Middle Loup rivers in Nebraska, the Rio Grande in New Mexico, the Punjab Canal in India, and a variety of other canal data. This relationship has been criticized because it was presented in dimensional form, and thus, it is subject to scale effects when applied outside the range of the original data, particularly in large, deep rivers such as the Mississippi and lower Missouri. Others, including van Rijn (1984), developed dimensionless relationships that should not be subject to the same scale effects as the Simons and Richardson (1966) relationship. Bennett (1995) adopted the classification scheme of van Rijn (1984) to develop an analytical relationship for predicting bedform type and dimensions as a function of the dimensionless grain size ($d_* = D_{50}\{(SG-1)g/\nu^2\}^{1/3}$)) and the dimensionless transport strength (S'_*) (Figure 30). The specific boundaries in Figure 30 were established based on a broad range of field and laboratory data from Brownlie (1981), Guy et al. (1966) [the laboratory data set on which the original Simons and Richardson (1966) relationship was, in part, based], and Nordin (1976).

A key feature of the Bennett (1995) relationship is that it quantifies the two well-recognized components of hydraulic resistance (grain resistance and form drag) that were described by Einstein and Barbarossa (1952) and subsequently refined by a number of more recent studies, including Engelund (1966 and 1967) and Smith and McLean (1977). In applying this concept, which is referred to as *shear partitioning*, grain resistance for a particular flow is considered to be the same as that for a plane bed flow at the same depth (van Rijn, 1982 and 1984); thus, it can be quantified using the standard logarithmic vertical velocity profile from basic fluid mechanics, with the characteristic roughness height defined as a multiple of the bed material size. The remaining portion of the flow resistance is caused by form drag that is associated with a variety of factors, including the size and shape of the bedforms, non-linearity of the channel, and in-stream debris, among others. In quantifying grain and form resistance, it is customary to separate the hydraulic radius (or depth in wide channels) into two parts, that due to grain resistance (R') and that due to form roughness (R''). Bed material transport rates, and thus, the processes that create the bedforms, are controlled by the grain resistance, while the total channel roughness can be significantly influenced by the form roughness.

Numerous definitions for the characteristic roughness height (k_s) that is necessary to apply the semi-logarithmic velocity profile have been proposed that are typically applicable to a specific range of bed material sizes. In developing his relationship, Bennett (1995) found that the value suggested by Engelund and Hansen (1967) of $k_s = 2.5D_{50}$ (where D_{50} is the median grain size of the bed material) provided the best results for defining the grain shear stress in sand-bedded systems. To estimate the magnitude of the form drag caused by the bedforms, Bennett (1995) used a relationship developed by Nelson et al. (1993) based on the relationship between the average velocity that would exist over the height of the bedform if it were removed from the flow



from Simons and Richardson, 1966

Bedform Predictor

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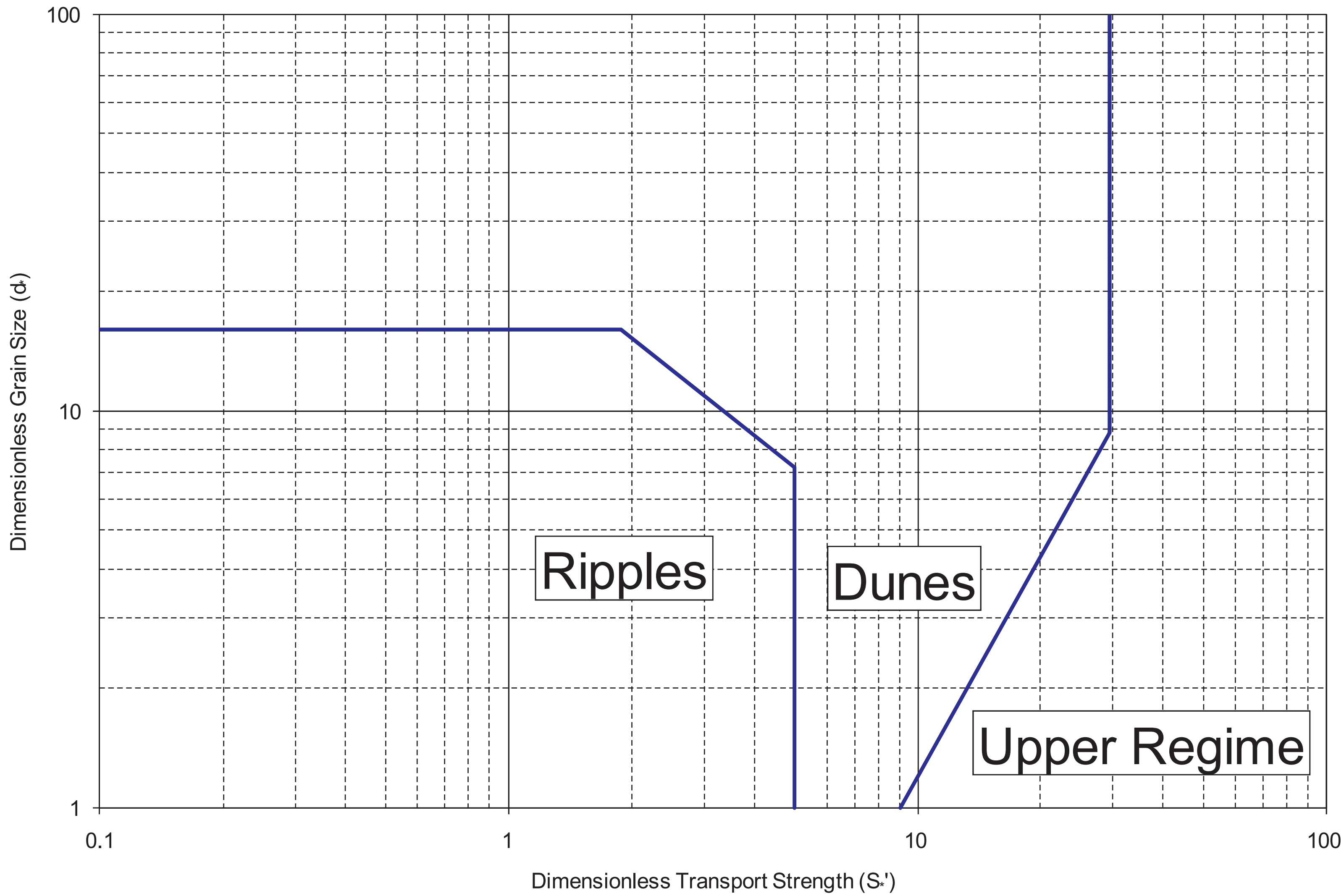

from Bennett, 1995

Classification Scheme for Bedform Regions

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Figure
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field and the average velocity at that location in the presence of the bedform. This relationship is given by:

$$\frac{\tau_0^{'}}{\tau} = 1/(1 + \frac{C_d}{2_K^{-2}} \frac{\Delta}{\lambda} ln^2 \frac{11\Delta}{k_s}) \tag{1}$$

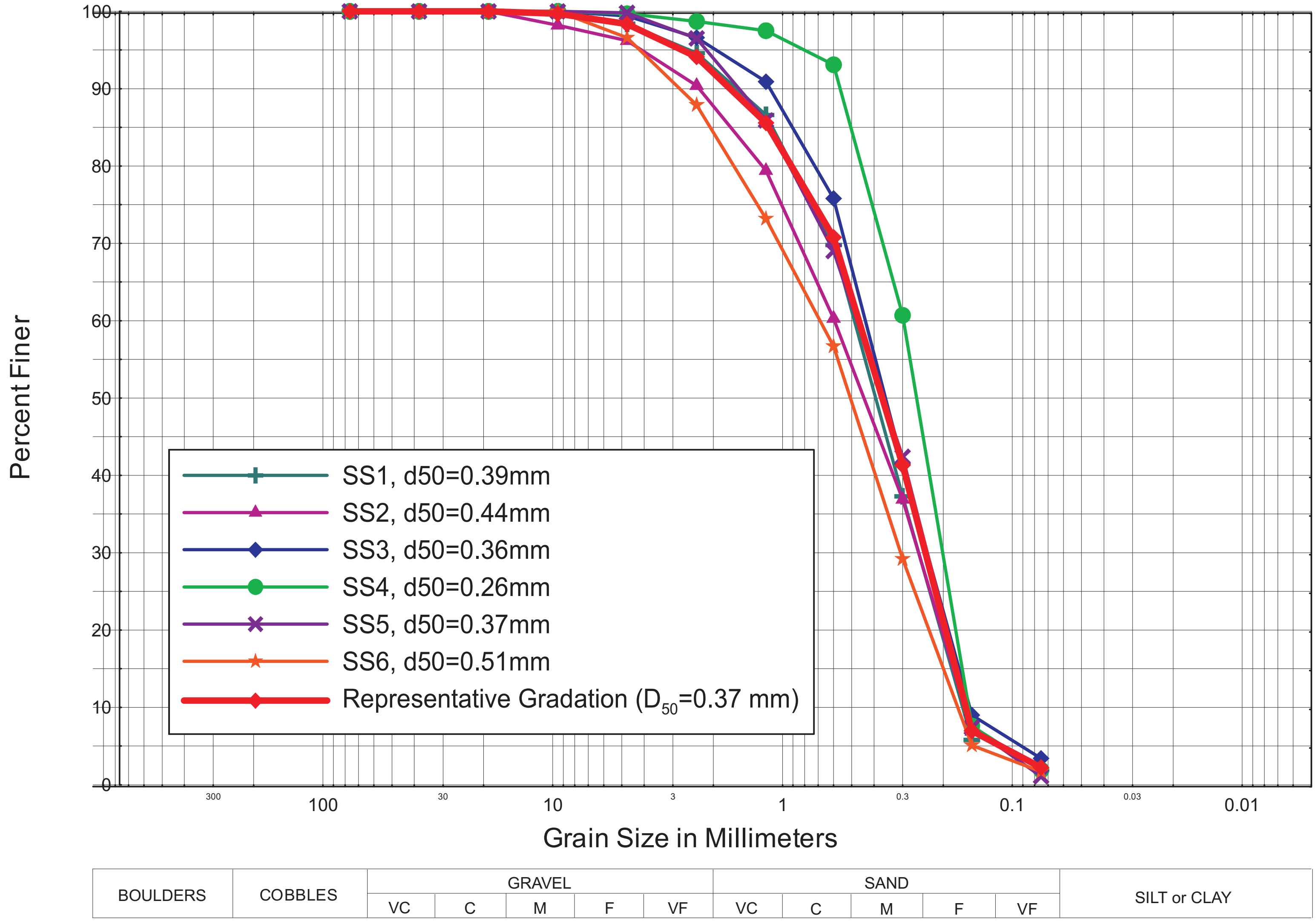
where $\tau_0^{'}$ is the shear stress due to grain resistance, τ is the total shear stress, C_d is the drag coefficient = 0.2, κ is the von Karman constant = 0.4, Δ is the bedform height, λ is the bedform length, and k_s is the characteristic roughness height. (As noted above, Bennett assumed k_s = $2.5D_{50}$). In the above relationship, the form drag is simply the difference between the total shear (τ) and the grain shear stress ($\tau_0^{'}$). Ripple size and geometry are primarily associated with bed particle size and are independent of hydraulic characteristics, and the ripple data set used in Bennett's (1995) analysis indicates that ripple length (λ) $\cong 1{,}000D_{50}$ and steepness ratio (Δ/λ) averages 0.074; thus, ripple height $\Delta \cong 74D_{50}$. Dune height, on the other hand, is a function of the hydraulic characteristics, and Bennett (1995) used the following modified form of the relationship originally proposed by van Rijn (1984) to quantify dune height:

$$\frac{\Delta}{h} = A\left(\frac{D_{50}}{h}\right)^{0.3} \left(1 - e^{0.5S_*^{'}}\right)\left[(S_*^{'})_u - S_*^{'}\right] \tag{2}$$

where h is the flow depth, A is a constant suggested to be ~0.11 by van Rijn (1984), but calibrated to a value of 0.164 by Bennett (1995), S'_* is the sediment transport strength defined as (τ'/τ_{cr}-1), and $(S'_*)_U$ is the transport strength at the threshold between dunes and upper regime flow. The critical shear stress (τ_{cr}) is quantified using the Shields relationship given by $\tau_{cr}=F^*(SG-1)\gamma D_{50}$, where F^* is the Shields parameter assumed here to be 0.047 (Meyer-Peter, Muller, 1948), SG is the specific gravity of the sediment (assumed to be 2.62), and γ is the unit weight of water (62.4 lb/ft^3).

For purposes of this Study, the transport strength ($S^{'}_*$), bedform type, and bedform height (Δ) were estimated for each node in the 2D model grid for each modeled discharge based on the hydraulic conditions predicted by the model and the representative bed material grain size (D_{50}) of the Study Reach. Based on six grab samples of the surface bed material within the reach covered by the 2D model, the median (D_{50}) size of the bed material is about 0.37 mm (Figure 31). For purposes of estimating the bedform characteristics, the median size was rounded up to 0.4 mm. Because of the form of the above equations, it is not possible to solve directly for the grain shear stress and bedform height. A VisualBasic program was therefore developed for this purpose that iteratively solves for the necessary values by initially computing the grain shear stress and bedform height from Equations 1 and 2, above, based on the total shear stress, comparing the resulting value of $\tau_0^{'}$ and adjusting the value until the initially assumed value and the computed value match within a reasonable tolerance.

The predicted bedform types from the above procedure were mapped over the model domain for each discharge (Appendix E), and the percentage of the total area of the site and only the portion of the site represented by each type of bedform was then computed based on the spatial distribution of the estimated bedforms (Figures 32 and 33). The results for the 4,300-cfs model run (Appendix E2) are very consistent with the bedforms observed during the field data collection. Based on these results, the subaerially exposed portion of the site varies from about 30 percent at 3,700 cfs to about less than 1 percent at discharges above 20,000 cfs (Figure 32).



Curves for six grab samples of the surface bed material within the reach covered by the 2-D model. Also shown is a representative gradation curve for the reach based on the average of the six samples.

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Grain Size Distribution Curves

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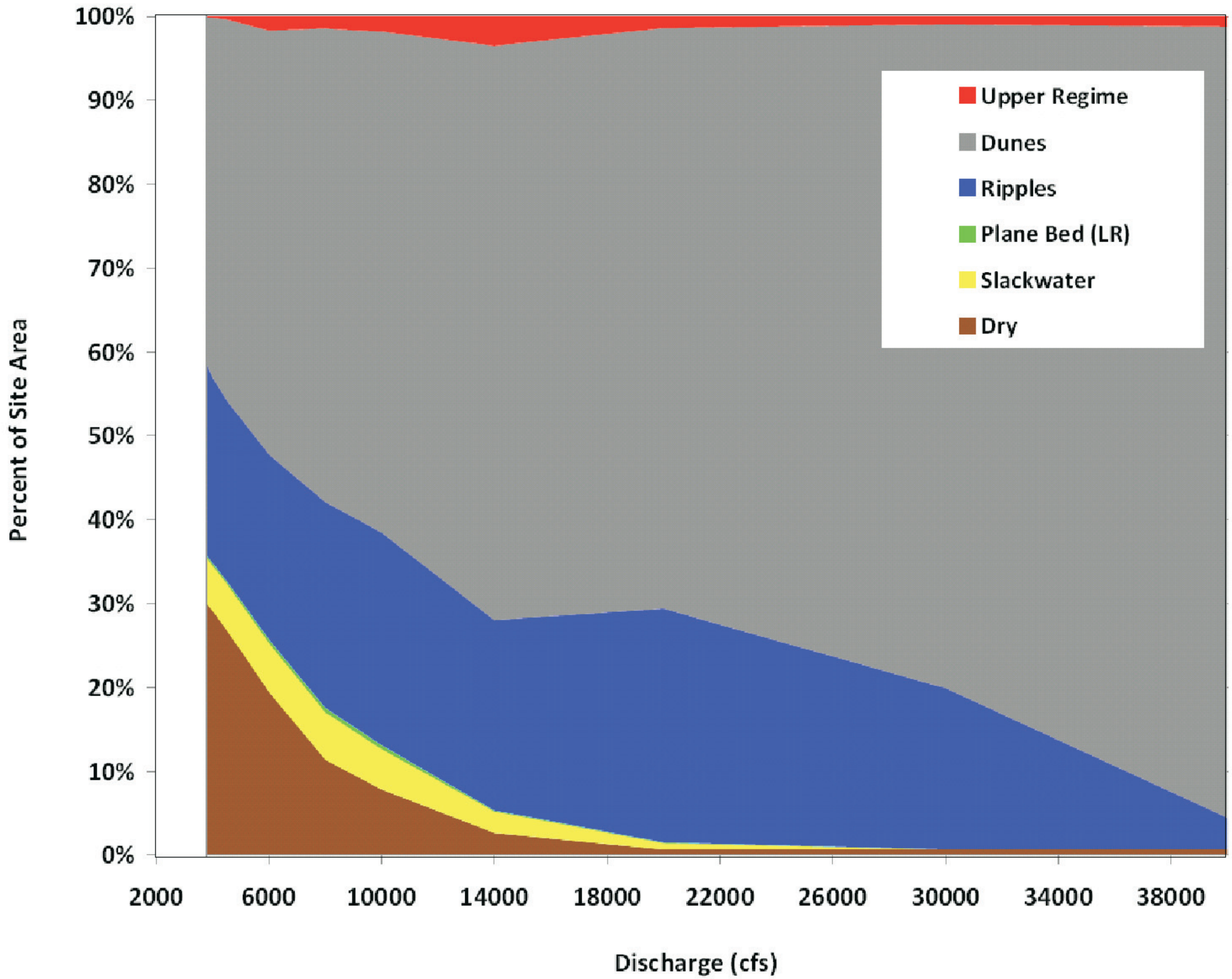

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Estimated Percentage of the Total Modeled Reach Represented by each Bedform Type

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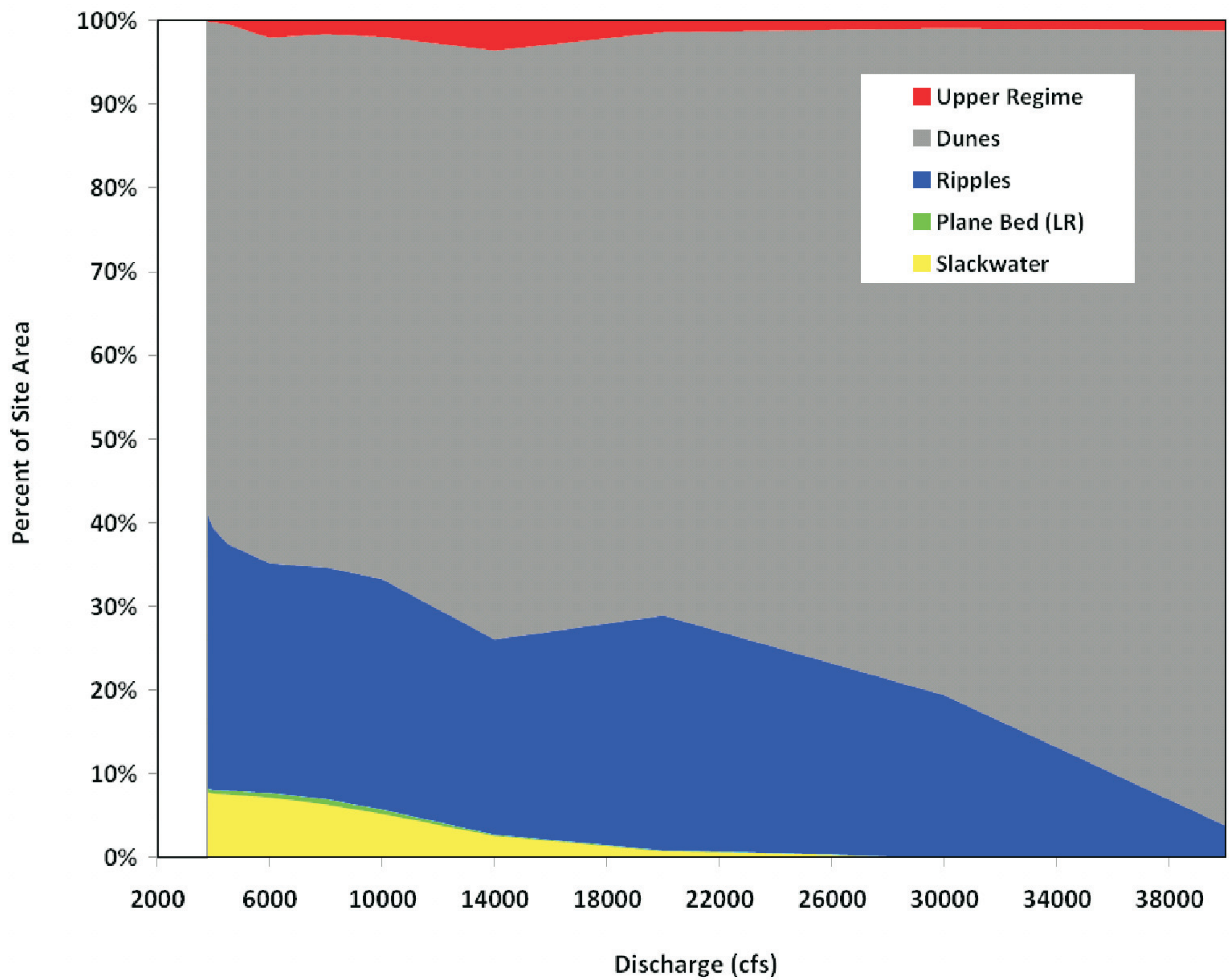

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Estimated Percentage of the Inundated Portion of Modeled Reach Represented by Each Bedform Type

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Figure
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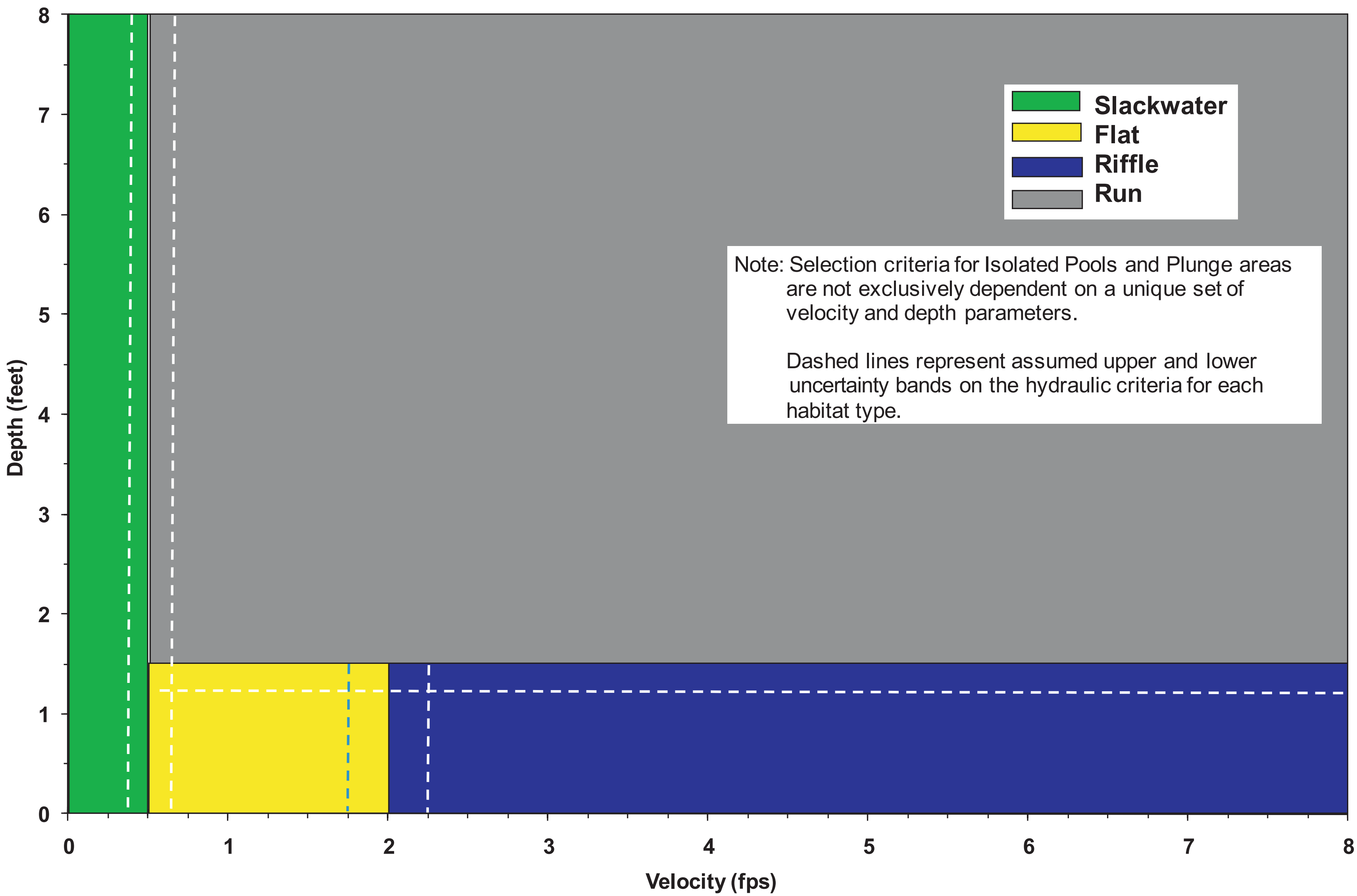
Ripples and dunes represent the largest proportion of the site, with the relative area of ripples in the inundated portion of the site decreasing from about 33 percent at 3,700 cfs to less than 4 percent at the highest modeled discharge of 40,000 cfs, and the area represented by dunes increasing from about 60 to 95 percent over this range of discharges (Figure 33). The slackwater areas also represent a significant portion of the sites at low flows, varying from about 8 percent of the inundated area at 3,700 cfs to about 5 percent of the site at 10,000 cfs, and then essentially disappearing at discharges above 10,000 cfs. Very little of the site is occupied by the plane bed (lower regime) category, even at the lowest modeled flows, because this category represents areas of moving water in which the shear stress is below the threshold for motion for the relatively sand-sized bed material. Somewhat surprisingly, very little of the site is also occupied by upper regime conditions, even at the highest modeled flows. In fact, the largest area of upper regime conditions occurs in the range from about 6,000 to 14,000 cfs, where relatively shallow, rapidly moving flow occurs in locally steep chute channels between the braid bars. The small amount of upper regime conditions at higher flows results from the relatively deep flow and flat overall gradient of the site. Evaluation of the areas occupied by dunes indicates that the median predicted dune height increases from 0.45 feet (~5.4 inches) at 3,700 cfs to 0.81 feet (~10 inches) at 40,000 cfs, with maximum heights ranging from 1.9 to 2.5 feet over this range of discharges.

Habitat Evaluation

Results from the 2D hydraulic model were used to evaluate changes in habitat with discharge and stage based on the local depth and velocity. For purposes of the analysis, six habitat classes were identified through a coordinated effort involving all members of the HDR team, including Dr. Mark Pegg, the fishery biologist who was involved in the field data collection for this Study and has been involved in a significant number of field exercises during which pallid sturgeon were captured, to fully describe the variability within the Study Reach. In developing the habitat classes, criteria based on depth, velocity, and connectivity that reflect the conditions within each habitat class were selected. The resulting classification scheme is described in Table 10 and Figure 34. Slackwater, Flat, Riffle, and Run habitat areas were identified strictly based on the hydraulic criteria and 2D model results. Isolated Pools were identified as any water feature disconnected from the main flow channel based on the assumption that any given discharge was preceded by a higher flow or groundwater connection that could have supplied water to those areas. The Plunge areas represent a complex habitat that is characterized by not only a rapid change of depth, but also its spatial location relative to bars and banklines within the detailed study reach. As a result, the following specific criteria were used to identify the Plunge areas:

1. Potential Plunge areas were visually identified based on a localized and rapid change in topography and locally steep channel bed gradients that occur along the margins of actively migrating bars.
2. Cross section plots of each potential Plunge area were then developed to evaluate the approximate dimensions of the identified feature. Based on the dimensions, a reference depth that represents the approximate depth of the Plunge pool relative to the average channel bed elevation was assigned (Figure 35).
3. Predicted depths from the 2D model were then applied to each potential Plunge area to determine whether the feature should, in fact, be classified as a plunge. In general, a plunge area was selected if:
    a. the depth of flow was sufficient to connect the Plunge area to other portions of the channel, and
    b. the depth of flow was less than three times the reference depth. (This criterion is based on the assumption that once the flow depth reaches three times the Plunge reference depth, the localized change in depth due to the Plunge feature is no longer significant).



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Depth and Velocity Criteria used to Specify Habitat Classifications

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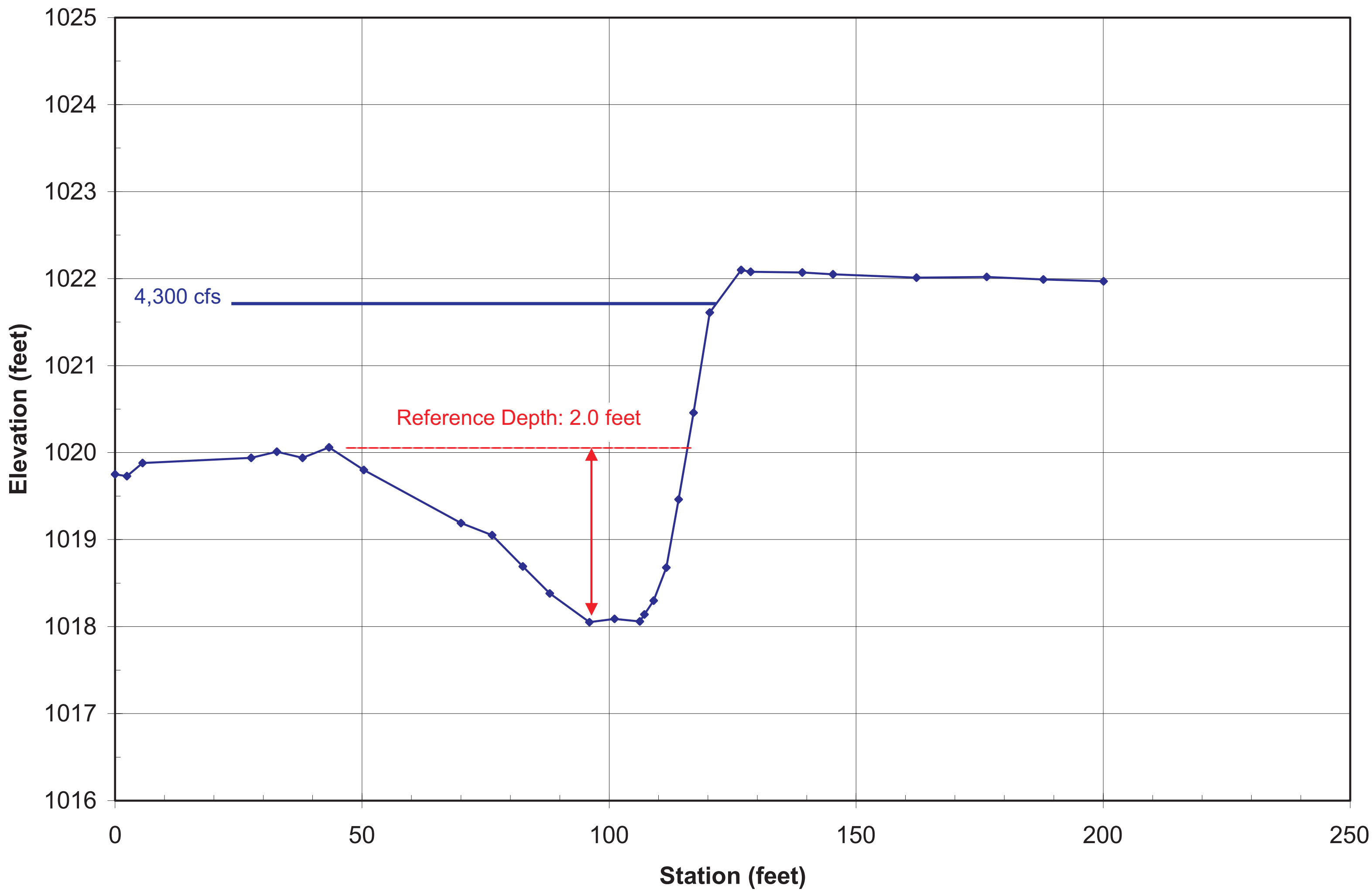

Cross Section Plot of Area

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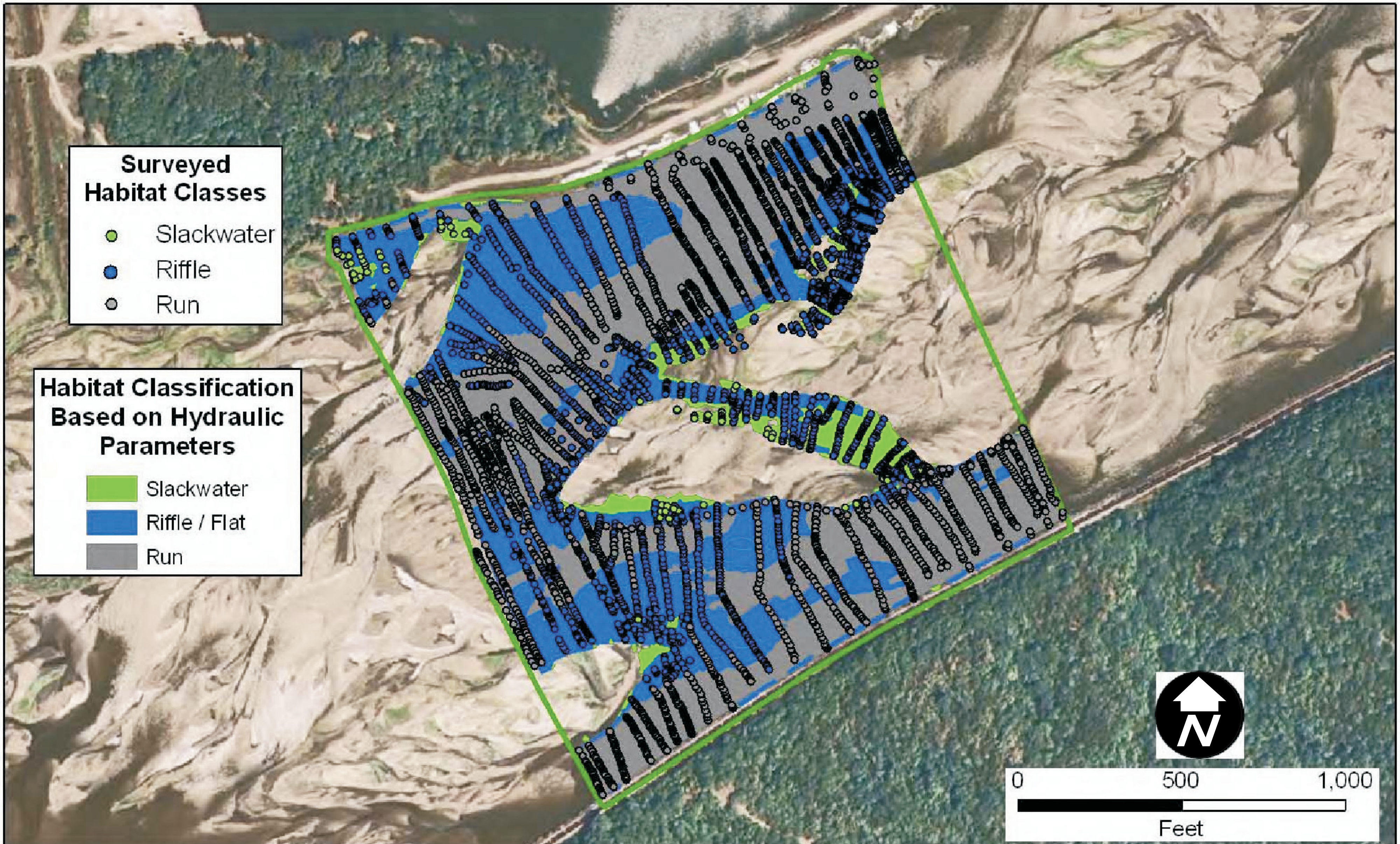
The resultant habitat classes based on the above criteria were compared to habitat that was identified during the field survey. Habitat observed during the field surveys was limited to Slackwater, Riffles, and Runs. (Because of the subtle differences between the Riffle and Flat classes, these were combined into the Riffle class). A comparison of the surveyed and estimated habitat indicates that the habitat selection criteria produce results that are in very good agreement with field-identified conditions (Figure 36). The habitat classes are also supported by the bedform analysis results, which indicate that Run habitat generally occurs in areas characterized by Dunes and Riffle habitat generally occurs in areas characterized by ripples, consistent with field observations at a flow of about 4,300 cfs (Appendix E2 and F2).

After validating the habitat identification process, the criteria were applied over a range of discharges between 3,700 and 40,000 cfs. Each habitat class was then converted into polygons and mapped (Appendix F). The total area of each habitat class and the equivalent percentage of the total flow area were estimated for each discharge (Figures 37 and 38). (The procedure used to develop the uncertainty bands in Figures 38a-d are described in the next section.) At flows in the range of 3,700 cfs, Slackwater habitat accounts for approximately 7 percent of the flow area, increasing to less about 9 percent at 6,000 cfs, and then decreasing to less than 1 percent at flows greater than 20,000 cfs. At 3,700 cfs, Flat habitat accounts for just about 37 percent of the area, and decreasing to less than 2 percent above 20,000 cfs (Figure 38). Riffle habitat makes up about 15 percent of the area at 3,700 cfs, decreasing to about 10 percent between 8,000 and 10,000 cfs, increasing back to about 16 percent at 20,000 cfs, and then decreasing back to about 10 percent at 40,000 cfs. The increase in riffle area between 10,000 cfs and 20,000 cfs occurs because areas that become inundated in this range of flows typically fall into the Riffle habitat range. At flows greater than 20,000 cfs, these bars then gradually become more inundated, transitioning into Run habitat (Figure 37 and Appendix F). Run habitat accounts for about 38 percent of the area at 3,700 cfs, increasing to nearly 90 percent at 40,000 cfs. Isolated Pools only tend to appear at discharges less than about 5,000 cfs, representing less than 1 percent of the area at 3,700 cfs. Plunge areas are very dependent on the topography and, based on the identification technique discussed above, account for about 3 percent of the flow area at 3,700 cfs. The Plunge habitat area remains relatively consistent up to approximately 20,000 cfs (Figure 37). As depths continue to increase at discharges greater than 20,000 cfs, many of the Plunge areas are reduced, and they disappear at about 30,000 cfs (Figure 37). Comparison of the bedform and habitat maps in Appendices E and F show remarkable agreement between the bedforms and the habitat types in which they are expected to occur.

Uncertainty in Habitat Evaluation

Although the habitat areas developed from the hydraulic criteria and model results are in good agreement with the field-mapped areas at approximately 4,300 cfs, there is uncertainty in both the hydraulic model results and the precise depth and velocity limits between habitat classes. Uncertainty in the hydraulic model results stems from two primary sources: (1) uncertainty in the hydraulic roughness and eddy viscosity values that control the modeled flow depths and velocities, and (2) uncertainty in the detailed bed topography in this sand-bedded reach that was surveyed at flows in the range of 4,000 cfs. Uncertainty in the hydraulic model results can be quantified by assessing the variability between the measured and modeled data. As discussed in the model development section, uncertainty in the hydraulic roughness and eddy viscosity, and therefore, one component of the uncertainty in depth, were eliminated, to the extent possible, by calibrating the modeled water-surface elevations to a suite of water-surface elevations that were measured at discharges ranging from 3,700 cfs to 37,400 cfs. The mean difference between the modeled and measured values was -0.01 feet with standard deviation of 0.24 feet, indicating that



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Surveyed and Estimated Habitat Classes at 4,300 cfs

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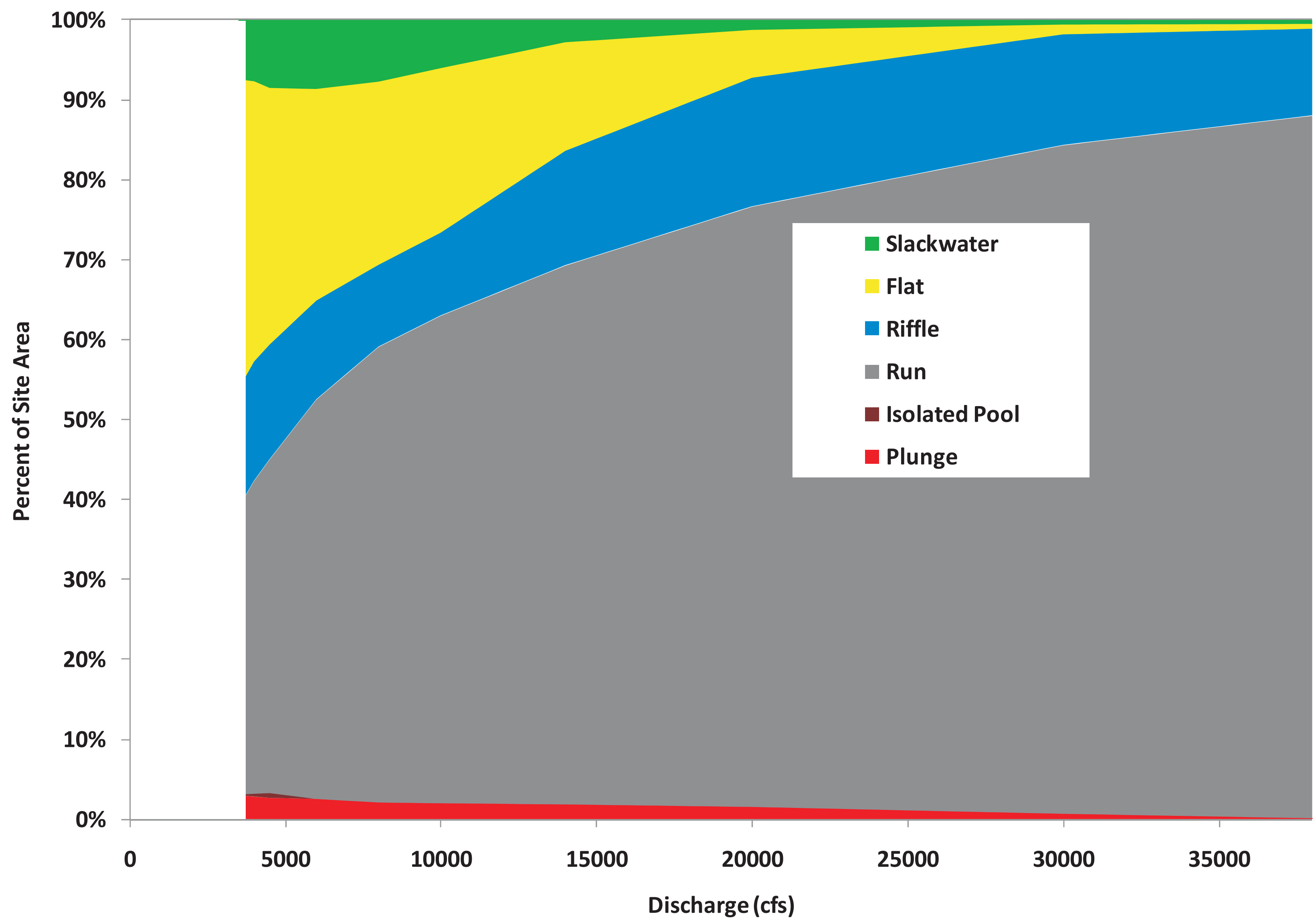

Percentage of Total Habitat Classification Area vs. Discharge

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Figure
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the model is well calibrated (Figures 24 and 25). Unfortunately, specific data are not available to quantify the uncertainty in the depth and velocity criteria for the habitat units.

To assess the overall uncertainty in relative area of the four habitat types that were identified using hydraulic criteria (slackwater, flat, riffle and run), a Monte Carlo simulation was performed using the variability between the measured and modeled hydraulic data and assumed uncertainty in the hydraulic criteria. The results of this analysis should be viewed as a sensitivity analysis since it is not possible to quantify the uncertainty in the hydraulic criteria with the available information. The simulation was performed using the following procedure:

1. The values for the depth and hydraulic criteria shown in Figure 34 were adjusted by adding a normally distributed, random value with mean of zero and an assumed upper and lower 90 percent confidence bound. For purposes of this sensitivity analysis, it was assumed that the upper and lower 90% confidence bounds on the velocity boundary between slackwater and flat/run habitat is +/-0.125 feet (i.e., +/-25%), and between flat and riffle habitat is +/-0.25 feet. It was also assumed that the 90% confidence bounds on the depth boundary between the flat/riffle and run habitat is +/-0.25 feet.
2. The modeled depth and velocity at each of the approximately 120,000 model nodes was adjusted by adding a normally distributed, random value with mean and standard deviation matching the variability between the measured and modeled values. During the field surveys, individual depth and velocity measurements were taken at 87 locations within the site (Figure 26). The differences between the measured and modeled values are normally distributed, with mean and standard deviation of $^{+}$10.6% and +/-30.8%, respectively, for the velocities and $^{+}$5.7% and +/- 45.3%, respectively, for the depths.
3. The area within each of the four habitat types was recomputed based on the randomly adjusted habitat criteria and hydraulic conditions.
4. The above steps were repeated 1,000 times for each modeled discharge to develop composite uncertainty bands about the best-estimate values.
5. The distribution of the resulting habitat areas at each discharge was analyzed to develop overall uncertainty bands on the best-estimate values.

The results of this simulation indicate that the uncertainty bands generally decrease with increasing discharge (Figures 38a through 38d). The uncertainty bands on the slackwater habitat range from +/-2.8 percent at 4,300 cfs to +/-3.8 percent at 6,000 cfs, and this decreases to about +/-0.1 percent at high flows (Figure 44a). Similarly, the uncertainty bands for the flat habitat range from about 6.9 percent at 4,300 cfs to about +/-0.2 percent at 40,000 cfs, +/-5.7 percent at 4,300 cfs to +/-2.9 percent at 40,000 cfs for the riffle habitat and +/-7.8 percent at 4,300 cfs to +/-3.1 percent at 40,000 cfs for the run habitat. A test run for 6,000 cfs results indicates that the uncertainty in the modeled depth and velocities contribute only a very small amount to the overall variability in the estimates; nearly all of the variability is associated with the assumed uncertainty in the hydraulic criteria used to identify the habitat types.

Table 10. Summary of Habitat Classes

Habitat Class	Description	Hydraulic Criteria		
		Depth (feet)	Velocity (fps)	Connection to River
Slackwater	Standing or extremely low-velocity water that is often partially isolated from the primary flow channel and is generally located on the downstream end of exposed bars.	No depth requirement	< 0.5	Yes, but often limited
Flat	Subaqueous bed with relatively shallow depth and low to moderate velocity generally located on the top of an actively migrating linguoid bar. Resembles a mild riffle. Minor ripples are likely to be present along the bed.	< 1.5	< 2	Yes
Riffle	Somewhat shallow area of relatively high velocity. Often located between pools and runs. Typically slightly steeper than a flat with higher velocities. Low amplitude dunes are likely to be present along the bed.	< 1.5	> 2	Yes
Run	Deeper than average flow area with typically higher velocities. Actively migrating dunes are likely to be present along the bed in higher velocity zones; ripples could be present in low velocity zones.	> 1.5	> 0.5	Yes
Isolated Pool	Off-channel area with pooled standing water, no velocity and no connection to other open water habitat. Frequently formed by local scour at higher flows.	N/A	N/A	No
Plunge[1]	Areas of rapid depth increase and typically velocity decrease. Often located along the margins of an actively migrating linguoid bar.	*	*	Yes

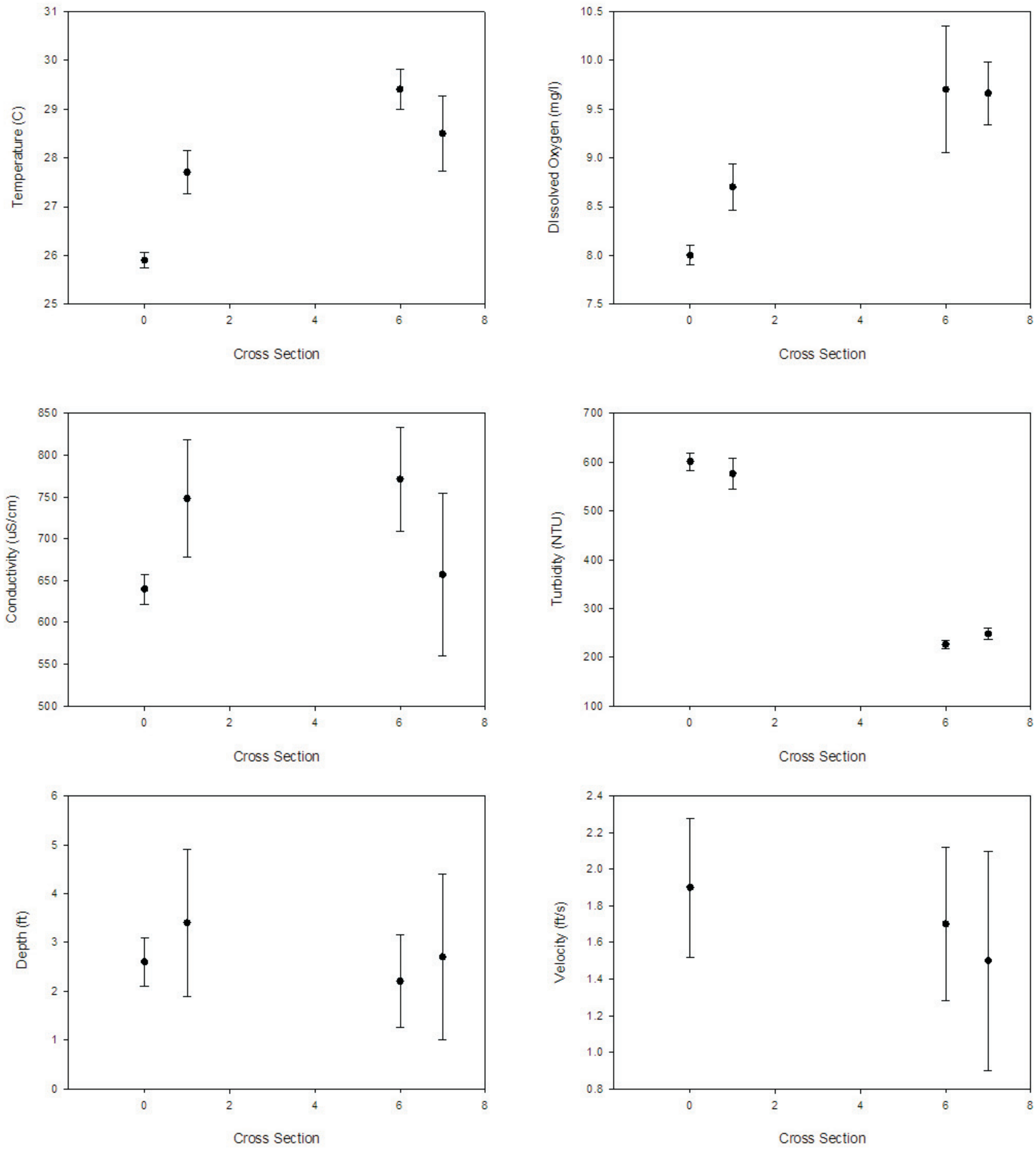
Note:
[1] Plunge areas were identified based on flow depths relative to the depth of the topographic plunge feature (see text).

Water Quality Measures

All water quality parameters exhibited variation among transects and among sample episodes, as shown in Table 11 (Figures 39, 40, and 41). However, analysis of variance results indicate that all water quality parameters were different among sample dates ($P < 0.01$), except for water velocities ($P > 0.95$), as shown in Table 12. The statistical power calculated for each water quality variable was high (Power > 0.99), suggesting that samples sizes were large enough to detect an effect for these variables. These findings corroborate differences identified in the analysis of variance and likely reflect real flow, water quality, and possibly habitat differences among the sampling periods.

Table 11. Mean Values for the Water Quality Parameters Measured on the Platte River, 2008-2009

	N	Temperature (°C)	Dissolved Oxygen (mg/l)	Conductivity (µS/cm)	Turbidity (NTU)	Depth (ft)	Velocity (ft/s)
July 2008	35	27.1	9.0	700	399	2.63	1.76
September 2008	46	21.9	11.1	568	88	1.98	1.81
May 2009	37	21.2	11.6	574	50	1.64	1.80
Power		>0.99	>0.99	>0.99	>0.99	>0.99	>0.99



Water Quality Samples - July 2008

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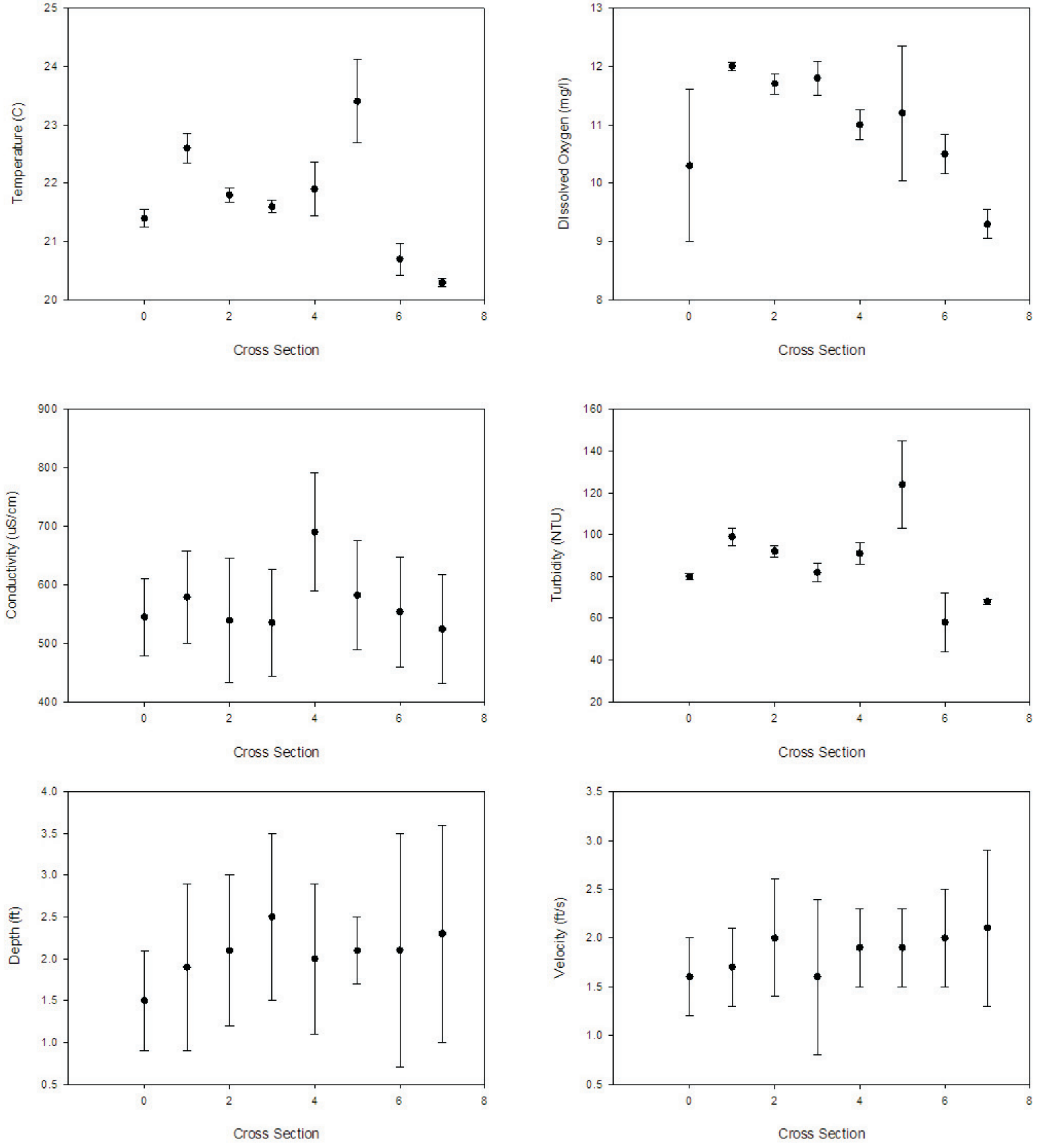

Water Quality Samples - September 2008

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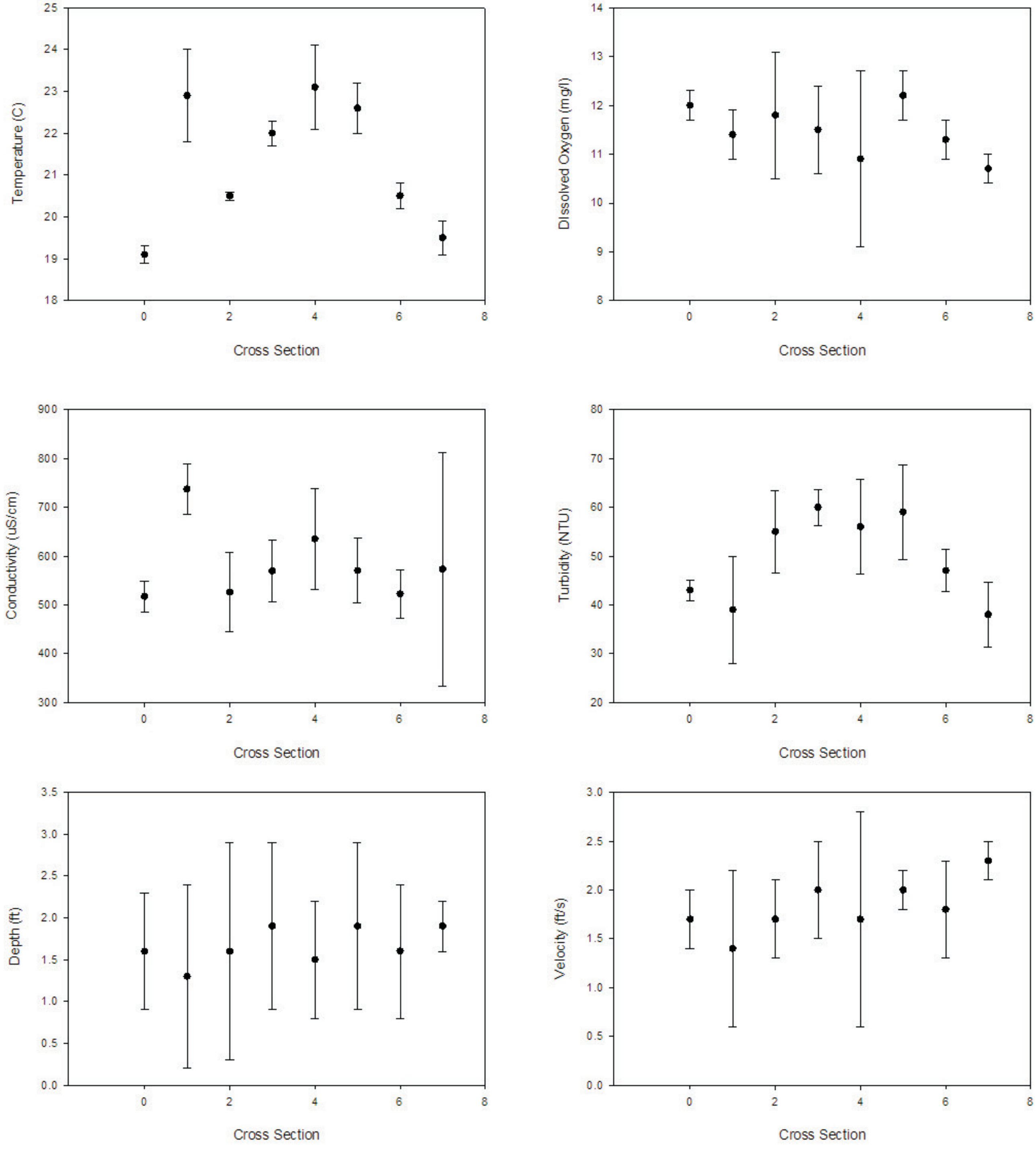

Water Quality Samples - May 2009

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Table 12. Results from Analysis of Variance for Water Quality Parameters Measured on the Platte River, 2008-2009

Variable	P	Phase Comparison[1,2]
Temperature	< 0.001	I > II = III
Dissolved Oxygen	< 0.001	III > II > I
Conductivity	< 0.001	I > II = III
Turbidity	< 0.001	I > II = III
Depth	< 0.002	I = II; II = III; I > III
Velocity	> 0.95	I = II = III

Notes:
[1] Phase I – July 2008, Phase II – September 2008, Phase III – May 2009.
[2] Phase comparisons represent post-hoc Tukeys comparisons to determine differences among Phases.

The water quality data collected during the May 2009 data collection effort was plotted versus discharge. Conductivity versus discharge and Turbidity versus discharge are shown in Figure 42, and Temperature versus discharge and Dissolved Oxygen versus discharge are shown in Figure 43. The respective water quality parameters recorded at the Louisville gage for the mean daily discharge are also plotted on Figures 42 and 43.

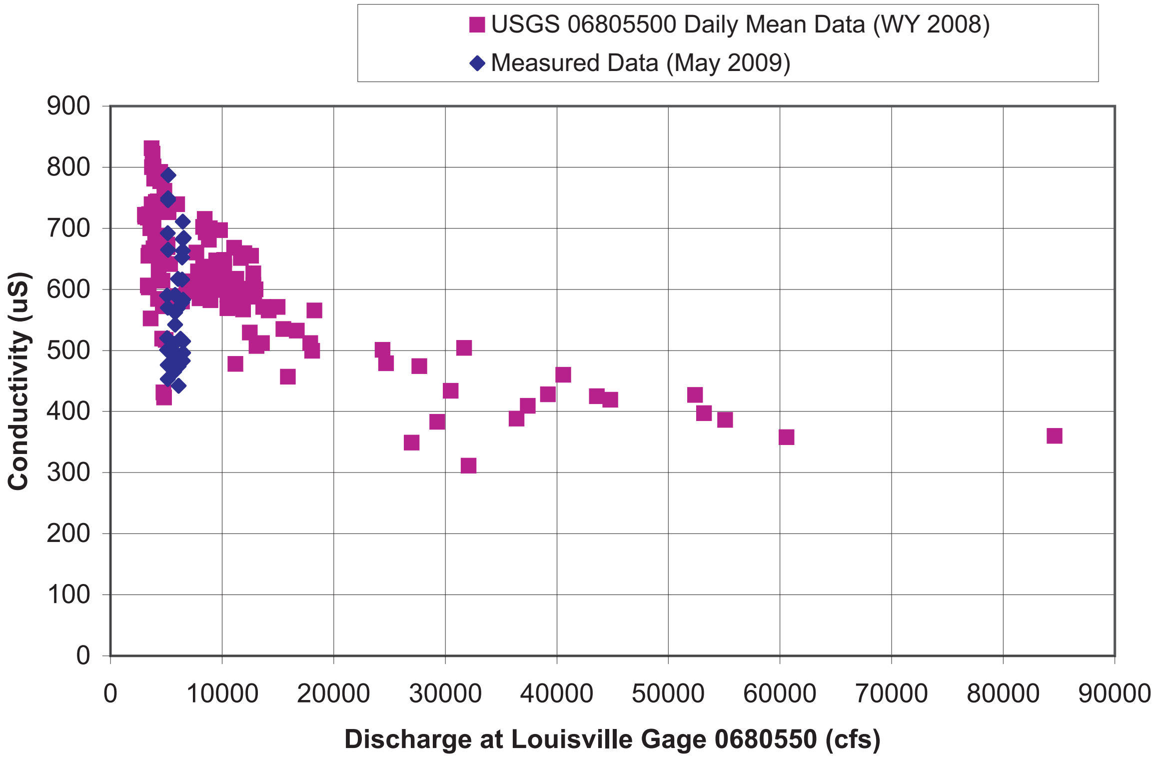
Interpretation and Analysis

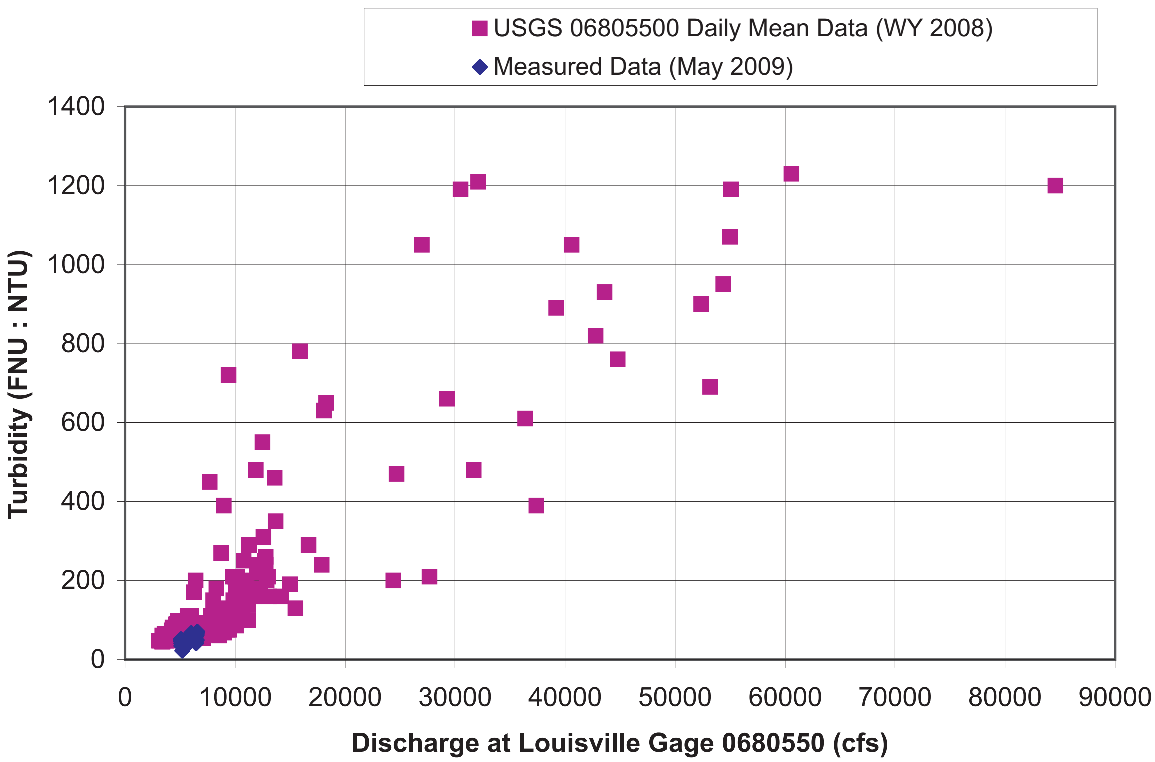
Discussion

This Study used 1D and 2D models to evaluate the distribution of depths and velocities across a range of discharges within the Study Reach between a relatively low flow of 3,700 cfs and the near-bankfull flow of 40,000 cfs. Generally, the amount of relatively deep and swift habitat (i.e., Run habitat) increases with increasing discharge, whereas the amount of shallow and lower velocity habitat (i.e., Slackwater and Flat habitat) decreases with increasing discharge, as expected. These results should provide a means of assessing availability and changes in habitat for species of concern such as the pallid sturgeon with changes in discharge.

Peters and Parham (2008) reported that pallid sturgeon captures most often occurred in the deepest and swiftest areas of the Platte River and that these habitat types were used more frequently than would be expected if used at random. Radio telemetry data further suggests that Platte River pallid sturgeon were typically found in depths ranging from 2 to 5.9 feet and average bottom velocities that ranged from 0.6 to 1.9 feet per second (Peters and Parham, 2008). Pallid sturgeon collected in the Platte River during 2009 were found in a similar range of depths (1.0 to 5.9 feet) and similar to greater bottom velocities (0.9 to 3.1 feet per second) (Pegg, unpublished). The depth and velocity information from these studies suggest that the Run and Plunge habitat classes identified in this study are likely most suitable as pallid sturgeon habitats. Considering this information and the information provided by this Study that evaluates changes in habitat availability with discharge (Figures 37 and 38), it can be concluded that changes in habitat areas as a result of 100 or 500 cfs environmental releases would have a negligible influence on pallid sturgeon habitat in the lower Platte River.

For example, the historical median discharge at Louisville in April, May and June, months during which the pallid sturgeon have been known to migrate and spawn, is approximately 7,000 cfs (Figure 2). Assuming an additional 1,000 cfs of Program water could be delivered to Grand Island, approximately 900 cfs would reach Louisville (Figure 4a). Based on the relationships





Measured Conductivity and Turbidity vs. Discharge

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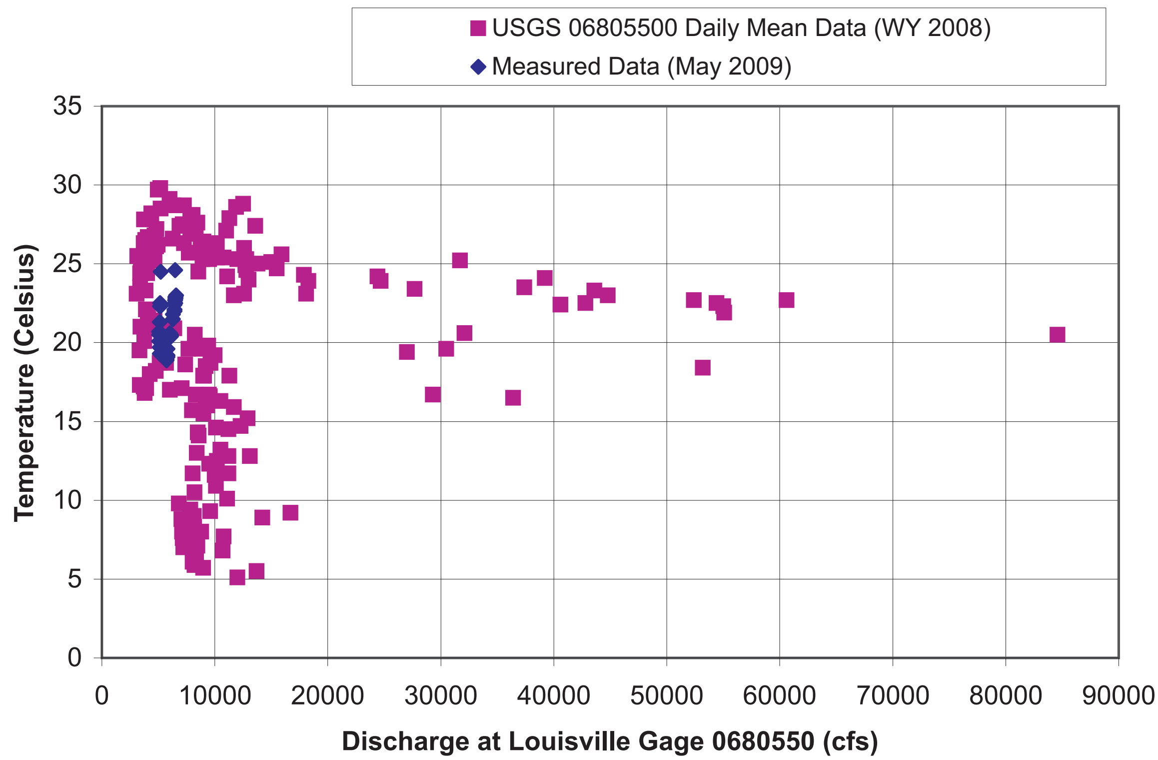

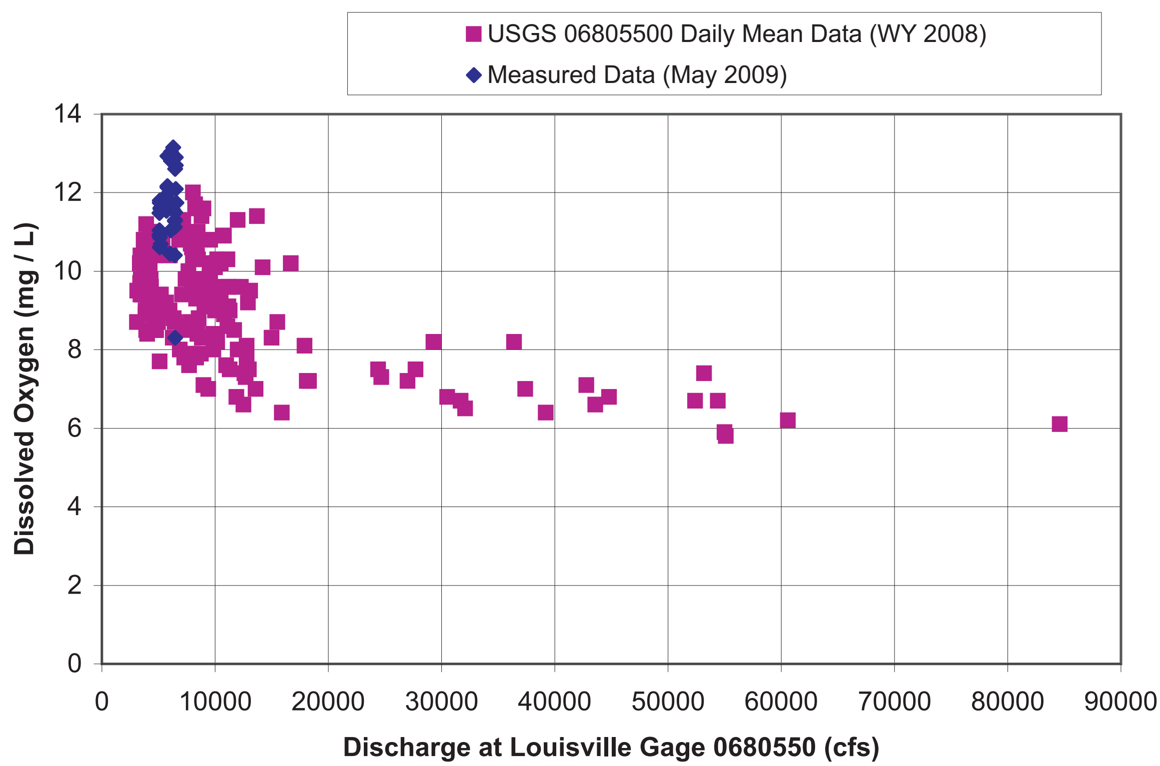

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Measured Temperature and Dissolved Oxygen vs. Discharge

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Figure
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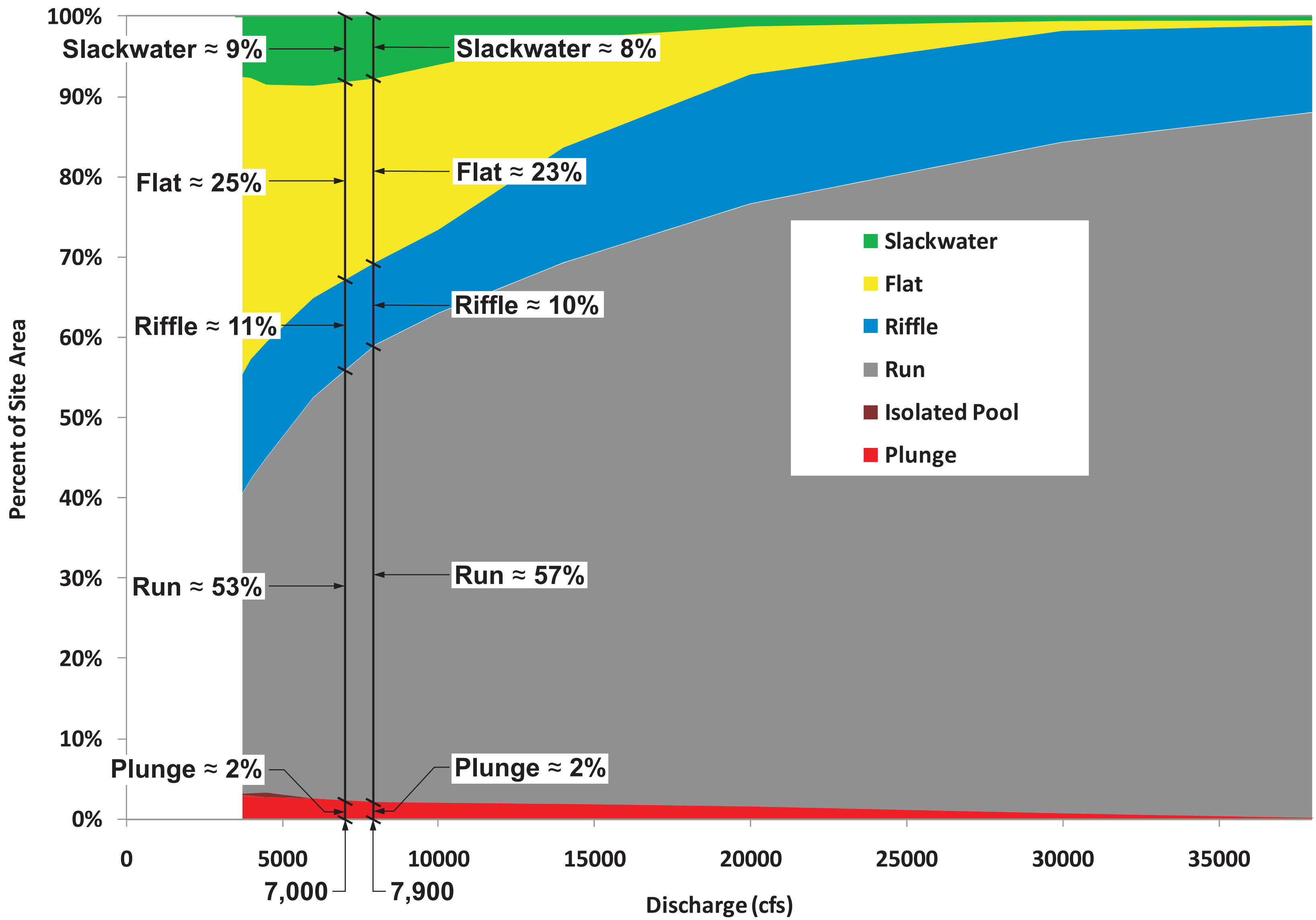
shown in Figures 37 and 38, the Run classification represents approximately 53% (± 7%) of the habitat area at 7,000 cfs and approximately 57% (± 6%) of the area at 7,900 cfs, an increase of about 4%. This is represented graphically in Figure 44. Similarly, the Flat classification represents approximately 25% (± 6%) and 23% (± 5%) of the habitat area at 7,000 and 7,900 cfs, respectively, an approximately 2% reduction. Finally, the Riffle category represents approximately 11% (± 4%) and 10% (± 4%) of the habitat area at 7,000 and 7,900 cfs, respectively, an approximately 1% reduction. In assessing the results of this example, it should be noted that the changes in relative area occupied by each habitat type are within the uncertainty bands of the analysis. In addition, the uncertainty in daily flow at the Louisville gage for the months of April, May, and June is approximately 800 cfs (Table 5); thus, the predicted change in discharge is only slightly larger than the uncertainty. This is not to suggest that the gage would not detect the change in flow, but the magnitude of the change in discharge is subject to the same uncertainty as the overall flow. In addition, based on the flow translation analysis for this Study, it was difficult to differentiate the water pulse flow from other water management activities in the lower Platte River. Finally, the increase in discharge does not move the conductivity, turbidity, temperature, or dissolved oxygen outside the typical range preferred by pallid sturgeon (Figures 42 and 43).

Similarly, a decrease in flow at Grand Island of 1,000 cfs would translate to an approximately 900 cfs decrease in flow at Louisville (Figure 4a). As represented graphically in Figure 45, the Run classification represents approximately 53% (± 7%) of the habitat area at 7,000 cfs, and approximately 50% (± 7%) at 6,100 cfs, a reduction of 3%. The Flat classification represents approximately 25% (± 6%) and 26% (± 6%) of the area at 7,000 and 6,100 cfs, respectively, only a 1% increase. Finally, the Riffle category is approximately 11% (± 4%) and 12% (± 5%) of the habitat area at 7,000 and 6,100 cfs, respectively, an increase of 1%.

Program activities may include regulating or trimming the hydrograph in the central Platte River. One proposed Program action is to divert flows above target in an effort to re-time flows for release during periods of interest or concern. Based on this stage change study, the % habitat in the lower Platte River experiences a relatively high rate of change for flows ranging between 4,000 cfs to 6,000 cfs. In addition, some literature has suggested connectivity concerns at the lower end of this range (Peters and Parham, 2008). In order to estimate the flow affect, and subsequent change in stage, in the lower Platte River for flow regulation, the results of this stage change study were coupled with a review of historic flow records. The analysis is detailed in Appendix G, and is summarized in this section.

Assuming Program diversions would only occur in March, April, October, and November, the days in which the mean daily flow at Louisville was between 4,000 cfs and 6,000 cfs for the period of record were cataloged. This data set was filtered based on the corresponding flows at Grand Island (assuming travel time) being above target flow assuming a dry hydrologic condition. Finally, from this filtered data set, flows in excess of target flows at Grand Island were diverted, and the diversion amount was translated to Louisville and subtracted from the corresponding mean daily flow, again assuming travel time. The following table summarizes the results:



Percentage of Habitat Classification Area for Q = 7,000 cfs and 7,900 cfs

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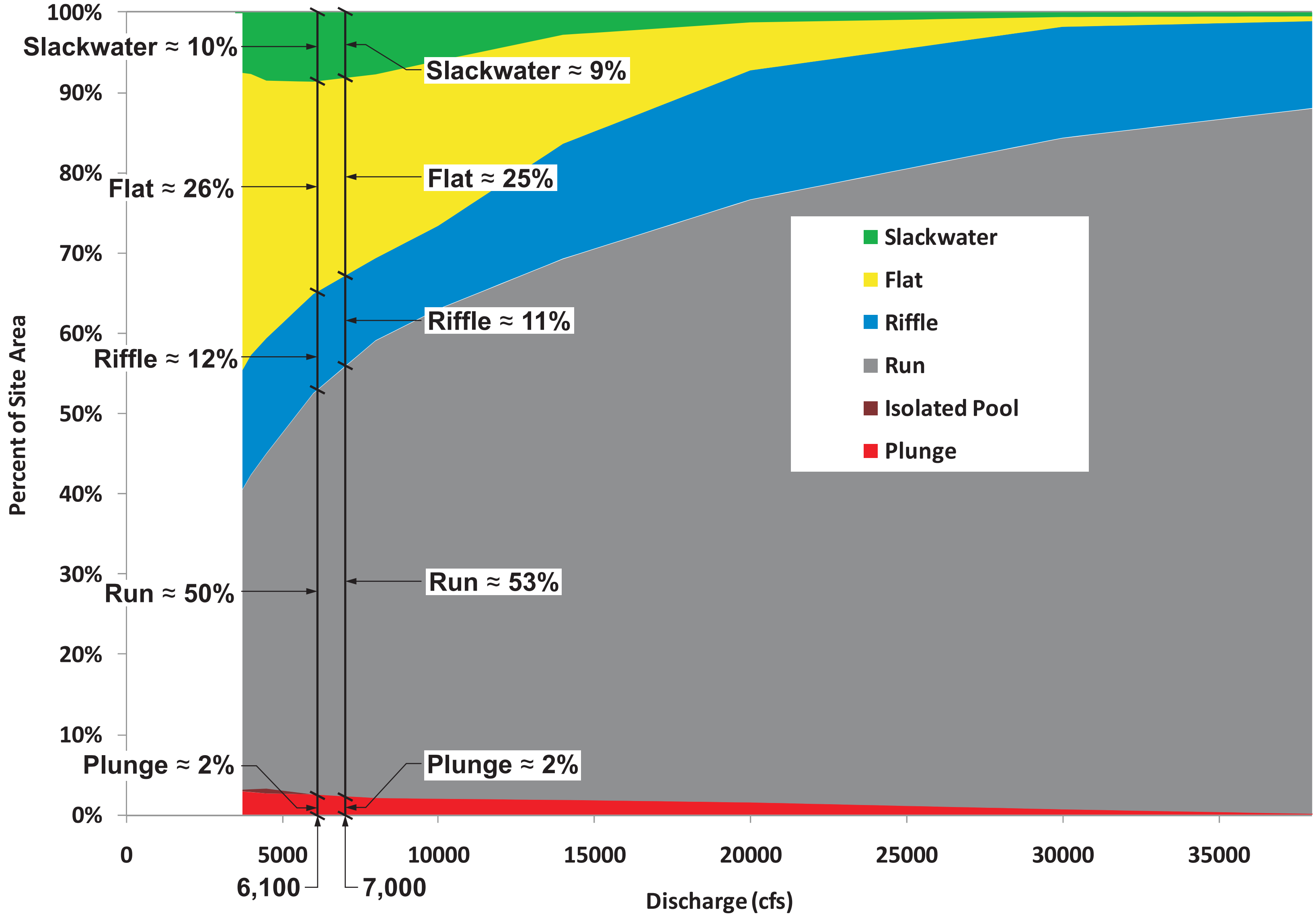

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Percentage of Habitat Classification Area for Q = 6,100 cfs and 7,000 cfs

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Table 13. Excess to Target Flows at Grand Island vs. Flows at Louisville Between 4,000 and 6,000 cfs

Condition	# of Days for Period of Record	# of Days Between 4,000 and 6,000 cfs @ Louisville	# of Target Exceedences @ Grand Island	# of Days Below 4,000 cfs @ Louisville	Range of Flows Below 4,000 cfs @ Louisville	# of Consecutive Days Below 4,000 cfs
Spring	3,976	847	145	11	30 to 950	2 days (once)
Fall	4,017	1127	635	184	9 to 1380	2 days (16 times) 3 days (10 times) 4 days (3 times) 5 days (once) 6 days (2 times) 7 days (once) 8 days (3 times) 14 days (once)

For the March to April period, the largest amount of flow that could have been diverted for the sample set occurred on March 22, 1972. Flow at Grand Island was 3,190 cfs, thereby allowing the program to divert 1,990 cfs above the target of 1,200 cfs. Based on this stage change study, approximately 88% of the flow would have reached Louisville, which would have reduced the flow at Louisville from 5,040 cfs to 3,290 cfs. Utilizing the relationship in Figures 37 and 38, the Run classification would have been reduced from approximately 45% (± 8%) of the habitat area to approximately 34% (± 8%) of the habitat area, a decrease of 1%. The Flat classification would have been increased from approximately 30% (± 7%) to 40% (± 8%) of the habitat area, a 10% increase. Finally, the Riffle classification occupies about 14% (±6%) of the habitat area at both discharges, increasing by less than 1%. The decrease in discharge does not move the conductivity, turbidity, temperature, or dissolved oxygen outside the typical range preferred by pallid sturgeon (Figures 42 and 43).

For the October to November period, the largest amount of flow that could have been diverted for the sample set occurred on November 25, 1972. Flow at Grand Island was 2,550 cfs, thereby allowing the program to divert 1,950 cfs above the target of 600 cfs. Based on this stage change study, approximately 85% of the flow would have reached Louisville, which would have reduced the flow at Louisville from 5,860 cfs to 4,200 cfs. Based on the relationships shown in Figures 37 and 38, the Run classification would have been reduced from approximately 49% (± 8%) of the habitat area to 40% (± 8%) of the area, a decrease of 9%. The Flat classification would have increase from 27% (± 6%) to 34% (± 7%) of the habitat area, a 7% increase. Finally, the Riffle category would have increased from approximately 13% (± 5%) to 15% (± 6%) of the habitat area, a 2% increase. The decrease in discharge does not move the conductivity, turbidity, temperature, or dissolved oxygen outside the typical range preferred by pallid sturgeon (Figures 42 and 43).

Existing and new data collection efforts on the Platte River for sturgeon species (shovelnose and pallid) suggest that these species use the river during spring and fall. Maintaining suitable habitat is critical for spawning (spring) and possibly for staging areas for overwintering or upcoming spawning movements (fall). Spring is likely the most critical period so that should be protected as best possible. However, catch rates during fall 2009 sampling showed a significant pallid sturgeon presence in the Platte River as well. The issue at hand would likely be loss of habitat connectivity that prevents movements should flows be reduced significantly during spring and/or fall during diversion. Diversion of flows would likely be limited to one or a few days during any season given the information above. This duration of diversion would likely not have a long-term influence on habitat connectivity, although short term connectivity could be problematic. However, these data suggest that proper monitoring of water levels in the lower Platte River and corrective actions implemented during diversions could prevent substantial negative impacts.

Not addressed in this scope of work are connectivity and temporal availability issues. From a connectivity standpoint, pallid sturgeon are typically found in deep, swift waters. If sturgeon are not able or willing to move through shallow water environments, then access to some habitat may be limited at smaller discharges. For example, Figure F3 shows that Run and Plunge habitats are mostly connected across the width of the river, or at least could be navigated, at 6,000 cfs. Discharges less than 6,000 cfs may lower water elevations enough to limit access for pallid sturgeon if they will not or cannot move through Flat or Slackwater habitat. This means that all of the potential habitat identified from the model results may not always be accessible.

Seasonal aspects of the hydrograph and use of the Platte River by pallid sturgeon should also be considered. Until recently, the Platte River was believed to be used primarily during spring and early summer (Peters and Parham, 2008). However, pallid sturgeon have recently been captured in the Lower Platte River during the summer and early autumn months (Pegg, unpublished), suggesting that at least some individuals may use the river for longer periods of time than originally thought. This also highlights the need to understand the life-cycles of pallid sturgeon to ensure that timing of releases does not significantly interfere with life-history requirements. For example, pallid sturgeon and many other riverine fishes have evolved to use the natural increase in spring flows to initiate spawning behaviors. Additional water released at this time may be less stressful, whereas water released in late summer could stimulate a behavioral response counter to the needs of the species that could conceivably isolate individuals in marginal or unsuitable habitats when the water releases cease.

Depth and velocity are two important variables in defining useable fish habitat for single or multiple species conservation, and are typically used to define suitable habitat in lotic systems. However, Annear et al. (2004) highlight that these two variables when used alone are not sufficient to fully constitute a species-habitat relationship. Other variables such as those associated with water quality (e.g., nutrients or pollutants), biotic interactions (e.g., predator-prey dynamics), timing of habitat availability, connectivity of appropriate habitats to allow movement, food availability, and appropriate substrate types are also important in defining the number and types of fishes found in a given area. Therefore, the results from this Study should be used as one part of a larger perspective on available habitat rather than an absolute factor in driving conclusions and decisions related to population dynamics.

One of the issues when dealing with water quantity in the lower Platte River is centered on the question “Will pallid sturgeon habitat be influenced by environmental releases that benefit tern and plover nesting activities in the middle Platter River?” and related questions. The information in this report that characterizes the present water management scheme for the lower Platte River predicts the amount of water that reaches the lower end of the system, and assuming careful consideration of the timing of the water releases when they occur in the future, it seems there would be little change to the amount of habitat available to pallid sturgeon in this reach of the river. The implication is not that pallid sturgeon populations will or will not be affected, as this is outside the scope of this Study, but rather that the relative change in habitat would be very small to undetectable and thus these changes should not provide additional stress to the pallid sturgeon population.

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Appendix A

Estimated Historic Losses by Stream Reach in the Platte River Below Grand Island, Nebraska, and Implications for Program-Augmented Flows
Draft Report
May 2002

ESTIMATED HISTORIC LOSSES BY STREAM REACH IN THE PLATTE RIVER BELOW GRAND ISLAND, NEBRASKA, AND IMPLICATIONS FOR PROGRAM-AUGMENTED FLOWS

U.S. Fish & Wildlife Service
Mountain-Prairie Region (Region 6)
May 15, 2002 *DRAFT*

Executive Summary

A daily flow tracking and accounting model was constructed for three reaches of the Platte River below Grand Island, Nebraska, in order to evaluate historic evaporation and seepage losses associated with flow in each of these reaches. A key objective of this exercise is to estimate the proportion of potential Platte River Program-augmented flows at Grand Island, Nebraska, that would be expected to reach the Platte River at Louisville under conditions that existed during the period evaluated.

To construct this model, daily stream flow gage data for the lower Platte River system were compiled for water years 1975 through 1994 (and, for one reach, for calendar years 1997 through 2000). In addition, monthly pan evaporation measurements were collected from two Nebraska weather stations (Grand Island and Omaha). For each reach, open-water surface areas and vegetated riparian areas were estimated. Based on these inputs, and based on assumed travel times for flow between the gages, estimates were made for daily reach losses due to evaporation, evapotranspiration and seepage for every day of the period of record.

The results of this analysis are summarized in Figures 9 and 10 of this report. The results suggest that less than 60% (in September of the worst years) to over 90% (in December, January, March, April and May of the best years) of 100 cubic feet per second (cfs) of Program-augmented flow at Grand Island would be expected to reach Louisville. (100 cfs equates to about 6,000 acre-feet/month). In median years, no more than 79% to 91% of this water would reach Louisville from October through June; in July through September, this percentage falls to 65% to 70%. For a variety of reasons described in Section 3 of this report, we believe that these estimates are generous. The actual percentages reaching Louisville are unlikely to be greater than the values presented here, and in many months they may be significantly less.

As the presumed flow augmentation at Grand Island is increased above 100 cfs, the proportion lost to evaporation decreases (particularly in summer months), and the proportion reaching Louisville increases. Conversely, flows of less than 100 cfs are expected to experience higher proportional losses.

This analysis was based on conditions that prevailed over the evaluated time period. To the extent that conditions in the lower Platte River have changed – for example, to the extent that more groundwater is pumped from alluvial aquifers adjacent to the river – the effects on future augmented Program flows in the lower Platte River may not be fully addressed by this analysis.

1. Introduction

This report describes the USFWS analysis of historic daily losses (including evaporative and seepage losses) associated with flow in three Platte River stream reaches downstream of Grand Island, Nebraska, as follows:

- Platte River from Grand Island to Duncan, Nebraska ("Reach 20");
- Platte River from Duncan to North Bend, Nebraska ("Reach 21"); and
- Platte River from North Bend to Louisville, Nebraska ("Reach 22").

These analyses were carried out pursuant to Phases II and III of the USFWS "Plan for Testing the Ability of the Program to Affect Lower Platte River Flows" (hereafter referred to as "the Plan") dated February 28, 2002. That Plan proposed estimating daily losses (evaporation plus seepage) associated with each of these stream reaches during water years 1975-1994, for purposes of developing estimates of the percentage of flow in the Platte River at Grand Island reaching Louisville under various flow conditions. When hypothetical quantities of Program-augmented flow are added to these historic Grand Island flows, the likely effects at Louisville also can be estimated.

For this report, a daily stream flow tracking and accounting spreadsheet was built using daily stream flow records compiled for four locations along the main stem of the Platte River beginning at Grand Island, Nebraska, plus five locations representing major tributaries entering the Platte River below Grand Island. These sites are identified in **Table 1** and illustrated in **Figure 1**. Different periods of record were used for different gages for reasons that are explained in the Methodology section that follows.

Table 1

Platte River Basin Gage Locations Used for Historic Loss Analysis

Nebraska Gage Location	Stream Reach	Period of Record Used in This Analysis
Platte River at Grand Island (06775000)	Reach 20	1975 - 1994
Platte River at Duncan (06774000)	Reach 20/21	1975 - 2000
Loup River at Genoa (06793000)	Reach 21	1997 - 2000
Loup Power Plant Return (estimated from power generation records)	Reach 21	1997 - 2000
Shell Creek near Columbus (06795500)	Reach 21	1997 - 2000
Platte River at North Bend (06796000)	Reach 21/22	1975 - 2000
Elkhorn River at Waterloo (06800500)	Reach 22	1975 - 1994
Salt Creek at Greenwood (06803555)	Reach 22	1975 - 1994
Platte River at Louisville (06805500)	Reach 22	1975 - 1994

2. Methodology

2.1 Daily Tracking and Accounting

The daily flow tracking and accounting spreadsheets used for this analysis were built using Microsoft Excel software. For each of the three stream reaches, a daily mass-balance evaluation (inflow vs. outflow) was performed.

Flows entering the reach (including but not limited to Platte River flows at the top of the reach) were considered subject to two kinds of losses along that reach: (1) losses due to evaporation and evapotranspiration (always greater than zero); and (2) losses due to seepage (which may or may not have occurred on the day being evaluated).

Losses due to evaporation and evapotranspiration (ET) were estimated using procedures described in Section 2.4.

Losses due to seepage (if any) were calculated from daily a mass-balance analysis of the reach, as follows:

Net seepage loss (if any) = Lagged inflows at one or more locations
- Outflow at the bottom of the reach
- Estimated daily evaporation and ET losses

Methods of quantifying the values used in the above equation for daily inflows and outflows, for daily evaporation and ET, and for inflow lag times are described in the following sections of this report. Some important assumptions implicit in this analysis are detailed in Section 3. Application of these estimates to the issue of "the ability of Program-augmented flows to effect flows in the lower Platte" is addressed in Sections 4 and 5 of this report.

2.2 Daily Inflows and Outflows

Mean daily stream flow records for the gages and periods of records listed in Table 1 were incorporated into spreadsheets for the mass-balance analysis described above. In all but two cases, the stream flow values that were used were the official, unadjusted USGS gage estimates. The two exceptions were:

(1) Loup Power Plant Return flows

Flows contributed to the Platte River from the lower Loup River "Columbus Hydroelectric Powerhouse" are substantial, and they vary substantially from day to day. For the 1997-2000 period of available daily data, estimated tailrace flows from this hydroelectric facility exceeded flow in the Loup River at Genoa on most days, especially during non-winter months. Thus, any meaningful analysis of daily gains/losses along this reach of the river should consider daily return flows from the Columbus Powerhouse.

Unfortunately, gaged measurements of return flows to the Platte River from the Columbus Powerhouse do not exist. The closest corresponding site of gaged flows is for diversions from the Loup River to the powerhouse through the Loup Power Canal (USGS gage #06792500). Because substantial capacity exists to store these diversions upstream of the power plant in Lake Babcock, these daily diversions do not correspond well to daily return flows to the Platte River. Thus they were not used in this accounting model. The only way to estimate daily return flows with reasonable accuracy is to estimate tailrace flows based on the amount of hydroelectric power generated during that day. To our knowledge, these daily tailrace flow estimates have been compiled only for the period of January 1997 through December 2000. It is our understanding that these tailrace flow estimates are based on the following formula:

Mean daily tailrace flows in CFS = 5.08 * megawatt-hours generated

For the sake of this analysis, the tailrace flows are assumed to equate to return flows reaching the Platte River. In fact, as noted by Loup Power District President/CEO R.E.White (2001), these estimates do not include “the Lost Creek diversion channel which enters the Tailrace just downstream of the powerhouse”, nor do they account for the fact that “there are also three irrigators who remove water from the tailrace”.

To cross-check the reasonableness of the hydropower-based tailrace flow estimates, annual diversions to the Loup Hydropower Canal (gage #06792500) were compared against estimated annual tailrace flows from the power plant from 1975 to 1994. On an annual basis, the total tailrace flow estimates were about 12% lower than the total flows through the Loup Power canal. For individual years, differences ranged from 9% to 15% lower. These differences likely reflect, at least in part, conveyance losses and evaporative losses from Lake Babcock.

(2) Loup River at Genoa gage

Daily Loup River flows that are not diverted to the Loup Power Canal historically have been measured at either the Loup River at Columbus, Nebraska (USGS gage #06794000, prior to 10/10/1978) or the Loup River at Genoa, Nebraska (USGS gage #06793000, 4/1/1929 to present). For this Platte River analysis, the former gage location is preferable to the latter because it is approximately 24 miles closer to the Platte River confluence. In fact, daily flows in the Platte River at Columbus were higher than flows in the Platte River at Genoa on 92% of days during the 1954 -1978 period. This is not surprising, given the significantly larger drainage area associated with the lower gage.

In an effort to develop more realistic estimates of daily inflows from the Loup River, USFWS established monthly regression relationships between daily flows at these two gages based on this 25-year period of overlapping record. For dates after 10/10/78, we used these relationships to estimate inflows to the Platte River based on flows measured at Genoa. The details of this procedure are described in **Appendix A**.

2.3 Lag Times

To construct the daily flow tracking and accounting model needed for this analysis, estimates of mean flow travel times between gages are required. These travel time (lag) estimates were developed under Phase I of the Plan (USFWS 2002a, 2002b), and are summarized in Table 2.

Table 2

Estimated Prevailing Travel Times Between Platte River Basin Locations

From-To Gage Locations	Reach Number	Estimated Prevailing Travel Time in Days
Grand Island to Duncan	20	1
Duncan to North Bend	21	1
Loup River (Genoa gage) to North Bend	21	1
Loup Hydropower Plant Return to North Bend	21	1
Shell Creek near Columbus to North Bend	21	0
North Bend to Louisville/Ashland	22	1
Elkhorn River (Waterloo gage) to Louisville/Ashland	22	0
Salt Creek (Greenwood gage) to Louisville/Ashland	22	0

The USFWS analyses producing the above estimates did suggest that prevailing travel times may vary under different flow conditions. For example, the data suggest that travel times in Reach 20 and 22 may be somewhat greater during the July-through-September period in dry years. However, we concluded that the times listed in Table 2 are probably the best general estimates to use for subsequent tracking and accounting models of the lower Platte River.

2.4 Evaporation and ET Losses

2.4.1 Estimated Areas of Open-Water Channel Evaporation and Vegetative Evapotranspiration

In order to estimate losses associated with (1) open-water evaporation and (2) vegetative evapotranspiration (ET) along each of the three Platte River reaches, estimates of the following were required:

- Total open-water area by sub-reach (for a discussion of "sub-reaches", see Section 2.5), and
- Total vegetated island and riparian areas contributing to ET of Platte River water by sub-reach.

Both of these quantities were estimated from 1993 and 1994 digital orthophoto quarter quadrangles (DOQQs) of the lower Platte River corridor. River channel features were digitized on-screen using a subset of 9 approximately evenly-spaced DOQQs, out of a total of 55 DOQQs covering the entire Platte River channel between Grand Island and Duncan (**Figure 2**). This equates to three DOQQs per stream reach. We assume that these DOQQs are reasonably representative of the corresponding reaches.[1]

In order to establish a reasonable range of values encompassing typical Platte flow conditions, "conservative" and "liberal" estimates of open-water areas were made for each stream reach. The conservative estimate excluded all exposed and unvegetated sand islands, sand bars, and beaches. The liberal estimate included these features, under the assumption that they would be inundated under high flow conditions.

DOQQ images used for the channel analysis were taken on one of eight different dates in 1993 and 1994. Each of these dates, and the corresponding flow conditions in the Platte River at Grand Island on that date, are listed in Table 3.

Table 3

Dates of Digital Orthophoto Quarter-Quadrangle (DOQQ) Images and Corresponding Flow Conditions in the Platte River at Grand Island

Image Date	Mean Daily Flow at Grand Island on Image Date (cfs)	Long-term Mean Daily Mean Flow at Grand Island on this Day of Year (cfs)*
4/14/1993	1,490	1,962
4/16/1993	1,140	1,900
4/21/1993	1,440	1,915
4/22/1993	1,740	1,888
5/04/1993	879	1,990
5/13/1993	1,810	2,175
3/21/1994	2,000	2,405
4/18/1994	1,730	1,864

* Based on a 67-year period of record from the USGS Daily Streamflow Statistics Web page, April 2002

For comparison, the mean daily flow in the Platte River at Grand Island has fallen in the range of 1,001 to 2,000 cfs on approximately 31% of days since 1940. Flows were 1,000 cfs or less on approximately 46% of days during this period, and greater than 2,000 cfs on approximately 23% of days (Stroup et al., 2001). Thus, Platte River flows at Grand Island, while somewhat lower-than-average for the specific days on which the DOQQ images were taken, were reasonably representative of river flows on a long-term, year-round basis. For this reason, we consider these acceptable DOQQs for purposes of estimating mean open-water channel widths in the lower Platte River.

For estimates of vegetative ET, the following areas were quantified and summed from the DOQQs (after Nebraska DNR, 2001):

- Vegetated islands less than 20 acres in size (entire area);
- Vegetated islands greater than 20 acres in size (100-foot perimeter area only); and

[1] DOQQ digitization is an ongoing effort; USFWS intends to digitize at least four or five DOQQs per stream reach before finalizing this analysis.

- Both channel shorelines (100-foot channel perimeter area, including the left and right banks).

Rates of evapotranspiration from these areas were estimated as described in Section 2.4.2.

Results of the channel areas analysis using the DOQQs are summarized below. These results are expressed in terms of *mean width* of the river. In other words, the areal estimates are divided by the length of river evaluated.

Note: Table 4 and the subsequent analyses will be updated as USFWS completes additional DOQQs

Table 4

Summary of Estimated Mean Open Water and Vegetative ET Widths For Each Stream Reach

Platte River Reach	Total # DOQQs Evaluated	"Conservative" Open Water Channel (ft)			"Liberal" Open Water Channel (ft)			Vegetative ET Width (ft)		
		Min	**Max**	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	**Mean**
20	3	1,349	1,563	1,445	1,432	1,643	1,536	489	1,010	740
21	3	1,693	2,354	1,957	1,881	2,692	2,252	391	1,125	822
22	3	1,224	1,690	1,505	1,392	1,807	1,639	234	674	463

At all four of the main stem Platte River gages (Grand Island, Duncan, North Bend, and Louisville), average monthly streamflow is higher than the average year-round flow in the months of February through June, and lower than the year-round average in July through January. For this reason, we applied the mean "liberal" estimate of open-water width to all February through June flows in all three reaches to estimate evaporative losses, and the mean "conservative" estimate to all other months. (For example, evaporative losses experienced by flows in Reach 20 in June of 1975 were calculated on the basis of an assumed mean open-water surface width of 1,536 feet, while in July of 1975 a width of only 1,445 feet was assumed).

To estimate additional ET losses associated with the vegetated islands and riparian areas, we applied the same mean width for each reach in all months.

Section 5.2 of this report discusses the sensitivity of the daily flow accounting model to the assumed open-water area. The results indicate that the model is only moderately sensitive to this variable. For this reason, we did not attempt to further refine the areal estimates to account for variations in flow conditions, beyond the high-flow vs. low-flow seasonal adjustments already described.

2.4.2 Estimated Unit-Area Rates of Channel Evaporation and ET

Estimated daily rates of evaporation and evapotranspiration from the Platte River channel were based on monthly "Class A" pan evaporation measurements for the October 1974 - September 1994 period (also January 1997 – December 2000 for Reach 21) from two Nebraska weather stations: Grand Island and Omaha. Records from Grand Island are complete for this period; records from Omaha are complete except for November 1991 through April 1992. For the missing Omaha values, synthetic monthly values were estimated by adjusting Grand Island pan evaporation by the average long-term ratio between monthly pan evaporation rates at the two stations.

Reach evaporation and ET estimates were based on these weather station data as follows:

- Reach 20: based on Grand Island pan evaporation measurements only;
- Reach 21: based on the mean of Grand Island and Omaha pan evaporation measurements;
- Reach 22: based on Omaha pan evaporation measurements only.

Pan evaporation values were adjusted by a pan coefficient factor of 0.70 to estimate the actual monthly rate of evaporation from the Platte River open water surface. For estimates of evapotranspiration loss rates from vegetated areas, an additional factor of 0.5 was applied to estimate ET rates during the winter season (October through April) and 0.8 was applied to estimate ET rates during the growing season (May through September). Our understanding is that these factors are generally consistent with those used by the Nebraska Department of Natural Resources for their Platte River evaluations upstream of Grand Island (Nebraska DNR, 2001).

2.5 Subreach Accounting

In setting up the tracking and accounting spreadsheets, two of the river reaches were further subdivided into shorter sub-reaches. This facilitated accounting for the fact that a substantial portion of the gaged tributary inflow along these reaches occurs a considerable distance downstream from the top of the reach, and thus is not subject to the same evaporative and seepage losses as is Platte River inflow at the top of the reach. Specifically:

- For purposes of accounting for losses, Reach 21 (which totals 41 miles in length) was subdivided into two sub-reaches: Duncan to the Loup River confluence (10 miles), and the Loup River confluence to North Bend (31 miles). Inflows from the Loup River system were subjected to seepage, evaporation and ET losses only over the lower sub-reach.

- For purposes of accounting for losses, Reach 22 (which totals 56.5 miles in length) was subdivided into three sub-reaches: North Bend to the Elkhorn River confluence (38.5 miles), the Elkhorn River confluence to the Salt Creek confluence (9 miles) and the Salt Creek confluence to the Louisville gage (9 miles). Inflows from the Elkhorn and Salt Creek watersheds were subjected to seepage, evaporation and ET losses only for the corresponding lower sub-reaches.

Table 5 Sub-reaches Used for Platte River Flow Accounting	
From-To Locations	**Stream Distance (miles)**
Grand Island to Duncan (Reach 20; no subreaches)	55
Duncan to Loup River confluence (Reach 21, Subreach A)	10
Loup River confluence to North Bend (Reach 21, Subreach B)	31
North Bend to Elkhorn River confluence (Reach 22, Subreach A)	38.5
Elkhorn River confluence to Salt Creek confluence (Reach 22, Subreach B)	9
Salt Creek confluence to Louisville (Reach 22, Subreach C)	9

2.6 Calculating Historic Losses

For purposes of characterizing flows in the lower Platte River, we are interested in the historic portions of Platte River inflows that were lost to evaporation and to seepage in each of the three reaches. In subsequent modeling ("Phase III" of the Plan), total losses due to evaporation will be assumed constant for any given reach on any given day, and evaporation losses associated with any additional Program water will be prorated accordingly. Percent seepage losses associated with additional Program flows will be assumed to be the same as they were for historic Platte flows.

For this reason, a **percent seepage loss** associated with *only the Platte River inflow* at the top of the subject reach was calculated for each day. The seepage loss in cfs associated with the Platte River inflow was assumed to be:

$$\text{Total reach seepage loss (cfs)} \quad * \quad \frac{\text{Platte River inflow, distance-weighted}}{\text{Sum of all gaged inflows, distance-weighted}}$$

Since Platte River inflow was always subject to seepage losses over the entire length of the reach, the "distance-weighted" factor for Platte inflow was always 1.0 (*e.g.*, 41 miles/41 miles for Reach 21). Therefore the Platte inflow seepage loss was always:

$$\frac{\text{Seepage loss} \ * \ \text{Platte River inflow}}{\text{Sum of all gaged inflows, distance-weighted}}$$

Which was converted to a percentage of Platte River inflow as follows:

$$\frac{\text{Seepage loss} \ * \ \text{Platte River inflow}}{\text{Sum of all gaged inflows, distance-weighted}} \quad * \quad \frac{100}{\text{Platte River inflow}}$$

Which simplifies to this formula:

$$\frac{\text{Seepage loss} \; * \; 100}{\text{All gaged inflows, distance-weighted}}$$

For example: on July 31, 1999, for Reach 21, the analysis was based on the following figures:

1130 cfs	Inflow from the Platte River at Duncan
286 cfs	Inflow from the Loup River at Columbus (estimated; see Section 2.2)
961 cfs	Inflow from the Loup Power Plant tailrace flows (estimated; see Section 2.2)
31 cfs	Inflow from Shell Creek near Columbus
135 cfs	Estimated evaporation and ET losses along entire Reach 21
1730 cfs	Outflow from the Platte River at North Bend (one lagged day later)

Using these figures, the net ungaged (seepage) loss was calculated as:

Inflows – Outflows – Estimated evaporation and ET losses

Or in this case:

$$(1130 + 286 + 961 + 31) - 1730 - 135 \;=\; 543 \text{ cfs}$$

The percent seepage loss associated with the Platte River at Duncan inflows (only) was calculated as:

$$\frac{543 \text{ cfs loss} * 100}{(41 \text{ miles}/41 \text{ miles})*1130 \text{ cfs} \;+\; (31 \text{ miles}/41 \text{ miles})*(286 + 961 + 31 \text{ cfs})}$$

which equates to 25.9% of the Platte River inflow at Duncan. The “distance-weighted” inflows in the denominator indicate that the Platte at Duncan inflows are subject to seepage losses over the entire length of the reach, while the other three inflows share these losses over only the lower 31 miles of the 41-mile reach. As a result, 293 cfs of the total 543 cfs of seepage losses along this reach on this day were considered losses associated with Platte River inflow at Duncan.

Percent ungaged gains were not calcuated, as this quantity is not relevant to this analysis. When there was no net seepage loss over the length of the reach (*i.e.*, when there was a net gain), then 100% of the Platte River inflow at the top of the was assumed to arrive at the bottom of the reach reach (except for that lost to evaporation and ET), and none was presumed lost to seepage. This is, as discussed in Section 3, a liberal assumption, as seepage losses to inflows may have occurred at some point along the reach, but were overwhelmed by gains occurring elsewhere along the reach.

3. Assumptions

The methodologies described above necessarily incorporate a number of highly simplifying assumptions. In addition to those already described, some major assumptions include:

1. ***Channel flow conveyance characteristics (e.g., rates of loss or gain) were assumed to be relatively constant over the entire length of the examined reach on any given day***. This is perhaps the most problematic assumption, as it presents many opportunities to underestimate

(or fail to identify) losses over subsections of a full reach. In the current analysis, stream flow gages are typically separated by considerable distances (*e.g*., 55 miles between Grand Island and Duncan). Over such distances, it is very possible that some portions of the stream were losing while others were gaining. In such cases, the mass-balance calculation of seepage loss may seriously overestimate the portion of water at the top of the reach which actually reached the bottom, because the extent of losses in some subreaches was partially or fully masked by gains in others. The best "solution" for coping with this limitation (short of installing additional stream flow gages) is to explicitly recognize that, with respect to our mass-balance analysis, the seepage loss estimates are necessarily conservative. That is, to the extent that our other mass-balance quantities are accurate, seepage losses may be considerably greater than we estimated, but would not be less.

2. ***Open water areas in each reach were assumed to be approximately the same every year between February and June, and between July and January***. This was already discussed in Section 2.4.1. Obviously, open water areas will generally be greater during days of higher-than-normal flow, and less during days of lower-than-normal flow. While the option exists to fine-tune our monthly (and daily) evaporation estimates for each reach based on presumed relationships between surface area and rate of flow, our sensitivity analysis (Section 5.2) suggests that such adjustments would have a negligible effect on the final results.

3. ***Evaporation and ET rates per unit area were assumed constant for all days in any given month***. In reality, evaporation and ET rates along each reach vary daily with the prevailing weather conditions. No attempt was made to make daily adjustments; instead, daily values were derived from the corresponding monthly pan evaporation rates at the corresponding weather station(s). For example, if the entire month exhibited a higher-than-normal rate of evaporation, then each day in that month also had a higher-than-normal rate in the mass-balance model.

4. ***Travel times between gages were assumed to be those listed in Table 2 in all months of all years.*** As already mentioned, a previous analysis (USFWS, 2002a) suggests that travel times in Reach 20 and 22 may be somewhat greater during the July-through-September period in dry years. To the extent that travel times are greater, evaporation losses would also be greater than estimated in this analysis. Model runs do indicate that increasing the one-day travel times in this model to two days has a significant impact on the bottom-line Program water loss estimates (see Section 5.2). Thus, this assumption implies that, in certain months of certain years, we may be underestimating expected Program water losses.

5. ***The effects of individual storm/precipitation events were ignored***. In reality, storm events that generate increased stream flow as the result of direct precipitation on the stream channel and ungaged inflow along the reach may partially or fully mask seepage losses to inflow at the top of the reach (see Assumption #1). This is another simplification that suggests our seepage loss estimates are conservative.

6. ***The effects (if any) of adjacent well pumping on river flows were included in seepage losses***. That is, no attempt was made to separately quantify or account for the effects of well pumping near the river channel. If we assume that future Program flows in the lower Platte

River will be subject to comparable well pumping activities near the river, it is reasonable to include this factor in our loss estimates. However, to the extent that pumping from alluvial aquifers has increased or will increase relative to the period modeled, our analysis may again underestimate the losses that will be suffered by Program-augmented flows in the future.

7. ***The 1997-2000 time period evaluated for Reach 21 was assumed to represent conditions roughly comparable to the Water Year 1975-1994 period used to evaluate the other two reaches of the lower Platte River***. In reality, the 1997-2000 period in the lower Platte basin was, on average, somewhat wetter than the 1975-1994 period, based on a comparison of total streamflow measured in the Platte River at Louisville during these years.

8. ***Columbus Powerhouse tailrace flows were assumed to accurately represent (in daily quantity and timing) return flows to the Platte River associated with Loup Power Canal diversions***. As already mentioned, the tailrace flows do not account for water removed from the tailrace by three irrigators. On the other hand, the tailrace estimates do not include inflows to the Platte River from Lost Creek – neither flood flows diverted into the tailrace channel through a flood diversion channel, nor regular Lost Creek flows that eventually enter the Platte River some 20 miles downstream. Without further investigation, we do not know the extent to which this simplifying assumption introduces errors.

At least four of the above assumptions (#1, #4, #5, and #6) are likely to result in an underestimation of losses (either evaporation or seepage or both) in at least some months of some years. The impacts of the other assumptions are either neutral or difficult to determine. Thus, it is our belief that the "percent delivery of Program water to Louisville" estimates presented in this report are probably generous; the actual percentages may be significantly less in many months.

4. Analysis and Results: Historic Losses to Evaporation and Seepage

Additional details regarding the analytical procedures used for each of the three reaches, along with the results of the historic loss analysis, are provided below.

4.1 Grand Island to Duncan, Nebraska (Reach 20)

No stream gage data are available for this reach between the two endpoints of Grand Island (upstream) and Duncan (downstream). Thus, this analysis consisted of direct mass-balance calculations for the entire stream reach between these two gages.

Total estimated daily evaporation + ET losses over the entire length of Reach 20 ranged from a low of 4 cfs (February 1988) to a high of 190 cfs (June 1988). Over the Water Year 1975-1994 period evaluated, the percent of days in each month for which seepage losses were also evident for inflow at Grand Island are summarized in **Figure 3**. The magnitude of these losses, when they did occur, are summarized in **Figure 4** as percent of Platte River inflow at Grand Island.

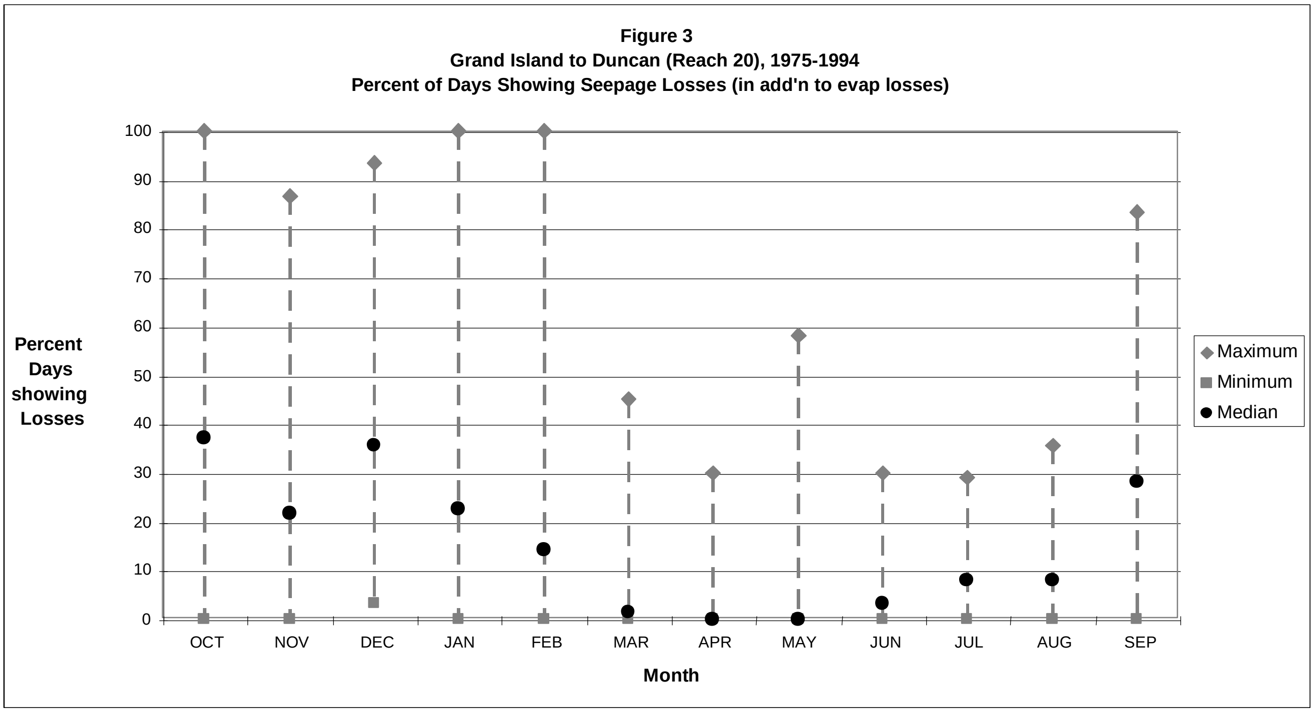


Figure 3
Grand Island to Duncan (Reach 20), 1975-1994
Percent of Days Showing Seepage Losses (in add'n to evap losses)
Percent Days showing Losses
100
90
80
70
60
50
40
30
20
10
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
Month
Maximum
Minimum
Median

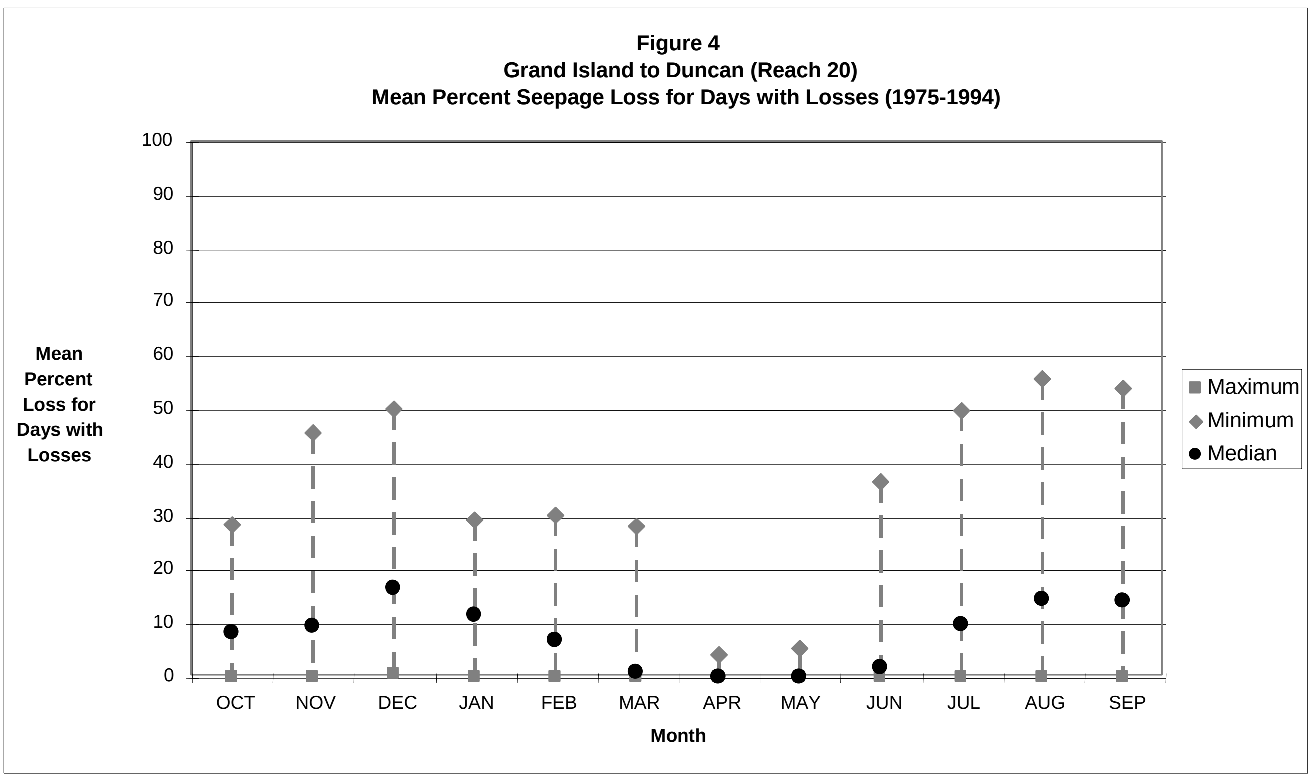


Figure 4
Grand Island to Duncan (Reach 20)
Mean Percent Seepage Loss for Days with Losses (1975-1994)
Mean Percent Loss for Days with Losses
100
90
80
70
60
50
40
30
20
10
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
Month
Maximum
Minimum
Median

As indicated by Figure 3, Reach 20 is not typically a losing reach of the Platte River during any month of the year. It is most commonly a losing reach in the months of September through February, and least commonly a losing reach in March through August. In a "typical" (median) year, seepage losses in March, April, May, and June are negligible. When seepage losses do occur (in September through January, this typically occurs on 21 to 38 percent of days), losses are rarely greater than 40 or 50 percent of inflow, and are typically in the range of 9 to 16 percent (Figure 4).

Implications of these characteristics relative to Program-augmented flows are discussed in Section 5.

4.2 Duncan to North Bend, Nebraska (Reach 21)

Stream gage data are available for this reach not only at the two endpoints of Duncan (upstream) and North Bend (downstream), but also at three points of tributary inflow to the reach (the Loup River near Genoa, return flows from the lower Loup basin Columbus Powerhouse, and Shell Creek near Columbus). Thus, this analysis considered four points of inflow to the reach, and evaluated evaporation losses separately for two subreaches (above and below the Loup River confluence). Although the Columbus Powerhouse return flows enter the Platte River a few miles downstream of the Loup River confluence, for simplicity they were assumed to enter the Platte River at the same location as the other Loup inflows, ten miles downstream from Duncan.

Because daily estimates of inflow from the Columbus Powerhouse are available only for the period of January 1997 through December 2000, our analysis for Reach 21 was undertaken only for this 48-month period, rather than the 1975-1994 period used for Reaches 20 and 22.

Total estimated daily evaporation + ET losses over the entire length of Reach 21 ranged from a low of 17 cfs (March 2000) to a high of 150 cfs (June 1998). Over the 1997-2000 period evaluated, the percent of days in each month for which seepage losses were apparent along Reach 21 are summarized in **Figure 5**, and the magnitude of these losses (as a percentage of the Platte River inflow at Duncan) are summarized in **Figure 6**.

As indicated by Figure 5, Reach 21 is commonly a losing reach of the Platte River during most months of the year, at least for the four-year period evaluated. About half or more of the days in eight months of the median year are losing days, exceptions being April, May, June and November. Reach 21 is most commonly a losing reach in the months of March, July, August and September.

On days when seepage losses do occur, Platte at Duncan losses are rarely greater than 20 or 25 percent of inflow, and are typically in the range of 7 to 19 percent (Figure 6).

Implications of these characteristics relative to Program-augmented flows are discussed in Section 5.

Figure 5
Duncan to North Bend (Reach 21), 1997-2000
Percent of Days Showing Seepage Losses (in add'n to evap losses)

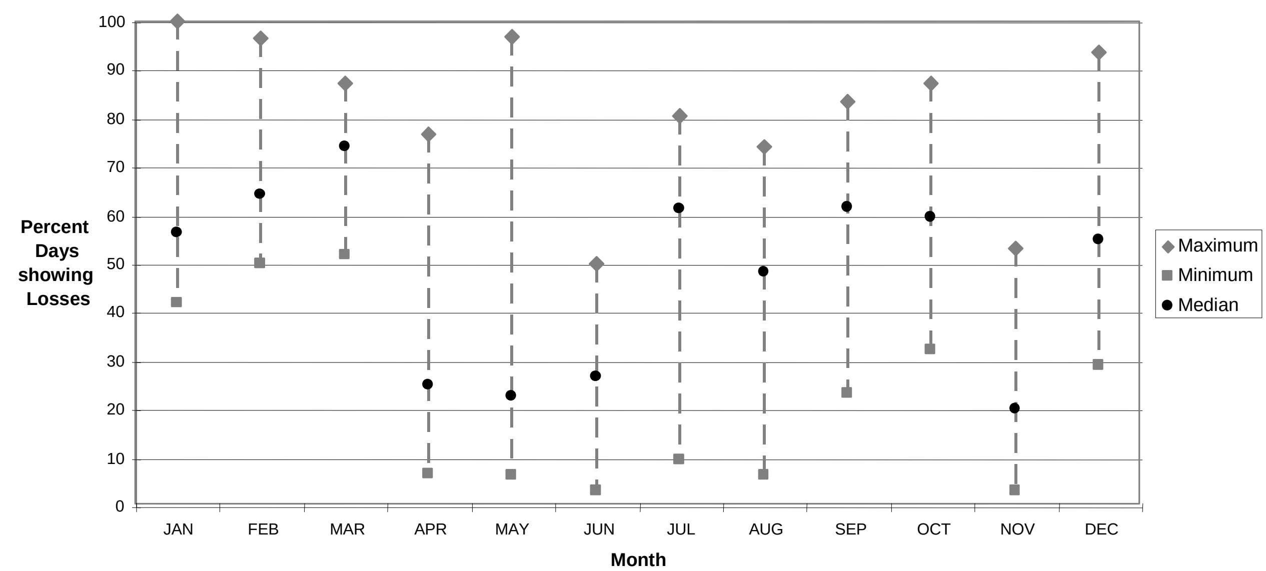
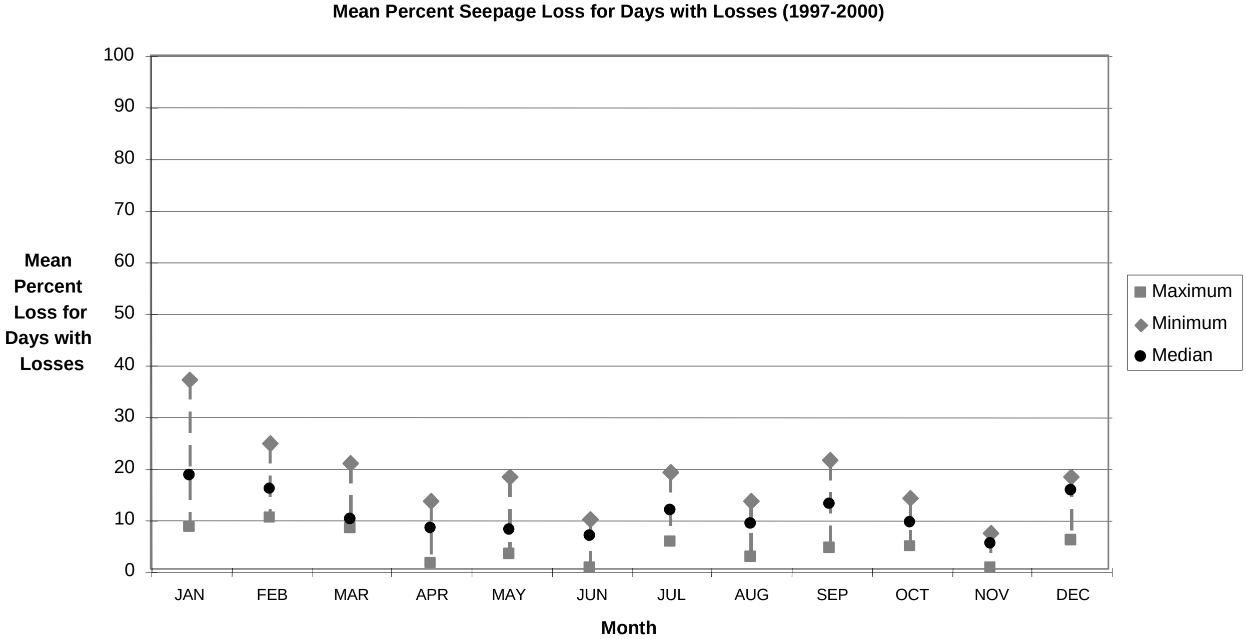


Figure 6
Duncan to North Bend (Reach 21)
Mean Percent Seepage Loss for Days with Losses (1997-2000)



4.3 North Bend to Louisville, Nebraska (Reach 22)

Stream gage data are available for this reach not only at the two endpoints of North Bend (upstream) and Louisville (downstream), but also at two points of tributary inflow to the reach (the Elkhorn River at Waterloo, and Salt Creek at Greenwood). Thus, this analysis considered three points of inflow to the reach, and evaluated evaporation losses separately for three subreaches.

Total estimated daily evaporation + ET losses over the entire length of Reach 22 ranged from a low of 3 cfs (December 1979 and January 1980) to a high of 146 cfs (June 1988). Over the 1975-1994 period evaluated, the percent of days in each month for which additional seepage losses were indicated by the data are summarized in **Figure 7**. The magnitude of these losses, when they did occur, are summarized in **Figure 8** as percent of inflow at North Bend.

As indicated by Figure 7, Reach 22 is not typically a losing reach of the Platte River for most days during any month of the year. However 19 to 37 percent of days are losing days in the median year in all months except April and May, when losing days are less common (about 10 percent). When seepage losses do occur along this reach, they are most commonly the greatest (as a percentage of Platte inflows) from June through September (9 to 17 percent losses for the median year) and the least in April (3 percent losses in the median year). Losses in Reach 22 were never greater than 40 percent of inflow except on rare occasions in July, August, September and October (Figure 8).

Implications of these characteristics relative to Program-augmented flows are discussed in Section 5.

5. Analysis and Results: Estimated Losses of Program-Augmented Flows to Evaporation and Seepage

5.1 Analysis and Results

The ultimate objective of this investigation is to estimate the proportion of Program-augmented flows in the Platte River at Grand Island, Nebraska, one would expect to reach the Platte River at Louisville, under conditions existing during the evaluated period.

To accomplish this, we added various hypothetical quantities (as mean daily cfs) of additional Program water to the historic flows at Grand Island, and estimated the proportion of this added flow lost to a combination of evaporation and seepage between Grand Island and Louisville.

For each day, the **evaporation and ET loss** was estimated by prorating the total evaporation + ET loss in each subreach among all inflows. “All inflows” included (1) the historic Platte River inflow, (2) the additional Program-augmented flow, (3) any other gaged tributary inflows, and (4) a prorated portion of gains, if there were any.

Figure 7
North Bend to Louisville (Reach 22), 1975-1994
Percent of Days Showing Seepage Losses (in add'n to evap losses)

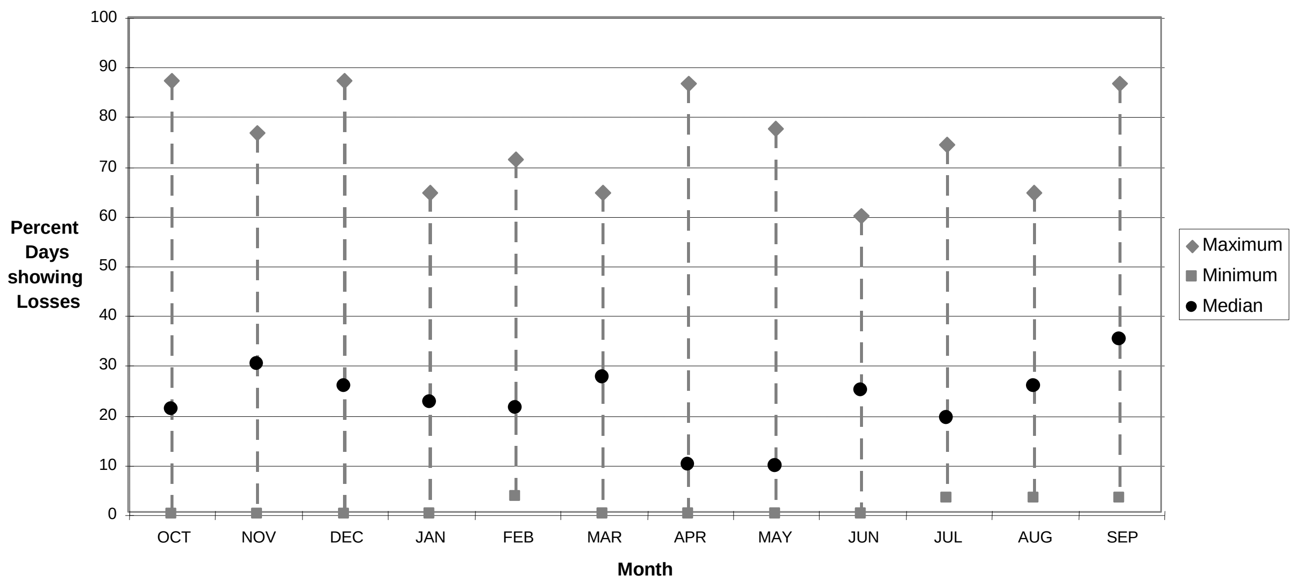
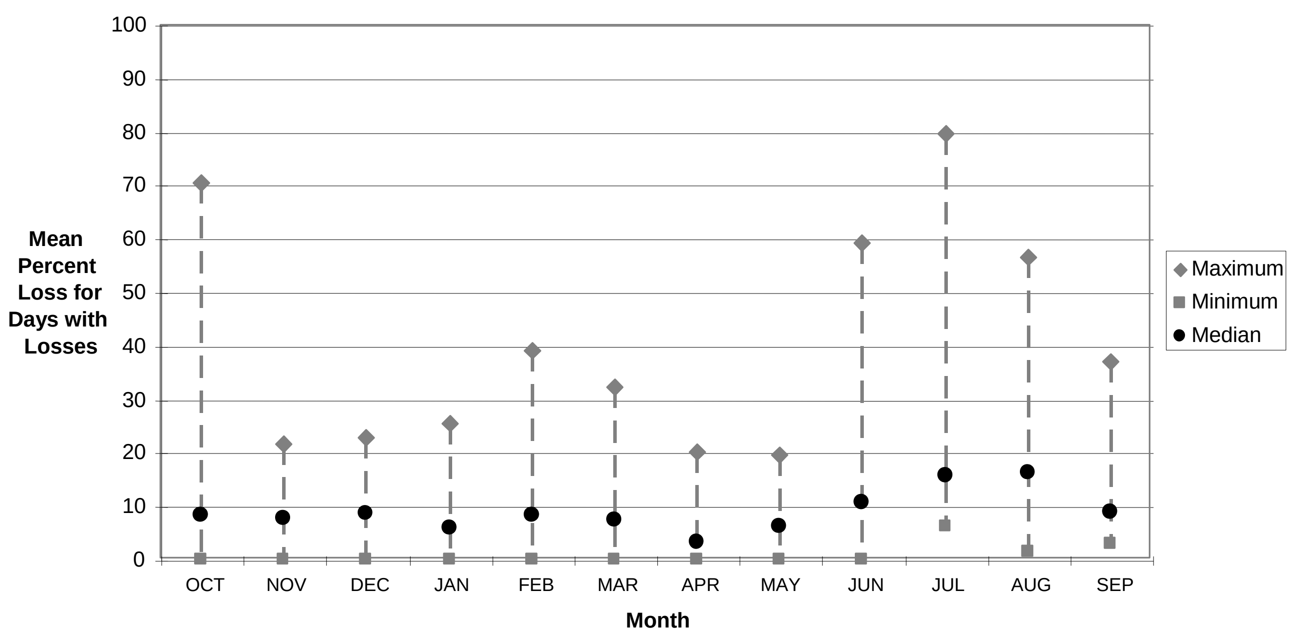


Figure 8
North Bend to Louisville (Reach 22)
Mean Percent Seepage Loss for Days with Losses (1975-1994)



For example, if the Platte River flow at Duncan was 1000 cfs on a particular day, and the evaporation and ET loss for Subreach 21A (above the Loup River confluence) was estimated to be 30 cfs on that day, this loss would be distributed between the historic Platte River inflow and the assumed additional Program-augmented flow. If the assumed Program flow was 200 cfs, then the evaporative loss suffered by Program water in this sub-reach would be 30 cfs * 200 cfs / (1000 + 200 cfs), or 5 cfs. If 500 cfs of additional ungaged gains occurred over the entire Reach 21 on that day, on average one-half of the gain would be subject to evaporative losses[2], and a distance-weighted portion (10 of 41 miles) of that 50% subject to losses over Subreach 21A. This would further reduce the evaporative losses associated with Program water to 30 cfs * 200 cfs / (1000 + 200 + (10/41)*(1/2)*500 cfs), or about 4.8 cfs.

For each day, the **seepage loss** for added Program water was assumed to be the same (in terms of percentage of flow) as the seepage loss experienced by historic Platte River inflow. For example, if 1000 cfs of Platte River inflow at the top of a reach experienced a 12% seepage loss on a particular day, 200 cfs of augmented flow was also assumed to experience the same 12% loss.

For each day, evaporation and seepage losses were added together to estimate **the total Program water loss**. To evaluate the results, these total daily losses were summarized for each month of the year in terms of the average daily Program water loss occurring in that month.

Because evaporation losses are prorated among the various inflows to a reach, evaporation losses suffered by Program water will vary depending upon the assumed Program flows. That is, the greater the quantity of Program water at Grand Island, the greater the proportion of downstream evaporation losses that will be shared by this water. For this reason, the spreadsheet analysis was set up to allow different rates (cfs) of Program water to be evaluated interactively. For simplicity, this report presents results for only two assumed rates of Program water inflow at Grand Island: 100 cfs and 500 cfs.

Table 6 presents a summary of the range of average daily losses over the period of record for each reach, assuming 100 cfs of additional Program water at Grand Island. **Table 7** presents the same information for a presumed 500 cfs of Program water at Grand Island. Both tables show a range of results encompassing the 75-percentile and 25-percentile years.

Finally, in order to estimate cumulative Program water effects at Grand Island, Program-augmented flows were "routed" through the three reaches, with the corresponding percent loss subtracted from the flow in each reach. Because the period of record used for the Reach 21 analysis did not overlap with the period used for Reach 20 and 22, this routing could not be done for each month of the period of record[3]. Instead, the monthly loss percentages associated with

[2] Without additional information, we assume any ungaged gains accrue at a constant, linear rate over the length of the reach. Thus the portion of the total gain subject to evaporation is zero at the top of the reach, 100% at the bottom of the reach, and 50% on average over the entire length of the reach.

[3] For the present analysis, the ideal period of record for Reach 21 would also be water years 1975-1994. Because daily tailrace flow estimates from the Loup District Columbus Powerhouse have not (to our knowledge) been compiled for this period, this cannot be evaluated. Reviewers of this analysis might consider whether it would be worth the effort to compile these data. USFWS estimates it would require at least 4-6 full days of one person's time to assemble this information, not including the additional time required to update the analysis.

the median, the 75-percentile, and the 25-percentile years were used to route and evaluate "normal", "high-loss", and "low-loss" scenarios, respectively. The results are summarized in **Figure 9**.

As is apparent from these figures, the estimated proportion of 100 cfs of Program water ultimately reaching Louisville ranges from less than 60% (in September of the worst years) to over 90% (in December, January, March and April of the best years). In median years, between 79% and 91% of the water reaches Louisville from October through June; in July through September, this percentage falls to 65% to 69%.

For the 500 cfs analysis, the patterns are similar (**Figure 10**). However, relative to 100 cfs, an additional 1 to 4 percent of Program-augmented flows are estimated to reach Louisville in the months of October through June of the median year, and an additional 6 to 10 percent in July through September. This reflects the fact that a smaller percentage of Program-augmented flow will be lost to evaporation as the amount of flow is increased (although the total volume lost will be greater). Conversely, smaller amounts of Program water at Grand Island (e.g., 50 cfs) would be expected to suffer correspondingly greater percentage losses.

5.2 <u>Sensitivity Analysis</u>

The sensitivity of the above "bottom-line" numbers were tested relative to two input values: (1) channel width (and corresponding evaporation/ET losses), and (2) lag time of inflows.

To test the sensitivity of the daily tracking and accounting model to **assumed channel widths**, the mean widths used for open-water areas were increased by 50% for all reaches in all months. This resulted in increased estimates of open-water evaporation losses along each reach. For the 100 cfs Program water analysis, this reduced the estimated amount of Program water at Grand Island reaching Louisville in the median year by about 1 cfs (December through March) to about 5 cfs (in August and September).

To test the sensitivity of the model to **assumed lag times**, the lag times were increased as follows:

- From one day to two days for Grand Island to Duncan flows;
- From one day to two days for Duncan to North Bend flows;
- From one day to two days for all Loup River basin tributary to North Bend flows; and
- From one day to two days for North Bend to Louisville flows.

These lag time adjustments were selected because, as already noted, an earlier analysis (USFWS, 2002a) suggested that under some conditions, travel times between some gage locations may be closer to two days than one. On average, this would not change the difference in inflow and outflow from each stream reach. However, increasing the residence time of flow in each reach increases evaporative losses. Also, changing the evaporation estimates and the timing of inflows and outflows may change the distribution, frequency, and magnitude of the seepage loss estimates.

100 CFS Program Water at Grand Island
Minimum percent of flow lost over length of reach

Reach 20 (Grand Island to Duncan)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
75 Pctl	16	10	15	6	3	2	7	10	14	22	25	27
25 Pctl	4	2	2	1	1	1	2	4	7	10	12	5
Median	10	6	8	5	3	1	4	6	13	19	23	17

Reach 21 (Duncan to North Bend)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
75 Pctl	9	12	8	23	16	12	5	8	6	15	9	12
25 Pctl	8	8	3	5	9	6	3	4	4	8	8	8
Median	8	10	4	13	13	8	4	4	5	11	8	10

Reach 22 (North Bend to Louisville)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
75 Pctl	7	5	4	6	3	4	3	5	5	10	10	8
25 Pctl	1	1	1	1	1	1	1	1	3	5	4	3
Median	4	3	4	2	3	3	1	3	4	8	8	6

Table 6. Estimated minimum percentages total loss per reach of 100 cfs Program water in the median, 25-percentile, and 75-percentile years.

500 CFS Program Water at Grand Island
Minimum percent of flow lost over length of reach

Reach 20 (Grand Island to Duncan)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
75 Pctl	12	9	14	6	2	2	5	7	10	15	14	18
25 Pctl	3	1	2	1	1	1	2	4	5	7	8	5
Median	8	6	7	4	2	1	3	5	9	13	14	10

Reach 21 (Duncan to North Bend)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
75 Pctl	9	11	8	23	16	12	5	8	6	14	9	11
25 Pctl	6	7	3	5	9	6	3	3	3	7	6	7
Median	7	9	3	13	13	8	4	4	5	10	7	9

Reach 22 (North Bend to Louisville)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
75 Pctl	7	5	4	6	3	3	3	4	5	9	9	8
25 Pctl	1	1	1	1	1	1	1	1	3	4	3	3
Median	4	3	3	2	2	3	1	3	4	7	7	6

Table 7. Estimated minimum percentages total loss per reach of 500 cfs Program water in the median, 25-percentile, and 75-percentile years.

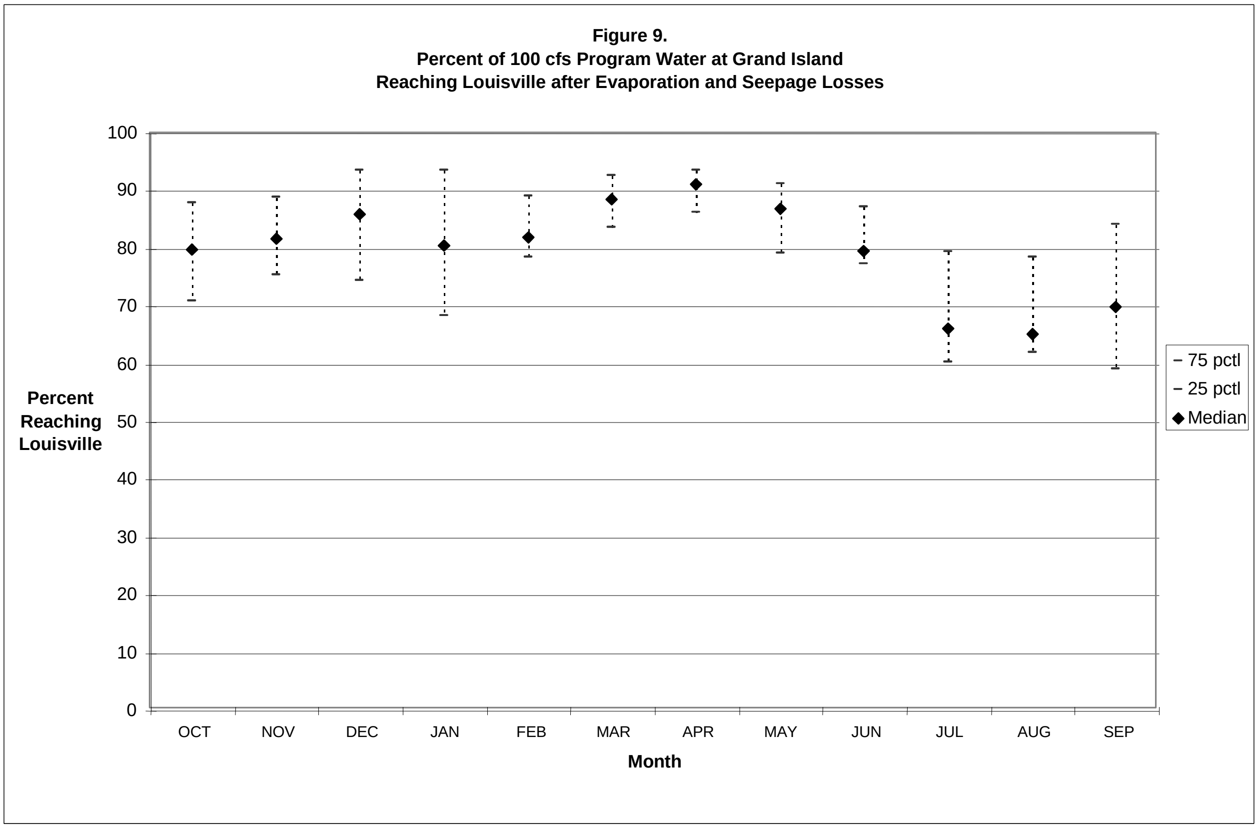


Figure 9.
Percent of 100 cfs Program Water at Grand Island
Reaching Louisville after Evaporation and Seepage Losses
Percent Reaching Louisville
100
90
80
70
60
50
40
30
20
10
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
Month
75 pctl
25 pctl
Median

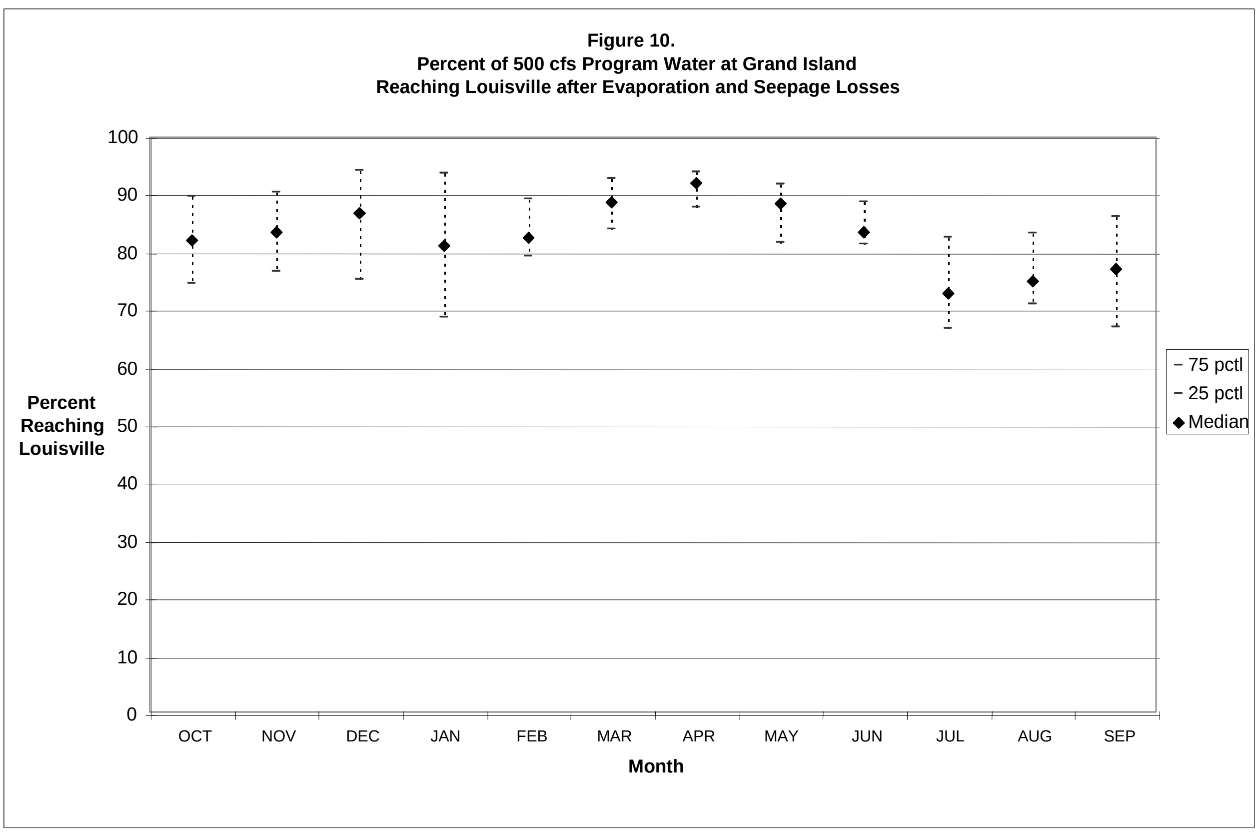


Figure 10.
Percent of 500 cfs Program Water at Grand Island
Reaching Louisville after Evaporation and Seepage Losses
Percent Reaching Louisville
100
90
80
70
60
50
40
30
20
10
0
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
Month
75 pctl
25 pctl
Median

For the 100 cfs Program water analysis, changing all of the above lag times from 1 to 2 days further reduced the estimated percentages of Program water at Grand Island reaching Louisville in the median year by 9 to 17 cfs in each month between May and September, and between 2 and 6 cfs from November to April. Thus, this model is relatively sensitive to assumed travel times, particularly during those months with the highest evaporation rates. To the extent that travel times are closer to two days than one, this suggests a further reason to consider Table 6 and 7 values to be conservative.

6. Summary and Conclusions

Based on an analysis of the available gage data for the lower Platte River system for water years 1975 through 1994 (and for calendar years 1997 through 2000), and an analysis of corresponding pan evaporation records from Grand Island and Omaha, likely percentages of Program-augmented flows in the Platte River at Grand Island which ultimately would have reached Louisville were estimated. The results of this analysis for 100 cfs and 500 cfs of Program flow are summarized in Figures 9 and 10.

The results suggest that less than 60% (in September of the worst years) to over 90% (in December, January, March and April of the best years) of these augmented flows would be expected to reach Grand Island if they were on the order of 100 cfs (about 6,000 AF/month). In median years, a maximum of between 79% and 91% of this water would reach Louisville from October through June; in July through September, this percentage falls to 65% to 70%.

For a variety of reasons described in Section 3 of this report, these estimated percentages are probably generous. The actual percentages reaching Louisville are unlikely to be any greater than the values presented here, and they may be significantly less. For augmented flows in excess of 100 cfs, percentages reaching Louisville would be somewhat higher, especially in summer months. Conversely, for augmented flows of less than 100 cfs, the percentages would be lower.

Compared to many Platte River reaches above Grand Island (WMC, 1998), these estimated losses are modest when considered on a per-mile basis. This is not surprising, for several reasons:

(1) Above Grand Island, unit-area evaporative losses during most of the year are greater than they are in the lower Platte basin;
(2) Below Grand Island, there are several major tributary inflows to the Platte River (including the Loup River, Elkhorn River, and Salt Creek), and these large inflows tend to reduce the portion of evaporative and seepage losses shared by main stem Platte River flows. On an average, year-round basis, only about 25% of flows in the Platte River at Louisville originate from the Platte River above Columbus (Nebraska DNR, 1983);
(3) Below Grand Island, higher flow velocities (which are suggested by the USFWS travel-time analysis, and are consistent with the generally higher rates of discharge) may also reduce opportunities for evaporative loss;

(4) Below Grand Island, there are no major surface-water diversions from the Platte River. Above Grand Island, such diversions and associated consumptive uses can substantially deplete flows along certain reaches.

Current hydrologic models of a possible Platte River Recovery Implementation Program suggest that augmented Program flows at Grand Island will commonly be on the order of those evaluated in this report, *i.e*., seldom more than 6,000 to 30,000 AF/month. In some cases – particularly in May and June of certain years when larger pulse flow releases are made, or unusually high levels of augmented flows are maintained for several weeks – it is possible that more than 30,000 AF/month of Program water will be added to flows at Grand Island. It should be noted that the proposed Program definitely proposes short-term (*e.g*., 1- to 3-day) Program-augmented flows in excess of 500 cfs at Grand Island; the fate of these pulse flows below Grand Island may be assessed by considering our evaluation of ten historic pulse flows in the lower Platte River (USFWS, 2000b).

This analysis is based on conditions that prevailed over the evaluated period of record. To the extent that conditions in the lower Platte River have changed – for example, greater groundwater pumping from alluvial aquifers adjacent to the river – the effects on future augmented Program flows in the lower Platte River may not be fully addressed by this analysis.

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APPENDIX A

Adjusted Daily Loup River Inflow Estimates

Daily flows to the Platte River from the Loup River, excluding those flows diverted to the Columbus Hydroelectric Power Canal (“Loup Power Canal”), historically have been measured near Columbus, Nebraska (USGS gage #06794000, prior to 10/10/1978) and/or the Loup River at Genoa, Nebraska (USGS gage #06793000, 4/1/1929 to present). For this analysis, the former gage location is preferable to the latter because it is approximately 24 miles closer to the Platte River confluence. However, gage records are not available for this location for the period analyzed in this report for Reach 21 (1997 through 2000).

For 92% of the days during the 1954 to 1978 period when daily flows were measured at both gages, daily flow in the Loup River at Columbus exceeded daily flow in the Loup River at Genoa, often substantially. This is not surprising, given the significantly larger drainage area associated with the Columbus location and the likely effects of inflows below Genoa. In an effort to develop better estimates of daily inflows to Reach 21 from the Loup River, USFWS developed monthly linear regression relationships between daily flows at these two gages based on the 1954 to 1978 record. Inflows recorded for the Loup River at Genoa for all months except August were then adjusted for use in the accounting model after 10/10/1978, as described below.

The Microsoft Excel spreadsheet function LINEST was used to determine the $y = mx + b$ linear relationship that best described daily flow in the Loup River at Columbus as a function of flow in the Loup River at Genoa on the same date. (Relationships based on one day of lag between the gages were also investigated, but these generally resulted in poorer correlation coefficients and thus were not further evaluated). Because relationships between daily flows are likely to vary under different hydrologic, climatologic, and water use conditions, each month was evaluated separately. The resulting least-squares best-fit linear relationships for each month are summarized below.

	Slope	Y-intercept (cfs)	R^2	Standard Error (cfs)
Jan	1.02	134	0.91	204
Feb	1.04	183	0.90	390
Mar	1.10	251	0.91	986
Apr	0.97	290	0.81	379
May	1.18	204	0.89	502
Jun	1.07	290	0.84	1154
Jul	1.17	143	0.89	276
Aug	0.64	208	0.34	2417
Sep	0.82	126	0.76	232
Oct	1.16	116	0.80	129
Nov	0.80	174	0.71	319
Dec	0.92	192	0.79	373

The coefficient of determination (R^2) expresses the degree to which the variability in daily flows at Columbus is explained by the daily flows at Genoa. For all but one of the twelve months, the Genoa gage explains at least 71% of this variabilty (R^2 >= 0.71). In addition, for eight of the twelve months, the standard error was 390 cfs or less, which compares to a year-round mean daily flow at the Columbus gage of about 1,050 cfs. Only for the month of August (with an unusually low R^2 value of 0.34 and an unusually high standard error of 2,417 cfs) does this relationship seem too poor to justify adjustments to the daily flow values.

Examination of residuals associated with these estimates suggests that the linear model is a reasonable one for the purposes of this analysis. The positive y-intercept in all months appears consistent with the generally gaining characteristics of the Loup River between Genoa and Loup. For example: flows at Columbus were typically on the order of at least 20 to 100 cfs, even when stream flow at Genoa was at or near zero.

Based on the above analysis, daily flows for the Loup River at Genoa from January 1997 through December 2000 were adjusted for all months except August to estimate the corresponding daily flow in the Loup River at Columbus. For example, a flow of 600 cfs in the Loup River at Genoa for a particular day in January would be adjusted as follows:

(600 cfs * 1.02) + 134 cfs = 746 cfs estimated inflow at Columbus

and the 746 cfs value would be used to estimate inflow to the Platte River from the Loup River on this day. For August, the daily flows in the Loup River at Genoa were used unadjusted.

Although adjustment of these Loup River flows introduces some additional uncertainty into the daily flow accounting calculations, they generally represent more accurate estimates of Loup inflows to the Platte River. On 73% of days during the 25-year "calibration period" (excluding August), flows at Columbus estimated as described above were closer to the actual measured flows than were the measured flows at Genoa. For this reason the adjusted flows were incorporated into the daily flow tracking and accounting model.

Appendix B

Summary Report on the Potential of Changes in Central Platte Flow Conditions to Affect Flows in the Lower Platte
Draft Report
December 2002

SUMMARY REPORT ON
THE POTENTIAL OF CHANGES IN CENTRAL PLATTE FLOW CONDITIONS TO AFFECT FLOWS IN THE LOWER PLATTE

U.S. Fish and Wildlife Service
Mountain-Prairie Region (Region 6)
December 31, 2002 *DRAFT*

EXECUTIVE SUMMARY

The U.S. Fish and Wildlife Service, working with members of the Water Management Committee, completed a preliminary analysis of how changes in flow conditions in the central Platte River due to proposed Recovery Program activities may affect flows in the lower Platte. This analysis was undertaken to help determine whether Program activities could provide measurable benefits to pallid sturgeon habitat in the lower Platte.

Our analysis considered the effect of both short-duration pulse flows and of sustained augmented flows in the central Platte River. Assessed effects included estimated changes in mean monthly flow, stage, velocity, and width in the Platte River at Louisville, Nebraska, due to Program activities. These estimates were based on modeled effects of the analyzed Program on flows at Grand Island combined with estimated conveyance losses between Grand Island and Louisville. The conveyance loss estimates were derived from a daily flow accounting model constructed from historic streamflow and pan evaporation records.

The estimated range of effects at Louisville of the Proposed Program, as summarized in Table 3 of this document, suggest modest increases in flow at Louisville (20 to 788 cfs) during the critical February-through-July period of most dry-to-normal flow years, as well as increases in flow (287 to 411 cfs) in May of wet years. However, for reasons detailed in this report, large uncertainties are associated with all of these estimates. Moreover, it is unlikely that the flow effects suggested by this study would be clearly detectable at Louisville except under unusual conditions, such as exceptionally low river flows and/or exceptionally large Program water releases.

A more detailed study of flow attenuation and conveyance losses in the lower Platte River system could improve upon this preliminary effort, however we believe a more thorough analysis is not justified unless or until:

- Better and more complete hydrologic data are available for the lower Platte River system;
- Pallid sturgeon habitat needs and the potential benefits of specific timing/quantities of augmented flow in the lower Platte are better understood; and/or
- If and when the Program is able to provide larger volumes of flow to the central Platte than is anticipated under the First Increment of the current Program.

The information presented in this report responds to the *hydrologic* questions raised by Cooperative Agreement Milestone R1A-Ext, but not the remaining biological question of whether these changes in lower Platte flow could “provide measurable benefits to pallid sturgeon habitat”.

1. BACKGROUND

This analysis was pursued to partially fulfill Milestone R1a-EXT of the Cooperative Agreement, which reads in its entirety:

> The Governance Committee and the FWS will develop a schedule and implement a plan for obtaining data to determine if changes in flow conditions in the central Platte will affect flows in the lower Platte. If changes can be detected then an assessment of the magnitude of the changes will be completed and a determination will be made regarding the potential for these changes to provide measurable benefits to pallid sturgeon habitat.

The U.S. Fish and Wildlife Service (FWS), working with members of the Program's Water Management Committee (WMC), developed a draft "Plan for Testing the Ability of the Program to Affect Lower Platte River Flows". On March 4, 2002, the Governance Committee gave its approval to implement the February 28, 2002 version of that Plan. The Plan describes a six-phase approach to addressing the Milestone, as summarized below:

Phase I	Estimate travel times for the three reaches between Grand Island and Louisville, and evaluate the attenuation of peak flows;
Phase II	Estimate historic losses by reach based on daily flow records below Grand Island;
Phase III	Estimate the likely range of possible effects of Program water at Grand Island on flow in the lower Platte River;
Phase IV	Translate the likely flow effects to depth/width/velocity effects at Louisville;
Phase V	Compare these effects to existing short-term variations in Platte flows/depths at Louisville.
Phase VI	If necessary, expand the scope of the evaluation.

2. IMPLEMENTATION

The phased analysis described above was undertaken by FWS with guidance and review by various members of the Water Management Committee, in particular the following:

- Ann Bleed, Nebraska Department of Natural Resources (NDNR)
- Mike Drain, Central Nebraska Public Power and Irrigation District (CNPPID)
- Frank Kwapnioski, Nebraska Public Power District (NPPD)

The first five phases of this preliminary evaluation have been completed. FWS and the above individuals do not believe the sixth phase is necessary at this time, because the existing analysis adequately addresses Milestone R1a-EXT.

Our analysis relied heavily on historic daily flow estimates from a number of gaging stations throughout the Platte River basin in Nebraska. Stream gaging locations used in this analysis are shown in **Figure 1**. In addition, records of daily hydroelectric power generation were compiled for the Columbus Powerhouse located near the mouth of the Loup River, in order to estimate the contribution of tailrace flows from the power plant to the Platte.

Below Grand Island, Nebraska, the lower Platte River was evaluated as three separate river reaches, each bounded by corresponding stream flow gaging stations[1]:

- Grand Island to Duncan ("Reach 20")
- Duncan to North Bend ("Reach 21"), and
- North Bend to Louisville ("Reach 22")

As described in this report, FWS considered possible effects on the lower Platte River of two kinds of flow changes in the central Platte:

- Short-duration pulse flows, and
- Augmented (or reduced) flow in the river over sustained periods (e.g., weeks or months).

3. CONTEXT: DESCRIPTION OF THE LOWER PLATTE RIVER SYSTEM

The Program's long-term goal is to improve and maintain associated habitats for four target species, one of which is the pallid sturgeon (*Scaphirhynchus albus*). The Cooperative Agreement defines "associated habitat" for the pallid sturgeon as the lower Platte River between its confluence with the Elkhorn River and its confluence with the Missouri River (approximately 33 river miles). The period during which FWS believes elevated flows in the lower Platte are most likely to benefit the sturgeon is February through July (FWS, 1996).

For the investigations described here, the stream gaging station for the Platte River at Louisville, Nebraska (about 16.5 river miles upstream from the mouth of the Platte) was used as the representative location for the lower Platte. This gage is located about halfway along the river reach identified as pallid sturgeon "associated habitat".

Beginning around Columbus, Nebraska (about 104 river miles from the mouth of the Platte), flow in the Platte River is strongly determined by tributary inflows, including the Loup River, the Elkhorn River, and Salt Creek. A study of 1950-1980 data by the Nebraska Department of Natural Resources (Nebraska DNR, 1983) concludes that, on an average annual basis, only about 25% of the flow in the Platte River at Louisville originated from the Platte basin above Duncan (**Figure 2A**). A similar analysis of the 1975-1994 period by FWS indicates that average annual
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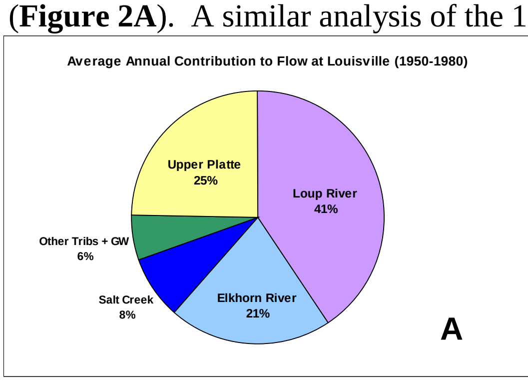

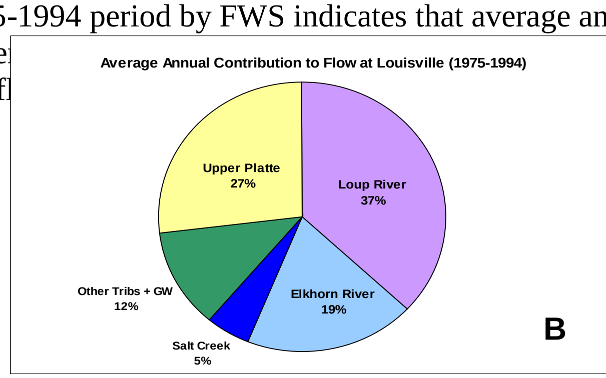

[1] Numbering of these reaches begins at 20 to avoid confusion with Reaches 1 through 19 above Grand Island previously defined by the Water Management Committee for a Milestone W14-1 study.

Figure 2. Average annual contribution to flow in the Platte River at Louisville from various sources, as evaluated by the Nebraska DNR for 1950-1980 (A), and by USFWS for 1975-1994 (B).

The contribution of the upper Platte basin relative to all other sources of inflow to the lower Platte hints at the challenges involved in providing flow benefits to pallid sturgeon habitat through upper basin activities alone. Nevertheless, it is important to recognize that the portion of lower Platte flow contributed by the upper basin, particularly during the May-June period, was almost certainly greater in the pre-development era than it is today (*e.g.*, Stroup et al., 2001).

Several studies suggest that the lower Platte River, particularly downstream of Duncan, is generally a neutral-to-gaining river over most of its length for most of the year (Waite, 1949; Lappala et al., 1979; Stanton, 2000). This contrasts markedly with the Platte River above Grand Island, which frequently suffers substantial seepage losses along many reaches over extended periods. From a practical standpoint, this suggests that increases in flow will generally suffer smaller conveyance losses downstream of the Grand Island-to-Duncan reach than they will upstream of that area.

4. STUDY FINDINGS

4.1 How do Changes in Flow Conditions in the Central Platte Affect Flows in the Lower Platte?

4.1.1 Limits of Understanding

Clearly, changes to flow conditions in the central Platte River (*i.e.*, in the Overton-to-Grand Island reach) will have some effect on flows in the lower Platte River. The only time this would not be true is when zero-flow conditions occur at some point below Grand Island, such that no surface flow from the central Platte can reach the lower Platte. From 1975-1994, the focus of our historic analysis, mean daily flow dropped to zero on just 52 days at Grand Island, and 72 days at Duncan.

Estimating the degree to which changes in flow conditions in the central Platte would affect flow in the lower Platte is hampered by limited data and limited understanding of the lower Platte River system. In particular:

- Flow gaging stations are few and far between on the Platte River system below Grand Island, as shown in Figure 1. For the period evaluated by FWS, extended reaches of the river and/or its tributaries were ungaged (for example, 55 miles between the Grand Island and Duncan gages, and 56.5 miles between North Bend and Louisville gages).

- Until recently, tailrace flows from the Columbus Powerhouse near Columbus, Nebraska have not been measured. This is a crucial data gap, as (on an average annual basis) more water returns to the Platte River via the Columbus Powerhouse tailrace than via the Loup River channel itself (from which the powerhouse diverts water). To partially compensate for this gap in this analysis, four years of daily power generation records were acquired, as well as daily records for selected pulse flow evaluation periods. From these records, daily tailrace flows were estimated as a function of daily power generation.

- Where gaging stations do exist, significant uncertainty is associated with the flow measurements. This is particularly true in winter months, when icing is common, confounding reliable estimates. This increases the uncertainty associated with our flow attenuation and conveyance loss models, particularly during winter months.

- Substantial variability and uncertainty is associated with our estimates of flow travel times in the lower Platte. The conveyance loss analysis described in this report relied on velocity measurements taken at a handful of sites, and these were used to estimate flow velocities under "median monthly" conditions between gages. In reality, flow velocities and travel times vary substantially over space and time under different flow and channel conditions. This limits the accuracy of daily conveyance loss estimates.

Within the context of these limitations, efforts were made under Phase I of the Plan to assess the effects of pulse flows in the central Platte River on flows in the lower Platte, and under Phases II and III of the Plan to assess the effect of sustained changes in flow.

4.1.2 Study results

Pulse flows

To assess the **potential effect of pulse flows**, FWS evaluated the historic attenuation of short-duration pulses as they have moved down the Platte River from North Platte, Nebraska to Louisville. Ten "case studies" of pulse flow events occurring between 1949 and 1999 were analyzed. The flow volume under the pulse event hydrographs was tracked through the central and lower Platte to estimate (1) travel times between gages and (2) percentage of the initial volume of the pulse remaining at each gage point downstream.

The FWS analysis took into account the operation of the Tri-County supply canal system, tributary inflows (including Columbus Powerhouse discharges), precipitation events, and changes in the hydrographs from one gage to the next. As a result of these analyses, FWS estimates that, for eight of the ten events considered, the portion of the pulse flow volume at North Platte that remained as a pulse in the Platte River at Louisville (or Ashland) was in the range of approximately 20 to 40 percent. In the remaining two cases, the percentages were about 55 and 65 percent. A summary of the individual events is included as **Appendix A** to this document.

As noted in Appendix A, the peak discharge associated with the evaluated pulse events ranged from 6,850 to 20,900 cfs. Because pulse flows created or augmented by the Program are more likely to be in the range of 6,000 to 8,000 cfs, the attenuation of Program pulses may be greater than for many of the events analyzed in this study.

Sustained flows

To assess the **potential effect of sustained flows**, FWS constructed a daily flow accounting model to estimate historic evaporation and seepage losses along each stream reach. To accomplish this, the following steps were followed:

- Travel times in each reach were estimated for each month of the year under median flow conditions (**Appendix B**);
- Open-water and vegetated island and riparian areas were estimated for each reach, and these areas were used together with historic pan evaporation data to estimate monthly losses to open-water evaporation and vegetative evapotranspiration (ET);
- Daily flow data for each gage were compiled for the 1975-1994 period (1997-2000 for Reach 21, due to the unavailability of reliable estimates of tailrace flows from the Columbus Powerhouse for any other period);
- After accounting for estimated daily evaporation and ET losses along each reach, daily seepage losses or gains along each reach were estimated;
- A distribution of losses by month of year was compiled. Evaporation losses and seepage losses were then summed to estimate a reasonable range of conveyance losses along each reach of the river (**Appendix C**), using methodologies that may somewhat underestimate actual losses.

As summarized in Appendix C, FWS conservatively estimates that at least 8 to 31 percent of sustained Program-augmented flows in the Platte would be lost to seepage and evaporation between Grand Island and Louisville under typical conditions, with a range of 19 to 60 percent more likely using less conservative assumptions. The predicted conveyance losses depend upon the time of year, flow conditions, and quantity of augmented flow. Estimated losses are highest in the summer months (30 to 60 percent in July and August) and lowest in late spring (8 to 25 percent in March and April).

4.2 Can Program Changes in Flow Conditions be Detected in the Lower Platte?

<u>4.2.1 Limits of Detectability</u>

While the effect of central Platte flow changes on the lower Platte was estimated as described above, the likelihood of being able to detect changes (that is, distinguish them from existing variability in flow and uncertainty in flow measurements) is another matter. Changes in flow conditions in the central Platte River *of the magnitude currently envisioned under the Program* are in fact not likely to be detectable at Louisville, Nebraska, except under unusual conditions. These "unusual conditions" include exceptionally low flow in the Platte River at Louisville, and/or exceptionally large Program water releases.

The detectability of flow changes at Louisville is limited for two reasons:

(1) USGS gage measurements are of limited accuracy.

The USGS describes the accuracy of the Platte River stream gage at Louisville, Nebraska as being "good" ("except for estimated daily discharges, which are poor"). This means the USGS believes about 95 percent of the reported daily discharges are within 10 percent of their true value. Over the 20-year period used for the FWS stream flow accounting model, the 10%, 50%, and 90% frequencies of daily flow exceedance at Louisville are as shown in Table 1:

Table 1. Mean daily flow in the Platte River at Louisville, Water Years 1975 through 1994, expressed as frequency of exceedance.

Percent days exceeding	Mean daily flow, WY 1975-1994 (cfs)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
90%	2,600	3,600	5,625	4,913	3,849	2,570	1,368	1,057	1,479	2,130	3,179	2,436
50%	4,700	6,600	10,200	8,100	7,720	6,955	4,135	3,545	4,340	4,170	4,835	5,000
10%	8,602	14,620	22,860	21,920	21,810	23,320	16,330	9,220	10,500	10,100	9,494	9,176

This implies the following approximate *uncertainties* associated with the corresponding flow measurements at Louisville, at the 95% confidence level:

Table 2. Uncertainty of USGS mean daily flow measurements in the Platte River at Louisville (cfs plus or minus), expressed at the 95% confidence level as frequency of exceedance, Water Years 1975 through 1995.

Percent days exceeding	Uncertainty in Daily Flow, WY 1975-1994 (plus-or-minus cfs)											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
90%	260	360	563	491	385	257	137	106	148	213	318	244
50%	470	660	1,020	810	772	696	414	355	434	417	484	500
10%	860	1,462	2,286	2,192	2,181	2,332	1,633	922	1,050	1,010	949	918

In other words, a change in daily flow of at least several hundred cfs would be necessary under median (50%) flow conditions in any month before that change would exceed the uncertainty inherent in the flow measurement. Under unusually low flow conditions (*i.e.*, at a rate of flow exceeded 90% of the time), a change of 150 cfs would be greater than this uncertainty in July, August, and September; a change of 213 to 563 cfs would be required in other months of the year.

(2) Flows at Louisville vary substantially on an hourly and a daily basis

An example of the hourly and daily flow variability of the Platte River at Louisville is illustrated in **Figure 3**. Mean daily flow at Louisville in this month (May 1997) ranged from 6,720 cfs (May 24) to 12,600 cfs (May 31), which is fairly typical for May. However, as is apparent in Figure 3, there was a strong and regular diurnal cycle in flow, with an amplitude on the order of 1,000 to 2,000 cfs. Diurnal cycles were typical of flows at Louisville throughout the 1996-2000 period evaluated, although they tended to be more apparent and more pronounced in summer months.

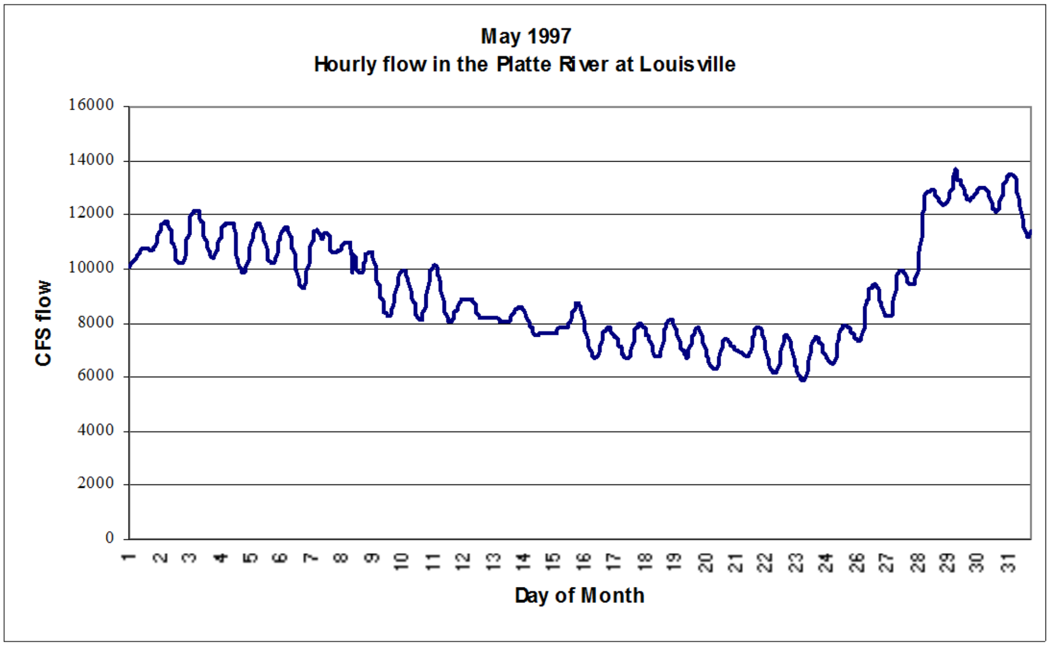

Figure 3. Hourly flow hydrograph, Platte River at Louisville, May 1997.

The diurnal pattern in Figure 3 is characterized by a peak in flows around mid-day, and a trough around midnight. This pattern is likely associated, at least in part, with diurnal cycles of releases made for hydropower generation purposes ("hydrocycling") from the Columbus Powerhouse (Steve Lydick, FWS, personal communication, August 2002). Tailrace flows from the powerhouse enter the Platte near the Loup River confluence, about 87 miles upstream from the Louisville gage.

Figure 4 illustrates the magnitude of the 24-hour range in hourly flows at Louisville in 1996-2000 in terms of frequency of exceedance (FWS, 2002e). As indicated by the figure, ranges in 24-hour flow were lowest in September, December, and January and highest in May and June. Even in the three months least prone to large variations in flow over the course of a day, 90% of days exhibited at least 170 cfs difference betweeen the daily high and daily low flow. In the months of most interest to FWS relative to potential pallid sturgeon benefits (February through July), the 90% exceedance threshold was 520 cfs. In the extreme case of June, 90% of days had a 24-hour range in flows of 1,390 cfs or more.

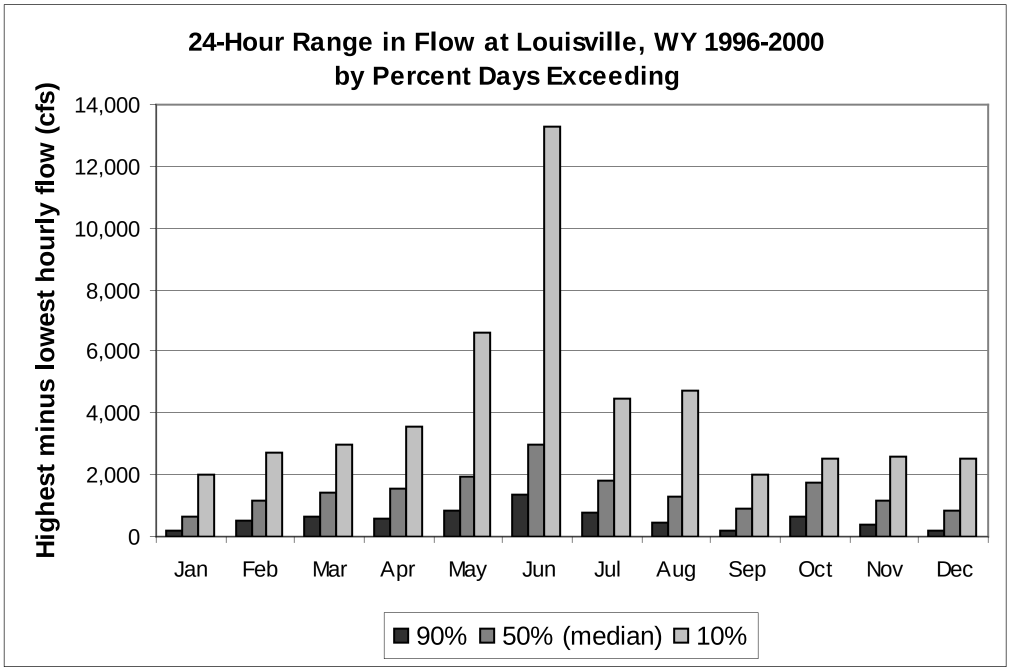

Figure 4. 24-hour range in flows (maximum - minimum hourly flow) in the Platte River at the Louisville gage, 1996 through 2000, expressed as a frequency of exceedance.

4.2.2 Modeled Changes in Lower Platte Flows

As already noted, large distances between key stream flow gages in the lower Platte River system impose limits on our understanding of river behavior between these gages. The location and magnitude of stream gains and losses, for example, is difficult to quantify except at a broad geographic scale. Thus, while the attenuation and conveyance loss estimates developed by FWS represent a valuable starting point for understanding the lower Platte system, they must be interpreted with caution until better data are available.

Keeping these limitations in mind, and using the output from a recent OPSTUDY Model analysis of Program effects on the central Platte, FWS estimated the effect that First-Increment Program activities would typically have on flows at Louisville under "Phase IV" of the analysis (USFWS, 2002d). The results are expressed as a "likely range of effects", as shown in Table 3:

Table 3. Estimated likely range of effects of First-Increment Program activities on flow in the Platte River at Louisville (change in cfs relative to baseline condition). Parentheses denote negative values.

	Delivery Efficiency	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Dry Conditions	Low	(52)	46	133	328	550	281	138	228	254	87	256	(64)
	High	(74)	66	190	470	788	402	197	326	364	125	366	(91)
Normal Conditions	Low	(187)	(55)	171	407	444	72	44	135	185	262	20	(163)
	High	(268)	(79)	245	582	635	103	63	194	264	375	28	(233)
Wet Conditions	Low	(328)	(293)	(205)	(84)	287	(748)	(55)	(27)	16	73	(200)	(273)
	High	(469)	(419)	(293)	(121)	411	(1,070)	(85)	(39)	23	105	(286)	(390)

An explanation of Table 3 follows:

(1) "Dry", "normal" and "wet" conditions were based on historic flow conditions at Grand Island from 1947 through 1994, the period used for the Central Platte OPSTUDY model. The 1/3 lowest-flow months constituted the "dry conditions", 1/3 highest-flow months "wet conditions", and the remainder "normal conditions".

(2) Total monthly flow in the Platte River at Grand Island, Nebraska, was compared for two OPSTUDY model scenarios: "baseline" versus "analyzed Program". Flows modeled for the baseline condition[2] were subtracted from flows modeled for the analyzed Program, and the results (in acre-feet/month) converted to mean monthly cfs.

(3) For each month, a high and low conveyance loss percentage (USFWS, 2002c and Appendix C) was applied to the change in flow at Grand Island determined in Step 2 to estimate the change in flow at Louisville. The "low delivery efficiency" values denote the estimated change at Louisville when liberal conveyance loss estimates are applied; "high delivery efficiency" values denote effects if conservative losses are applied. For various reasons described in the Phase II/III documentation, the higher conveyance losses (*i.e.*, lower delivery efficiencies) are probably more representative of real-world conditions.

A comparison of the estimated flow effects at Louisville (Table 3) to the uncertainties inherent in Louisville flow measurements (Table 2) suggests that changes to flows at Louisville attributable to the proposed Program are unlikely to be within the range of gage uncertainty in most months of most years. An exception is May through September of dry years, when the estimated changes in sustained flow at Louisville due the Program (138 to 788 cfs) are large enough to be "detectable", provided flow at Louisville is unusually low (*e.g.*, in the 10-percentile range). However, under such unusually low flow conditions, the Platte channel may not be wet throughout the Grand Island-to-Louisville reach, and thus changes in central Platte flow would not necessarily affect the lower Platte.

As part of this same analysis, the effects of these flow changes on river stage, velocity, and width at the Louisville gage were estimated. These estimates were based on recent (post-1995) relationships between discharge, stage, velocity, and width measurements made by the USGS at that location. These results are summarized in Appendix D. To cite the most important conclusions of this evaluation:

[2] "Baseline condition" is the condition of the river that would have existed if all of the water projects that were in place in the greater Platte River basin in 1994 had been in place over the entire 48-year period simulated by the OPSTUDY model.

- Projected **change in river stage** at Louisville was as high as +0.2 foot for only one month-of-year and river-condition combination in the entire analysis, that being the dry-condition, low-conveyance-loss scenario for May.

- The projected **change in flow velocity** did not exceed plus or minus 0.1 foot/second for any month in the analysis, and was effectively indistinguishable from zero for most months.

- The greatest **change in channel width** was +22 feet for the dry-condition, low-conveyance-loss scenario for May; most months showed a change in channel width of less than ten feet.

As described in the FWS documentation, very broad assumptions were made for these analyses. For this reason, the results should be interpreted as a “range of possible effects” rather than precise forecasts.

5. SUMMARY, AND IMPLICATIONS FOR THE PLATTE RIVER RECOVERY PROGRAM

1. Our ability to forecast flow changes at Louisville as the result of changes in flow at Grand Island is severely limited for the following reasons:

    - Flow gaging stations are few and far between on the Platte River system below Grand Island, leaving long reaches ungaged and adding uncertainty to our understanding of lower Platte hydrology and our interpretation of gage records;

    - Until recently, there were no measurements of tailrace flows from the Columbus Power Plant near Columbus, Nebraska, further limiting the accuracy of our historic flow accounting models;

    - Where gaging stations do exist, considerable uncertainty is associated with the flow measurements. This is particularly true in winter months, when icing conditions are common. This adds uncertainty to our estimates of historic flow attenuation and conveyance losses;

    - Substantial variability and uncertainty is associated with estimated travel times for flow in the lower Platte River, which limits the accuracy of conveyance loss estimates based on these assumed travel times.

2. Given the above limitations, we developed estimates of pulse flow attenuation and sustained-flow conveyance losses in the lower Platte River based on an analysis of the historic record. This analysis suggests that:

    - Short-duration pulse flow volumes will typically be attenuated by 60 to 80 percent between North Platte and Louisville, although attenuation can be as low as 40 percent under favorable conditions;

- Conveyance losses of sustained augmented flows typically range from 8 to 60 percent between Grand Island and Louisville, depending upon the time of year, flow conditions, and quantity of Program-augmented flow. Conveyance losses are highest in the summer months (30 to 60 percent in July and August) and lowest in late Spring (8 to 25 percent in March and April).

The estimated range of effects at Louisville of the Proposed Program, as summarized in Table 3, would provide modest increases in flow at Louisville from February through November in dry years (ranging from less than 1% to as much as 10% of the median monthly flow); from March through November of normal years (ranging from less than 1% to 8% of the median monthly flow); and in May, September and October of wet years (as much as 5% of the median monthly flow).

3. The “detectability” of changes in flow at Louisville is severely limited by:
   - Limited accuracy of USGS gage measurements at Louisville; and
   - Substantial variability in flows at Louisville on a daily and hourly basis.

   This implies that the Program flow effects indicated by this study are not likely to be clearly detectable at Louisville under most conditions.

4. Completion of Milestone R1A-Ext requires a biological assessment of the “potential for these changes [in flow in the lower Platte] to provide measurable benefits to pallid sturgeon habitat”. The analysis described here responds to the *hydrologic* questions raised by Milestone R1A-Ext, but not this *biological* question. Therefore, completion of this Cooperative Agreement Milestone requires additional biological comment.

5. The analysis summarized in this report should be considered preliminary. Nevertheless, to our knowledge, it provides the most thorough analysis of lower Platte River flow attenuation and conveyance losses available to date.

   FWS considers the analysis presented here to be sufficient for purposes of addressing Milestone R1A-Ext. The Water Management Committee concurs, and agrees that a more detailed analysis of flow attenuation and conveyance losses between the central Platte and the lower Platte River may be justified at a later time, for example:

   - When better and more complete hydrologic data are available for the lower Platte River system;

   - Should it be determined that pallid sturgeon habitat extends upriver from the confluence with the Elkhorn River;

   - When we have a better understanding of pallid sturgeon habitat needs and the potential benefits of specific timing/quantities of augmented flow in the lower Platte; and/or

   - If and when the Program is able to provide larger volumes of flow to the central Platte than is anticipated under the First Increment of the current Program.

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APPENDIX A
HISTORIC PULSE FLOW ATTTENUATION

Ten historic pulse flow events in the Platte River system were evaluated to determine the attenuation in the pulse volume between the North Platte, Nebraska and Louisville. The following tables are taken from USFWS, 2002a.

Examined Pulse Flow Events

Event[1]	Peak Discharge[2] (CFS)	Total Pulse Flow Volume at North Platte[1,2] (KAF)	Duration of Event (Days)
June 12-17, 1949	12,400	59.5	5
June 18-22, 1949	17,400	35.4	4
May 17-24, 1957	8,330	67.1	7
May 16-24, 1958	6,850	49.9	8
June 17-23, 1965	20,300	67.7	6
June 16-22, 1970	9,650	56.2	6
May 9-14, 1973	20,900	66.1	5
May 5-10, 1980	11,800	40.6	5
June 10-17, 1986	8,720	60.1	7
May 4-10, 1999	16,000	101.0	6

Notes:
(1) Details and definitions provided in USFWS, 2002a.
(2) Based on Total Platte River Flow at North Platte

Percentage of Total Pulse Volume at North Platte Reaching Louisville[1]
for Ten Pulse Flow Events at North Platte

Beginning of Event (chronological)	Percentage of Total Pulse Volume at North Platte Reaching Louisville	Beginning of Event	Percentage of Total Pulse Volume at North Platte Reaching Louisville (descending order)
June 12, 1949	40.6	May 9, 1973	64.7
June 18, 1949	21.4	June 17, 1965	64.7
May 17, 1957	19.7	June 16, 1970	40.9
May 16, 1958	27.1	June 12, 1949	40.6
June 17, 1965	54.7	May 5, 1980	40.6
June 16, 1970	40.9	May 16, 1958	27.1
May 9, 1973	64.7	June 18, 1949	21.4
May 5, 1980	35.1	May 4, 1999	20.5
June 10, 1986	19.8	June 10, 1986	19.8
May 4, 1999	20.5	May 17, 1957	19.7

Note:
(1) Ashland for Events prior to 1950.

APPENDIX B
TRAVEL TIME ESTIMATES BY RIVER REACH

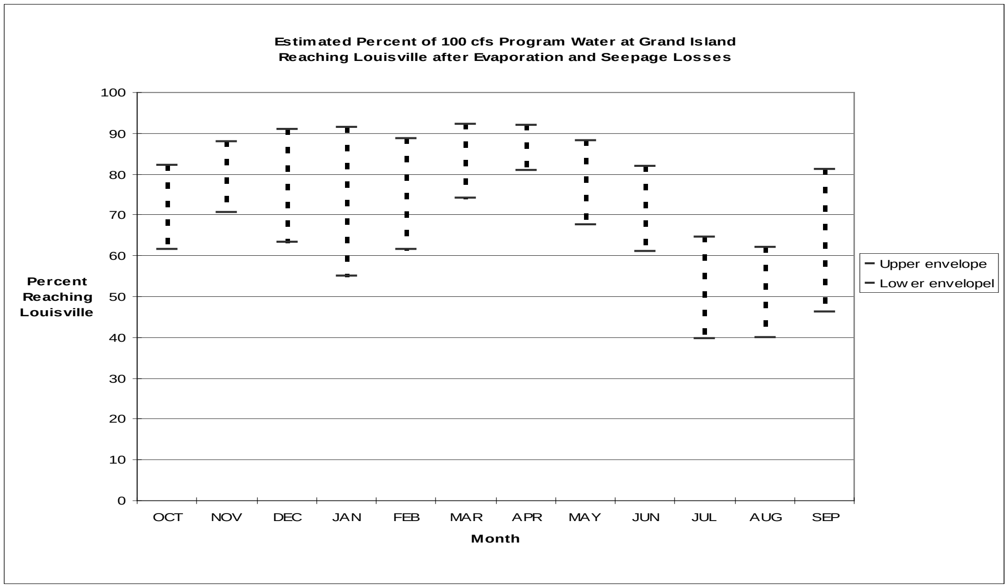
Estimated travel times of flow in the Platte River for three stream reaches between Grand Island and Louisville, Nebraska, based on an analysis of median stream flow conditions, 1975-1994 (USFWS, 2002b).

	Grand Island to Duncan		**Duncan to North Bend**		**North Bend to Louisville**	
	Median velocity (ft/sec)	Travel Time (days)	Median velocity (ft/sec)	Travel Time (days)	Median velocity (ft/sec)	Travel Time (days)
Jan	1.80	1.9	1.96	1.3	2.18	1.6
Feb	1.93	1.7	2.19	1.1	2.46	1.4
Mar	2.10	1.6	2.46	1.0	2.84	1.2
Apr	1.96	1.7	2.28	1.1	2.62	1.3
May	1.85	1.8	2.18	1.1	2.55	1.4
Jun	1.67	2.0	2.02	1.2	2.44	1.4
Jul	1.47	2.3	1.71	1.5	2.05	1.7
Aug	1.31	2.6	1.56	1.6	1.95	1.8
Sep	1.46	2.3	1.69	1.5	2.06	1.7
Oct	1.57	2.1	1.85	1.4	2.17	1.6
Nov	1.64	2.1	1.94	1.3	2.26	1.5
Dec	1.75	1.9	1.96	1.3	2.26	1.5

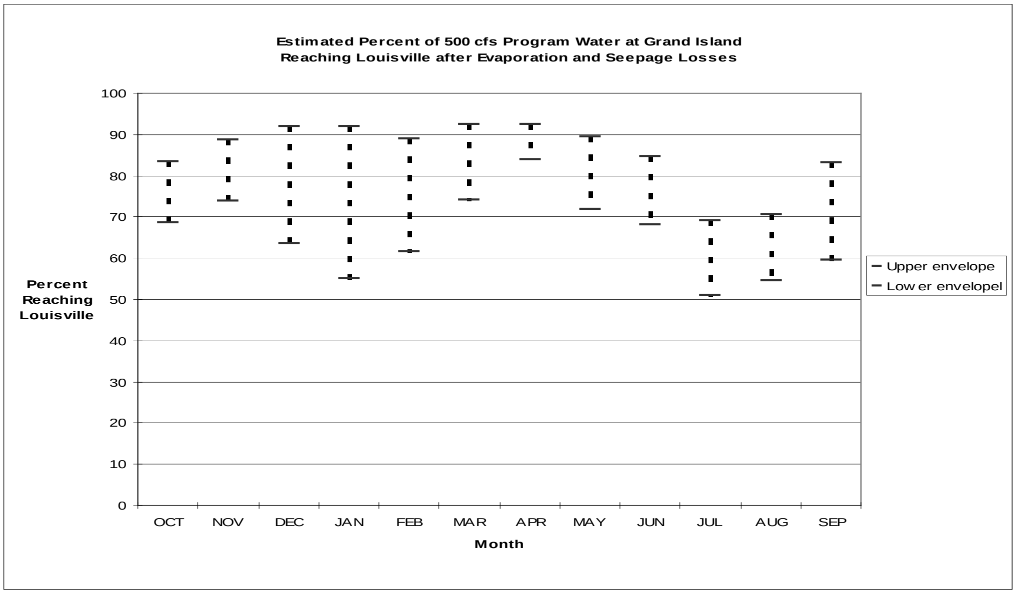
APPENDIX C
ESTIMATED CONVEYANCE LOSSES BY RIVER REACH

The following are estimated conveyance losses in the Platte River between Grand Island and Louisville, Nebraska, as percentage of augmented flow, based on an analysis of historic flows, 1975-1994 (USFWS, 2002c).

"Reasonable ranges" of estimated conveyance losses under typical conditions for **100 cfs** of Program water at Grand Island:



and for **500 cfs** of Program water at Grand Island:



APPENDIX D (Page 1)

ESTIMATED EFFECTS OF PROGRAM FLOW CHANGES ON STAGE, VELOCITY, AND WIDTH OF THE PLATTE RIVER AT LOUISVILLE

Estimated changes in discharge, river stage, mean flow velocity, and channel width at Louisville due to Program-augmented flows, assuming **low-delivery** (high-conveyance-loss) conditions in the Platte River between Grand Island and Louisville, Nebraska. (Details are provided in USFWS, 2002d):

Table 3
Change in River Conditions at Louisville as a Result of Changes in Flow - Low Delivery
Based on OPSTUDY Model Output for the Proposed Program at Grand Island

CHANGE IN MEAN MONTHLY DISCHARGE AT GRAND ISLAND (CFS)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Wet Conditions	-504	-451	-315	-130	442	-1151	-79	-42	24	113	-307	-419
Normal Conditions	-288	-85	264	626	683	111	68	208	284	403	30	-251
Dry Conditions	-79	71	204	505	847	433	212	350	391	135	393	-98

CHANGE IN MEAN MONTHLY DISCHARGE AT LOUISVILLE IN CFS FOR "LOW DELIVERY" YEAR
Based on the flow that will be left at Louisville in 75 percent of years.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Wet Conditions	-328	-293	-205	-84	287	-748	-55	-27	16	73	-200	-273
Normal Conditions	-187	-55	171	407	444	72	44	135	185	262	20	-163
Dry Conditions	-52	46	133	328	550	281	138	228	254	87	256	-64

CHANGE IN MEAN MONTHLY RIVER STAGE AT LOUISVILLE IN FEET

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Wet Conditions	-0.07	-0.05	-0.02	-0.01	0.04	-0.07	0.00	0.00	0.01	0.02	-0.05	-0.07
Normal Conditions	-0.05	-0.01	0.03	0.07	0.08	0.02	0.01	0.05	0.07	0.08	0.01	-0.04
Dry Conditions	-0.01	0.01	0.03	0.07	0.14	0.06	0.06	0.09	0.10	0.03	0.07	-0.02

CHANGE IN MEAN MONTHLY FLOW VELOCITY AT LOUISVILLE IN FT/SEC

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Wet Conditions	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Normal Conditions	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dry Conditions	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0

CHANGE IN MEAN MONTHLY CHANNEL WIDTH AT LOUISVILLE IN FEET

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Wet Conditions	-8	-5	-2	-1	4	-7	0	0	2	2	-5	-8
Normal Conditions	-7	-1	3	7	8	2	1	7	9	9	1	-5
Dry Conditions	-1	1	3	8	16	7	8	13	14	4	9	-3

APPENDIX D (Page 2)

Estimated changes in discharge, river stage, mean flow velocity, and channel width at Louisville due to Program-augmented flows, assuming **high-delivery** (low-conveyance-loss) conditions in the Platte River between Grand Island and Louisville, Nebraska. (Details are provided in USFWS, 2002d):

Table 4
Change in River Conditions at Louisville as a Result of Changes in Flow - High Delivery
Based on OPSTUDY Model Output for the Proposed Program at Grand Island

CHANGE IN MEAN MONTHLY DISCHARGE AT GRAND ISLAND (CFS)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Wet Conditions	-504	-451	-315	-130	442	-1151	-79	-42	24	113	-307	-419
Normal Conditions	-288	-85	264	626	683	111	68	208	284	403	30	-251
Dry Conditions	-79	71	204	505	847	433	212	350	391	135	393	-98

CHANGE IN MEAN MONTHLY DISCHARGE AT LOUISVILLE IN CFS FOR "HIGH DELIVERY" YEAR
Based on the flow that will be left at Louisville in 25 percent of years.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Wet Conditions	-469	-419	-293	-121	411	-1,070	-85	-39	23	105	-286	-390
Normal Conditions	-268	-79	245	582	635	103	63	194	264	375	28	-233
Dry Conditions	-74	66	190	470	788	402	197	326	364	125	366	-91

CHANGE IN MEAN MONTHLY RIVER STAGE AT LOUISVILLE IN FEET

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Wet Conditions	-0.11	-0.07	-0.03	-0.01	0.06	-0.11	-0.01	-0.01	0.02	0.03	-0.07	-0.10
Normal Conditions	-0.08	-0.02	0.04	0.10	0.11	0.02	0.02	0.07	0.10	0.11	0.01	-0.06
Dry Conditions	-0.02	0.01	0.04	0.10	0.19	0.09	0.08	0.13	0.14	0.04	0.10	-0.03

CHANGE IN MEAN MONTHLY FLOW VELOCITY AT LOUISVILLE IN FT/SEC

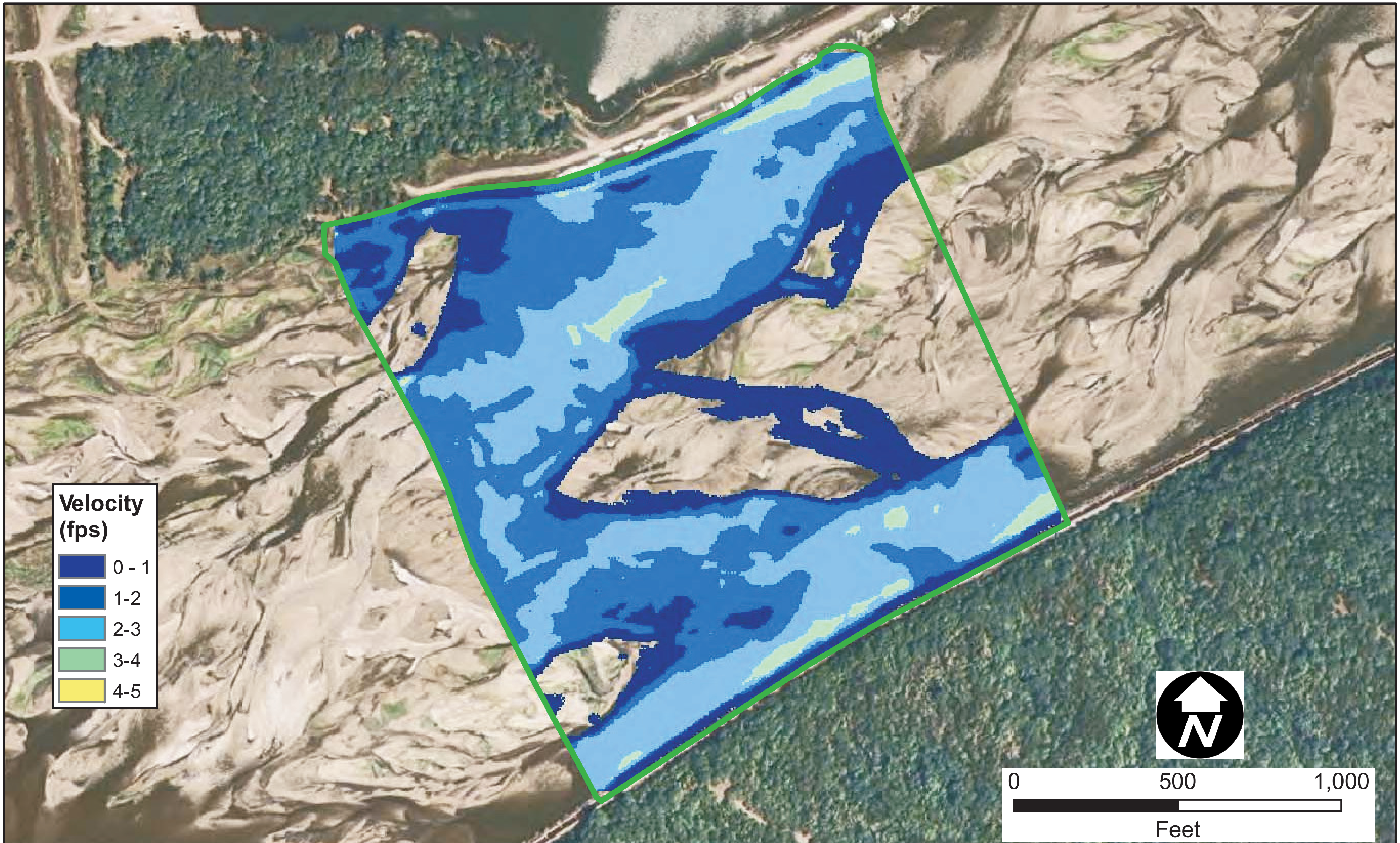
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Wet Conditions	-0.1	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	-0.1
Normal Conditions	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0
Dry Conditions	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.0

CHANGE IN MEAN MONTHLY CHANNEL WIDTH AT LOUISVILLE IN FEET

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Wet Conditions	-12	-7	-3	-1	6	-10	0	0	3	3	-8	-11
Normal Conditions	-9	-2	4	10	11	3	2	10	13	13	1	-7
Dry Conditions	-2	1	4	11	22	10	11	18	19	5	12	-4

Appendix C

Spatial Distribution Maps of Computed Channel Velocities from the SRH-2D over a Range of Discharges between 3,700 and 40,000 cfs



Computed Velocity at 3,700 cfs

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Platte River Recovery Implementation Program

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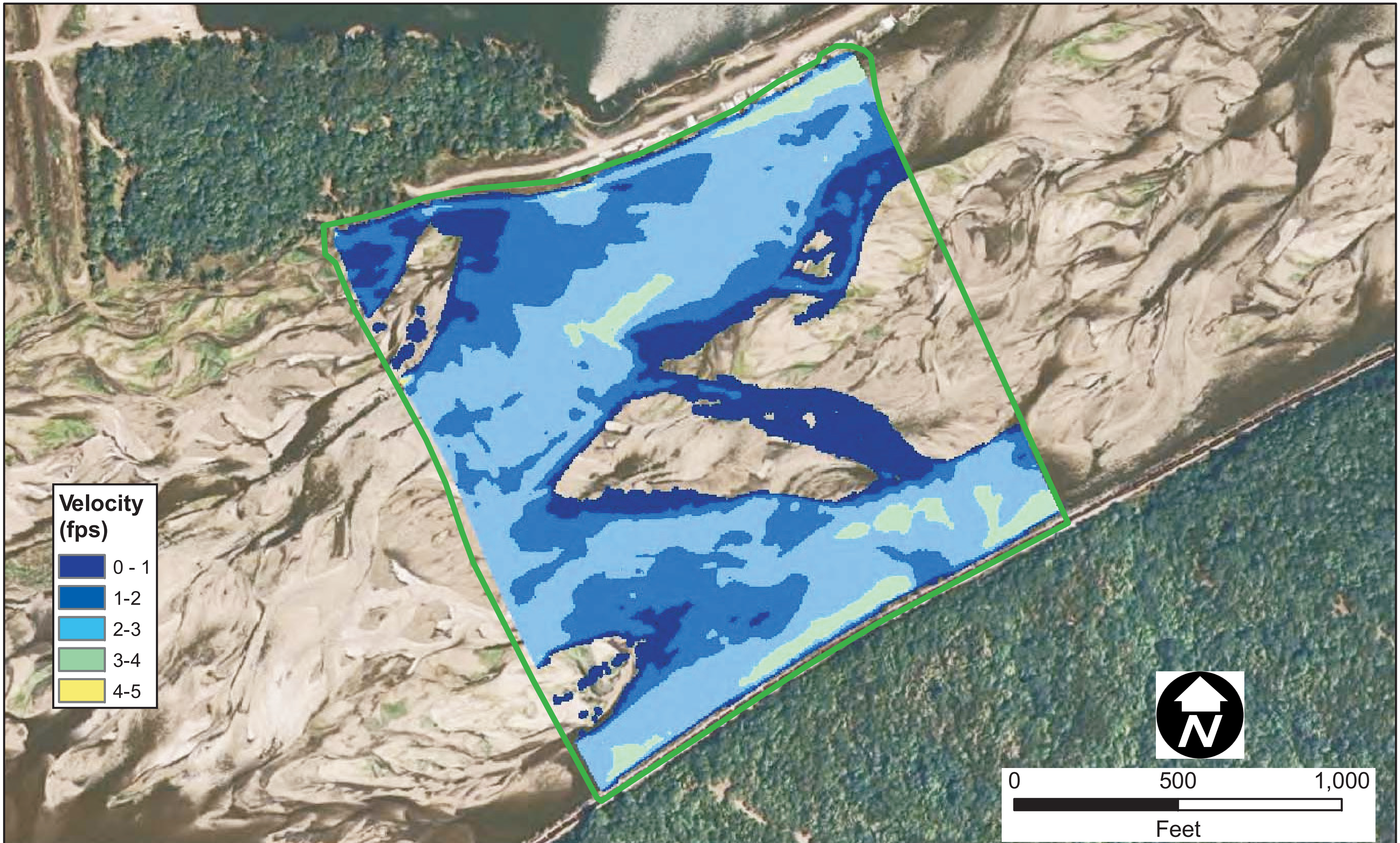
Dec. 2009

Figure:
C1



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Computed Velocity at 4,300 cfs

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Platte River Recovery Implementation Program

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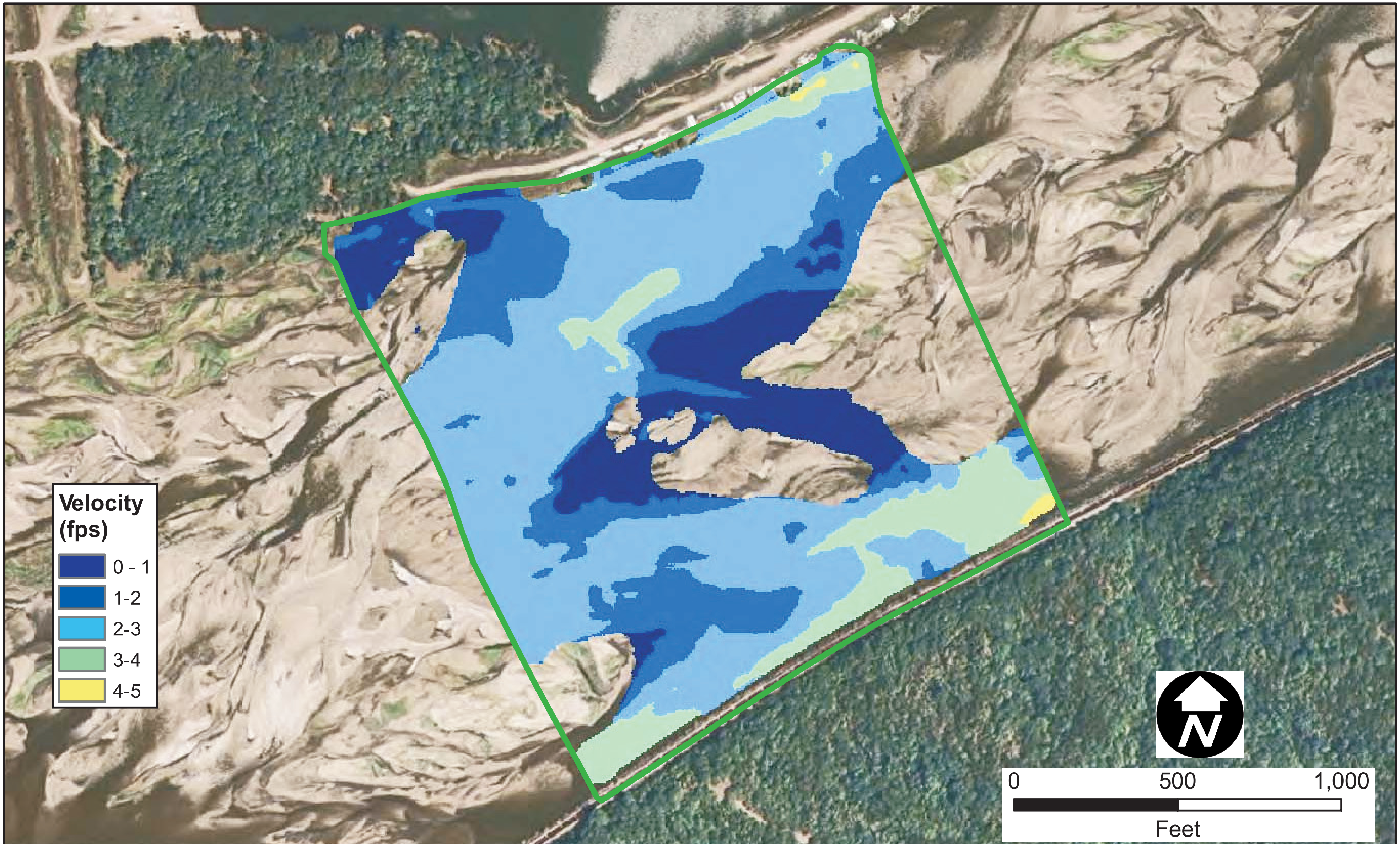
Figure: C2



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Computed Velocity at 6,000 cfs

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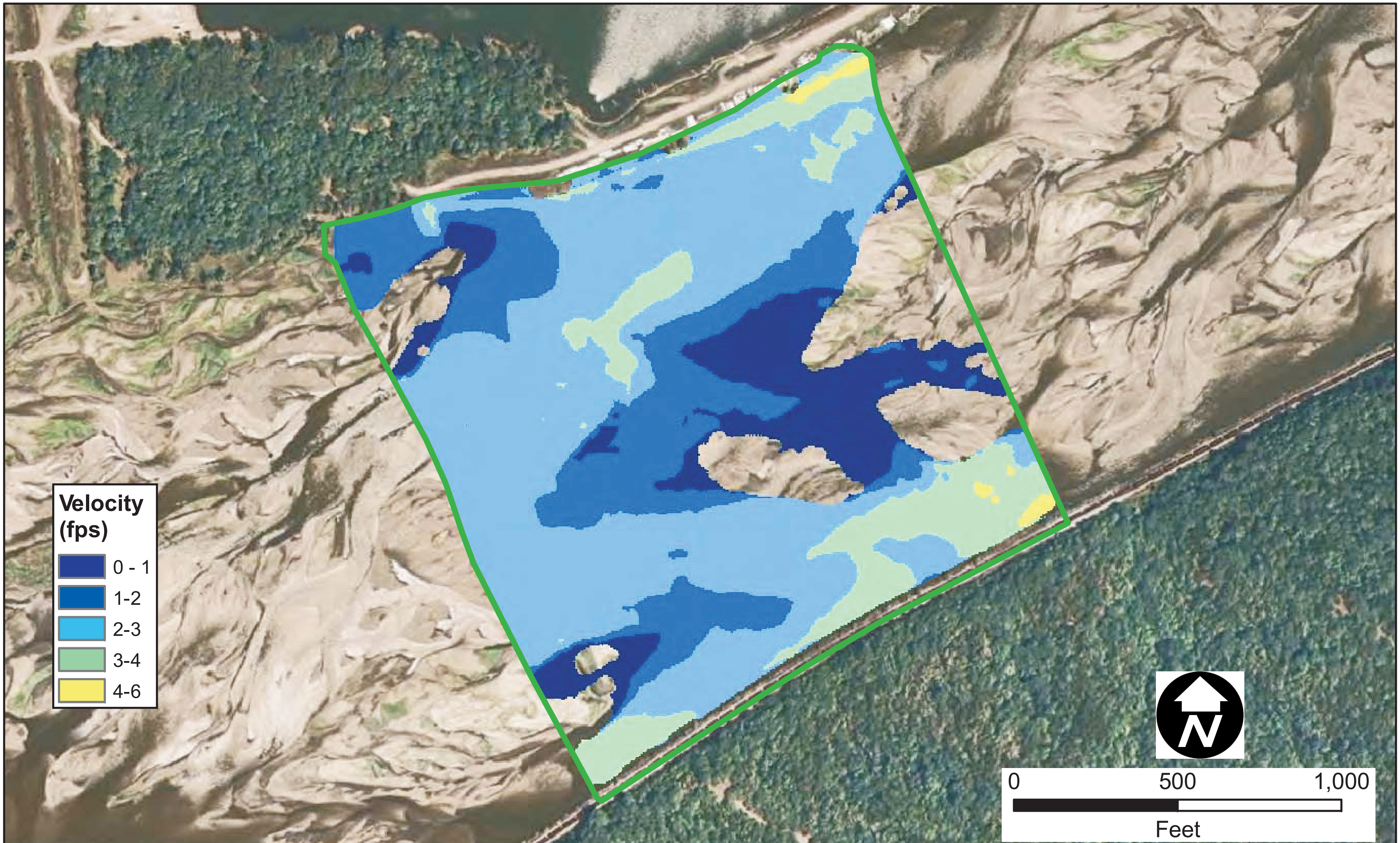
Figure:
C3



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Computed Velocity at 8,000 cfs

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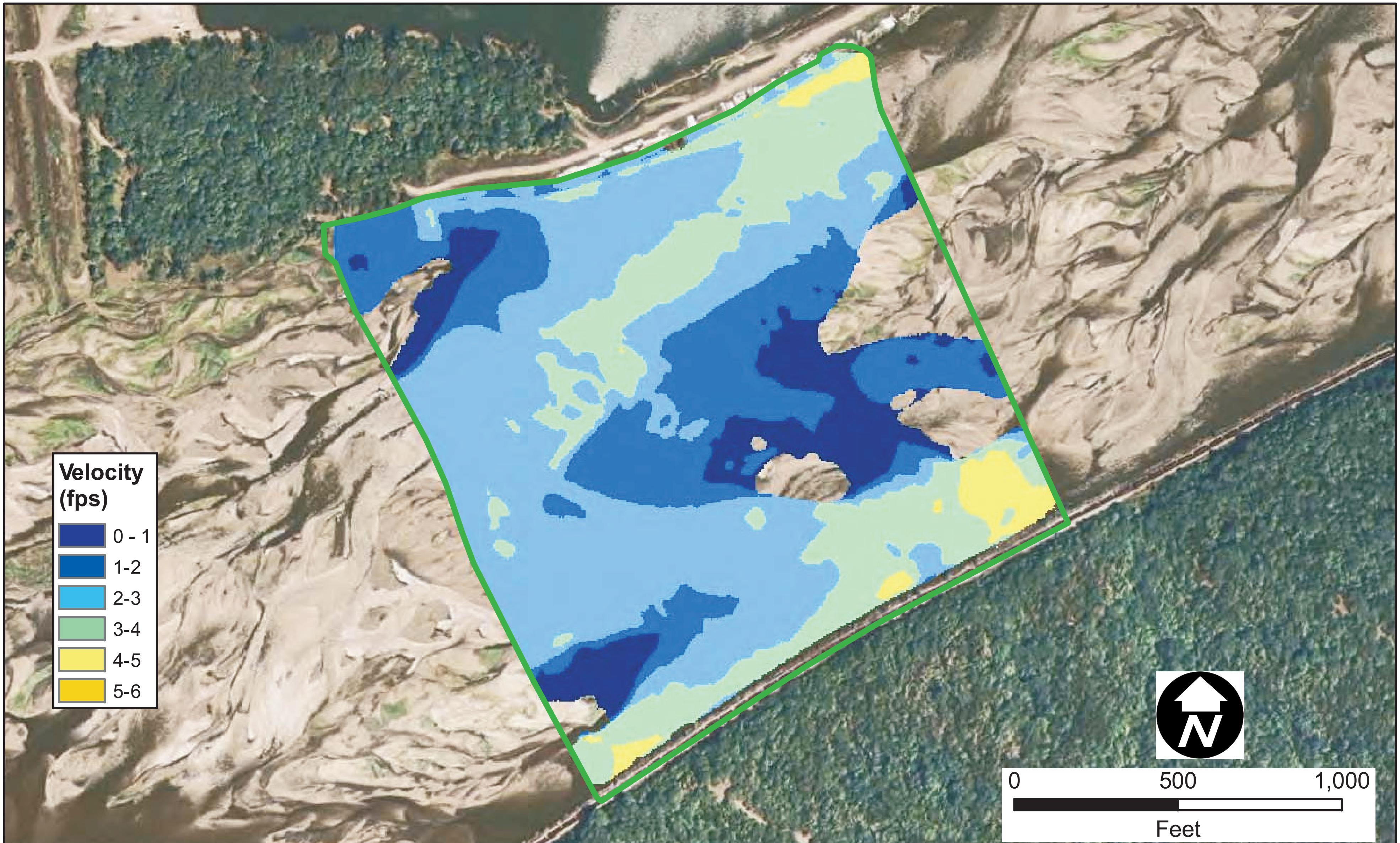
Figure: C4



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Computed Velocity at 10,000 cfs

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

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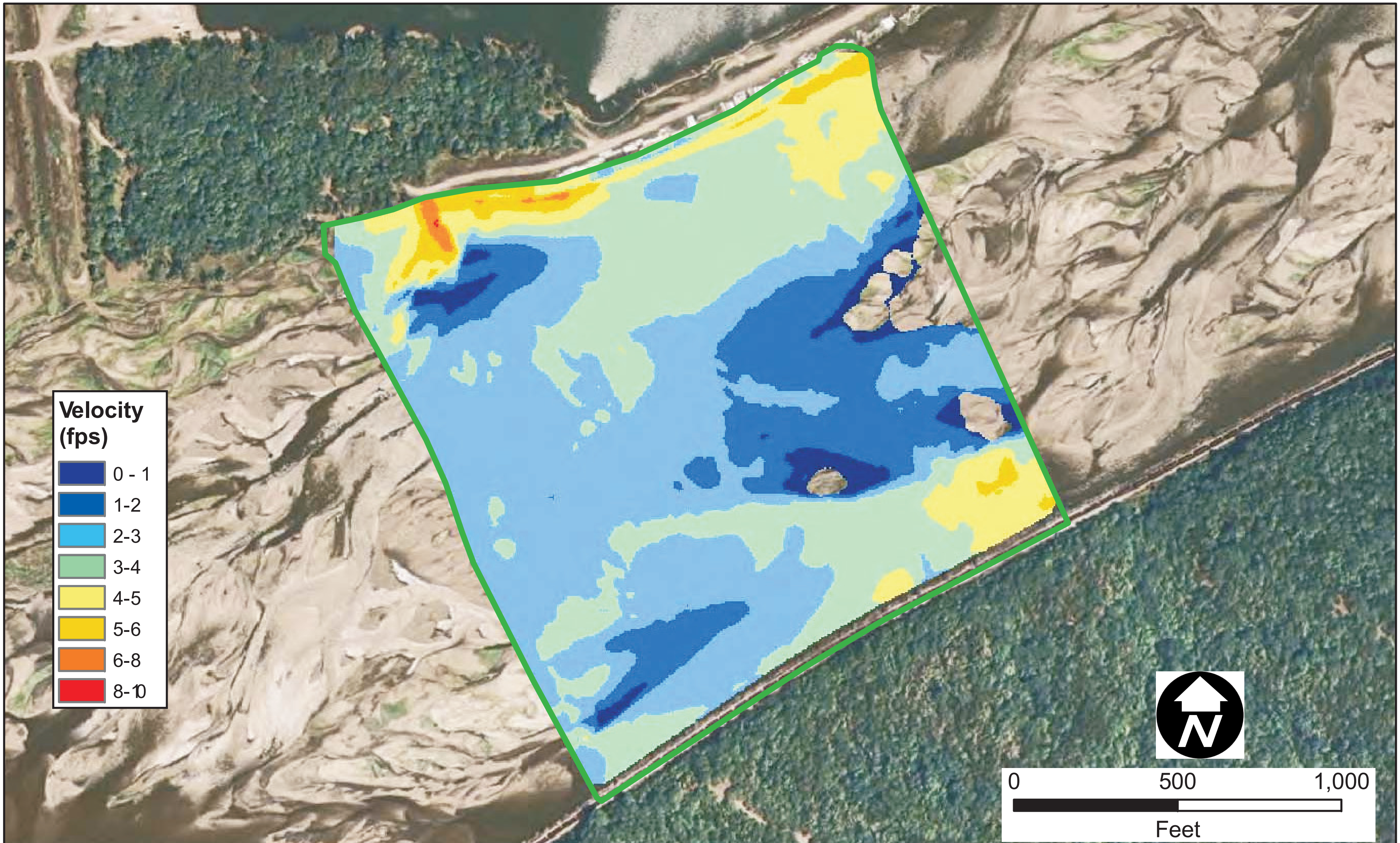
Figure:
C5



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Computed Velocity at 14,000 cfs

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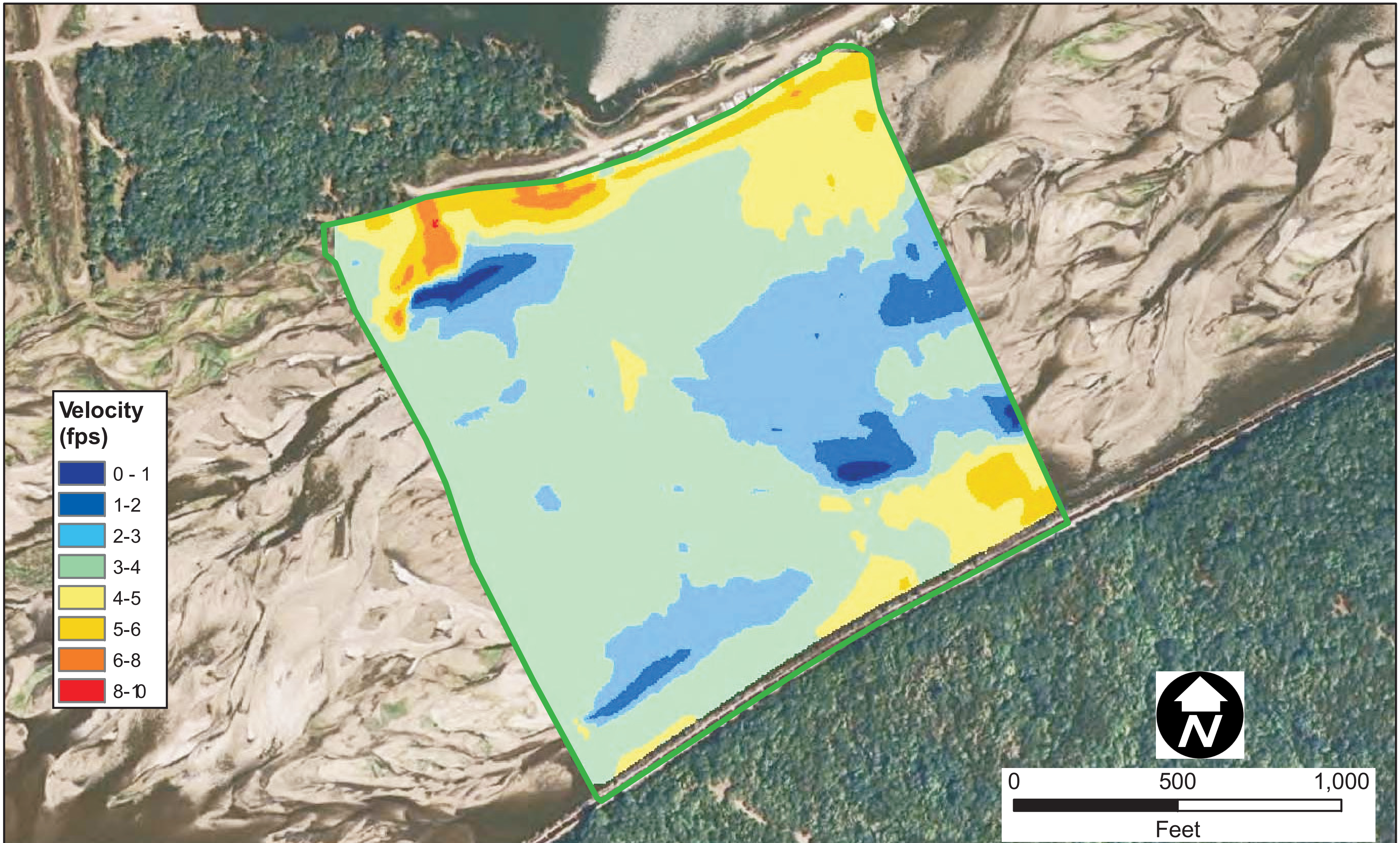
Figure:
C6



Computed Velocity at 20,000 cfs

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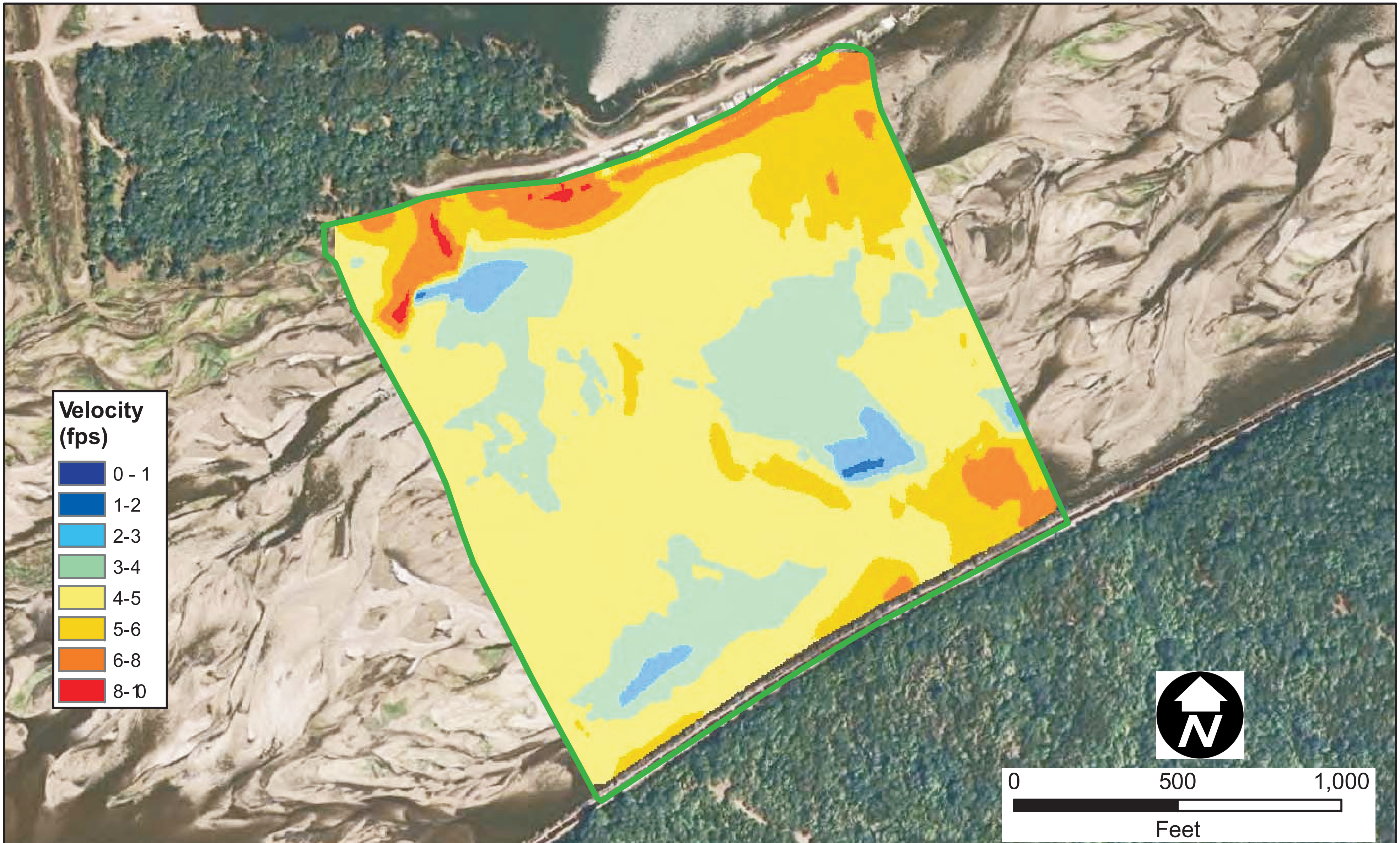
Figure:
C7



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Computed Velocity at 30,000 cfs

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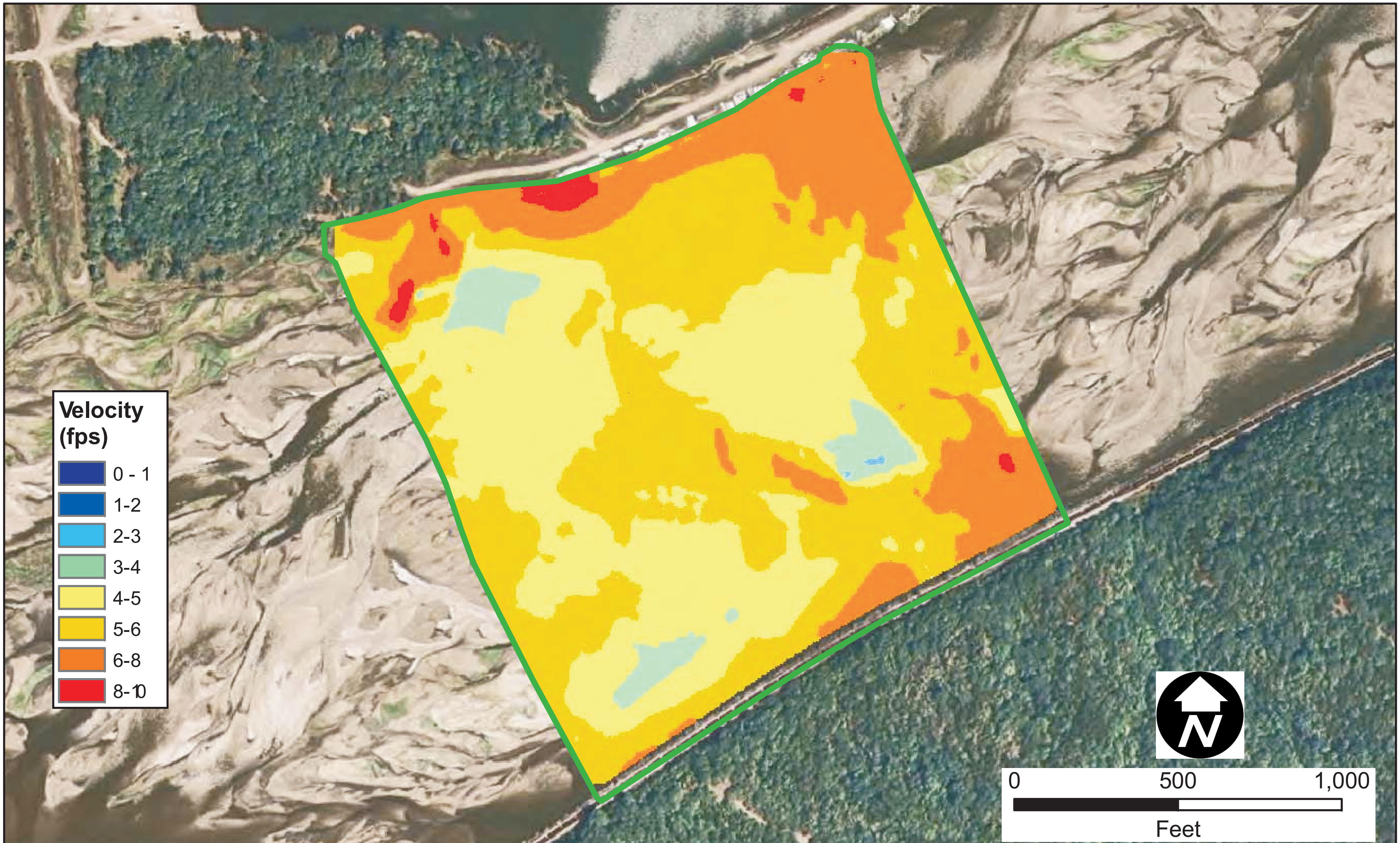
Figure: C8



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Computed Velocity at 40,000 cfs

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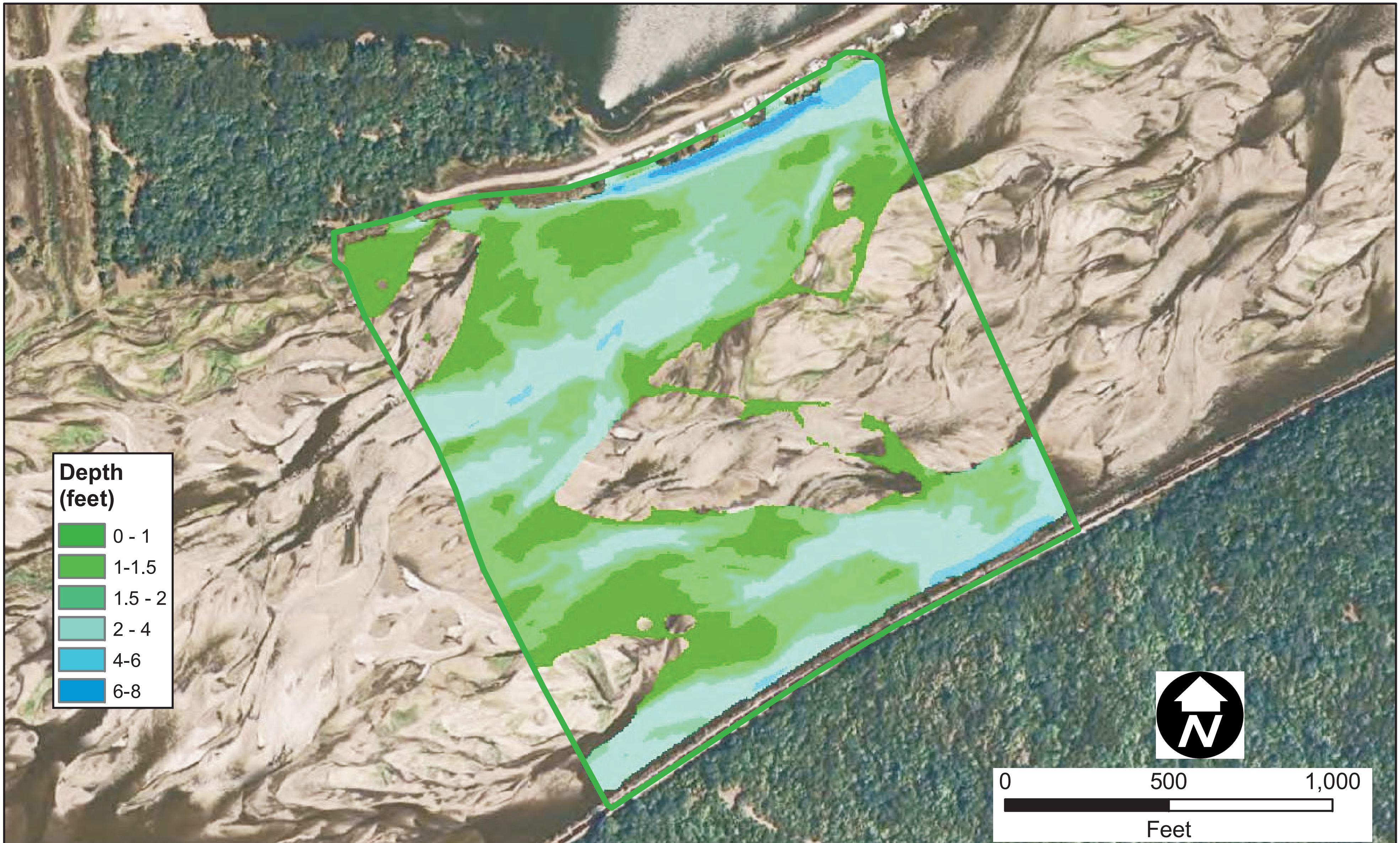
Figure:
C9

Appendix D

Spatial Distribution Maps of Computed Channel Depths from the SRH-2D over a Range of Discharges between 3,700 and 40,000 cfs



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Computed Depth at 3,700 cfs

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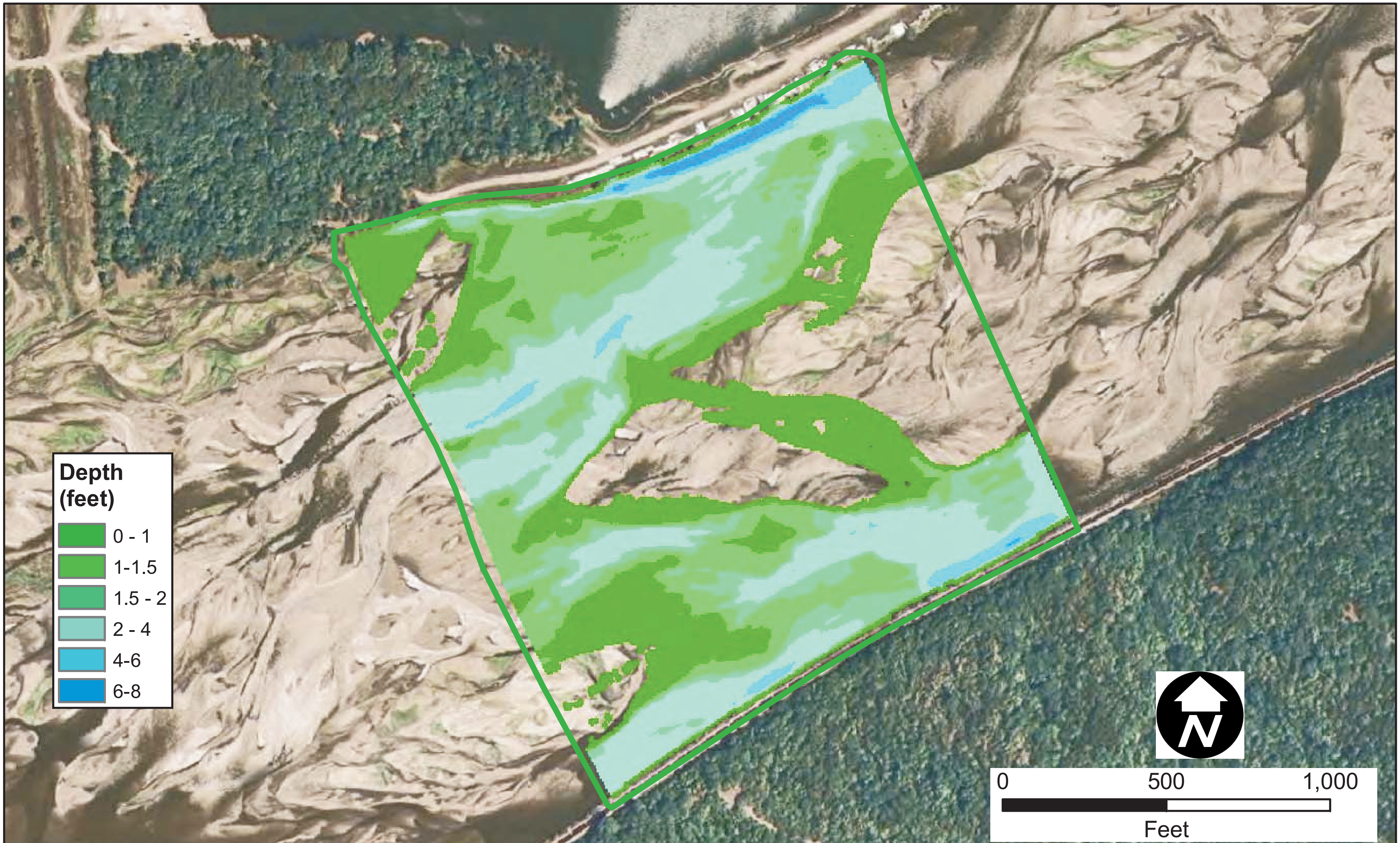
Figure:
D1



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Computed Depth at 4,300 cfs

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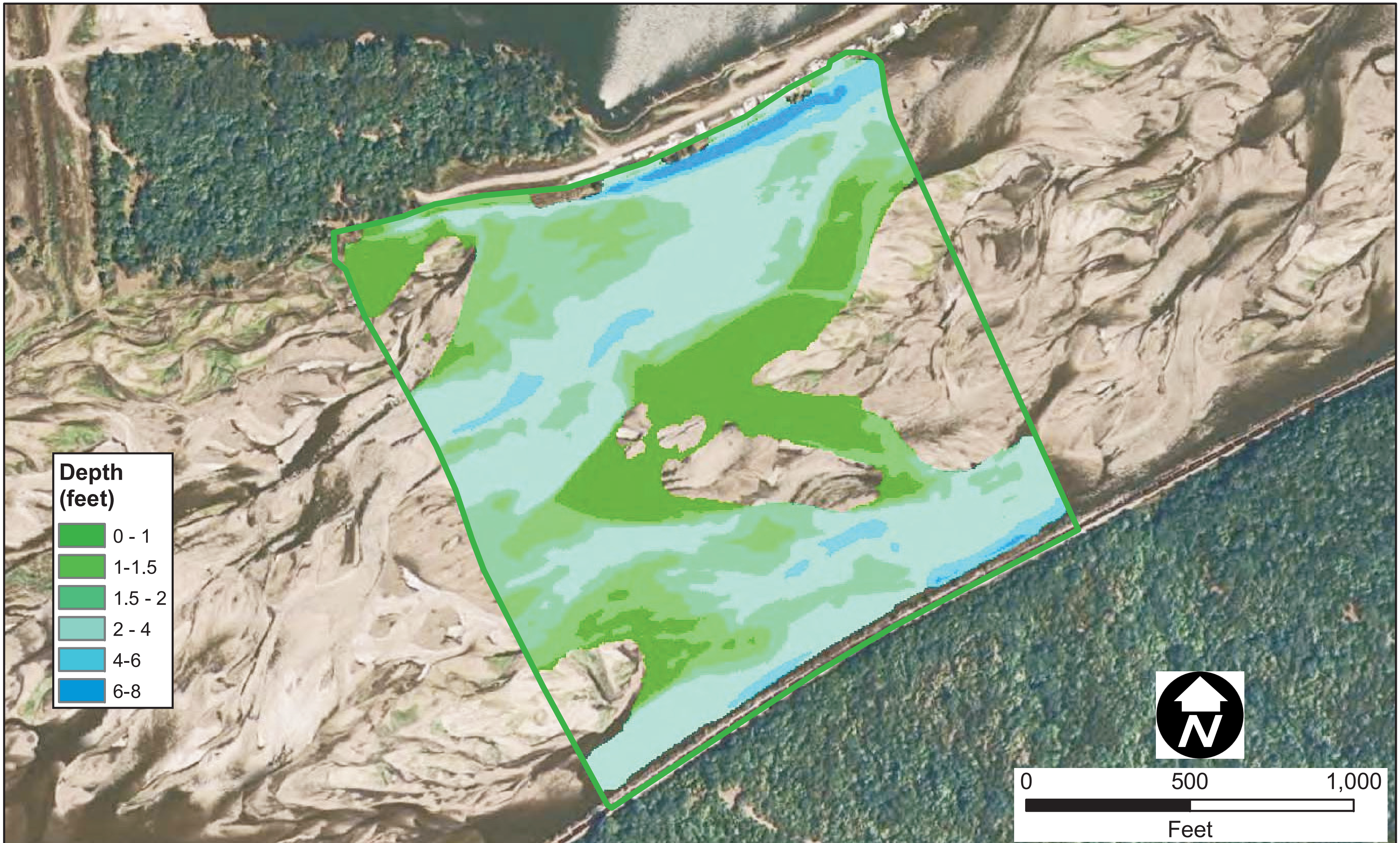
Figure: D2



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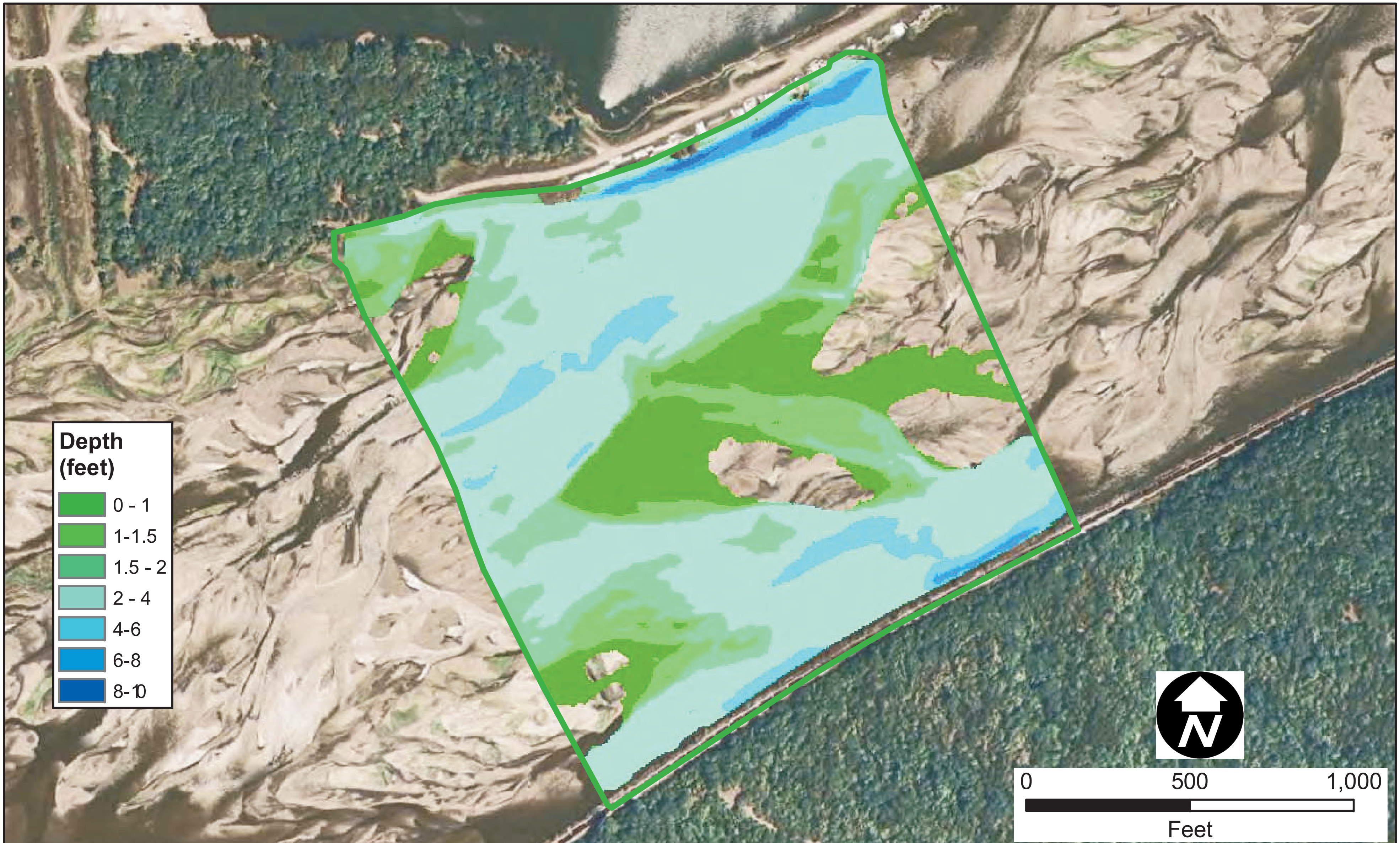
Computed Depth at 6,000 cfs

Lower Platte River Stage Change Study
Final Protocol Implementation Report
Platte River Recovery Implementation Program

Date: Dec. 2009

Figure: D3



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Computed Depth at 8,000 cfs

RECOVERY IMPLEMENTATION PROGRAM PLATTE RIVER

Lower Platte River Stage Change Study
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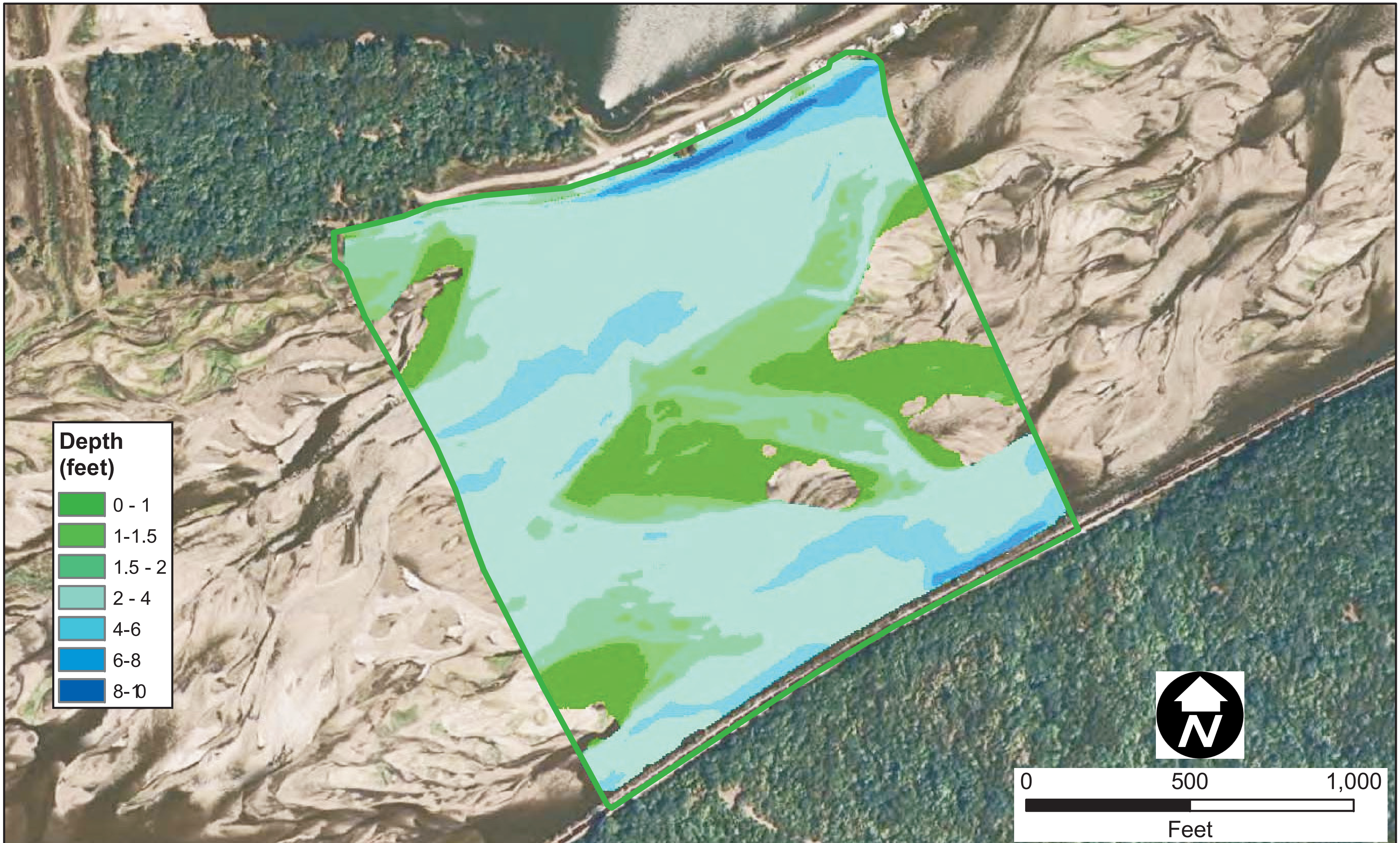
Figure:
D4



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Computed Depth at 10,000 cfs

RECOVERY IMPLEMENTATION PROGRAM PLATTE RIVER

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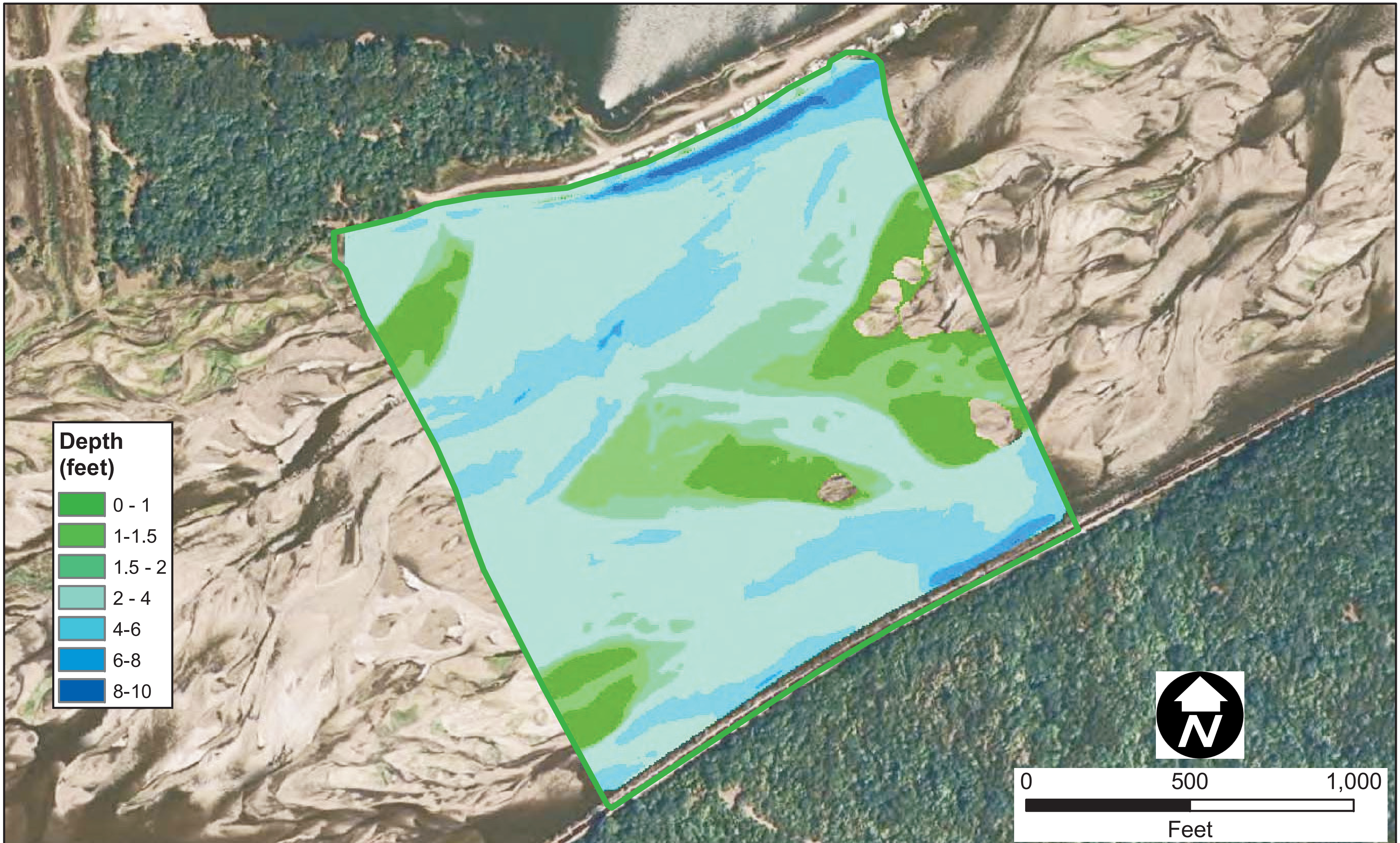
Figure: D5



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Computed Depth at 14,000 cfs

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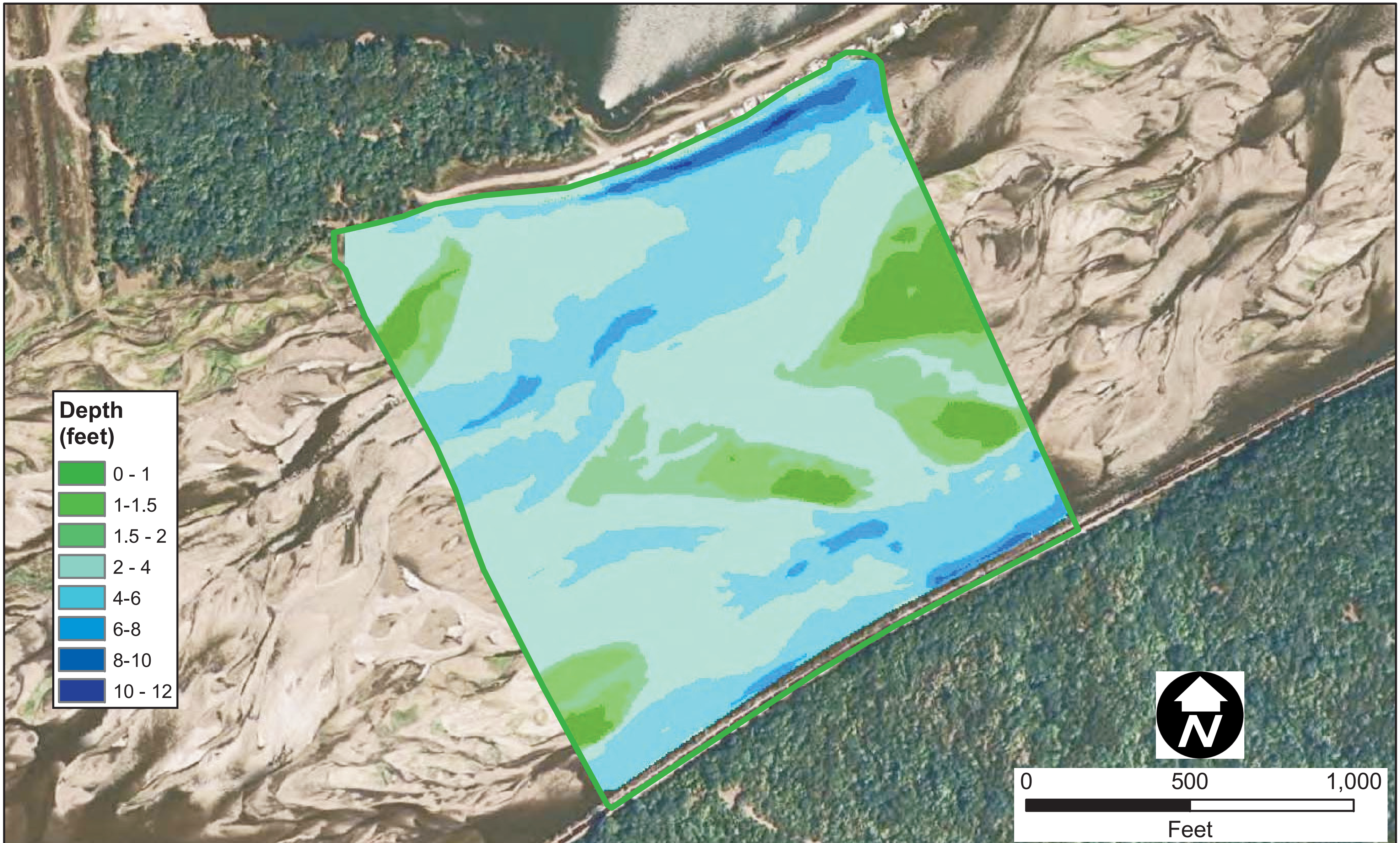
Figure: D6



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Computed Depth at 20,000 cfs

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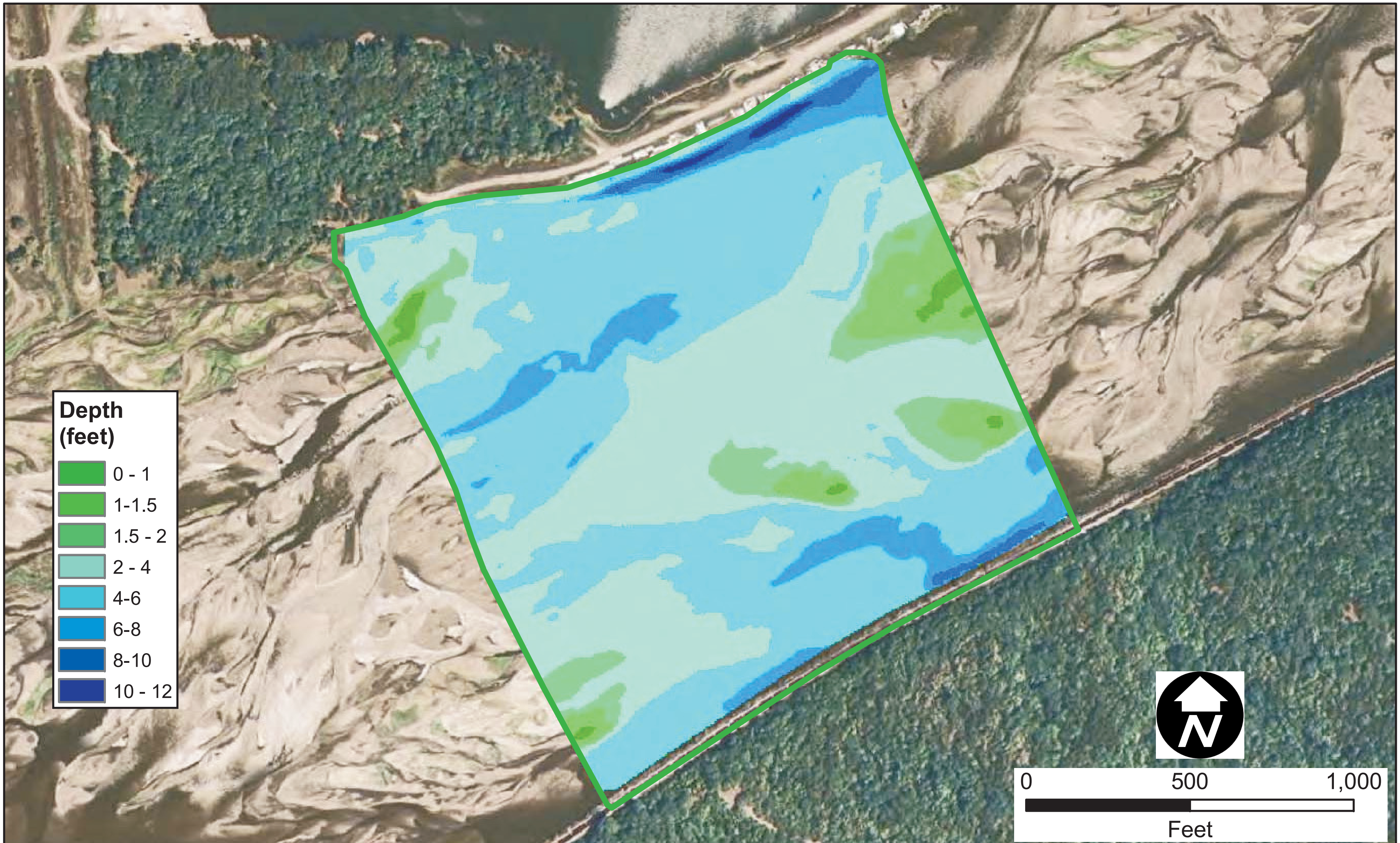
Figure: D7



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Computed Depth at 30,000 cfs

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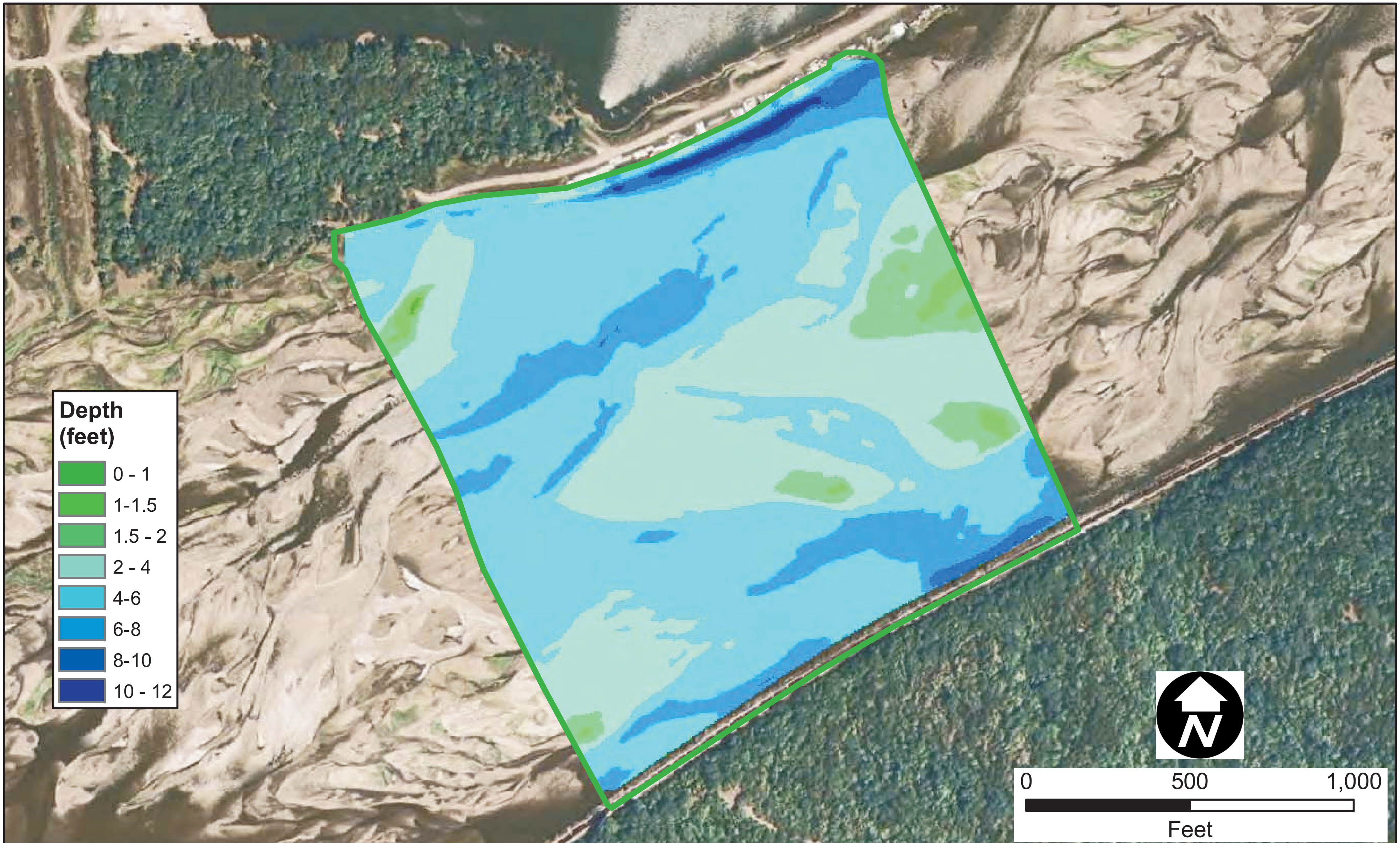
Figure:
D8



Computed Depth at 40,000 cfs

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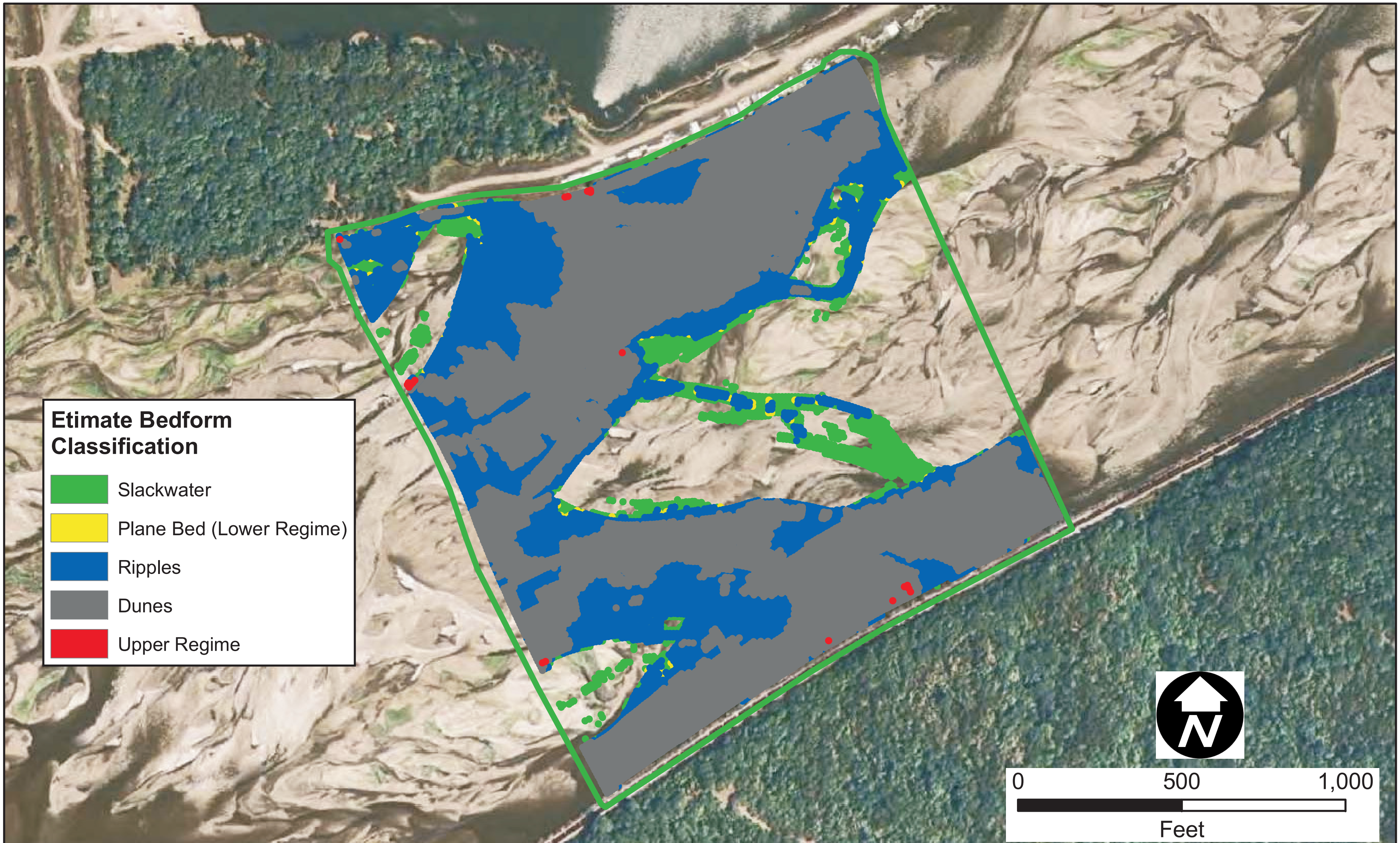
Figure:
D9

Appendix E

Spatial Distribution Maps of Estimated Bedform Types over a Range of Discharges between 3,700 and 40,000 cfs



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Estimated Bedform Classes at 3,700 cfs

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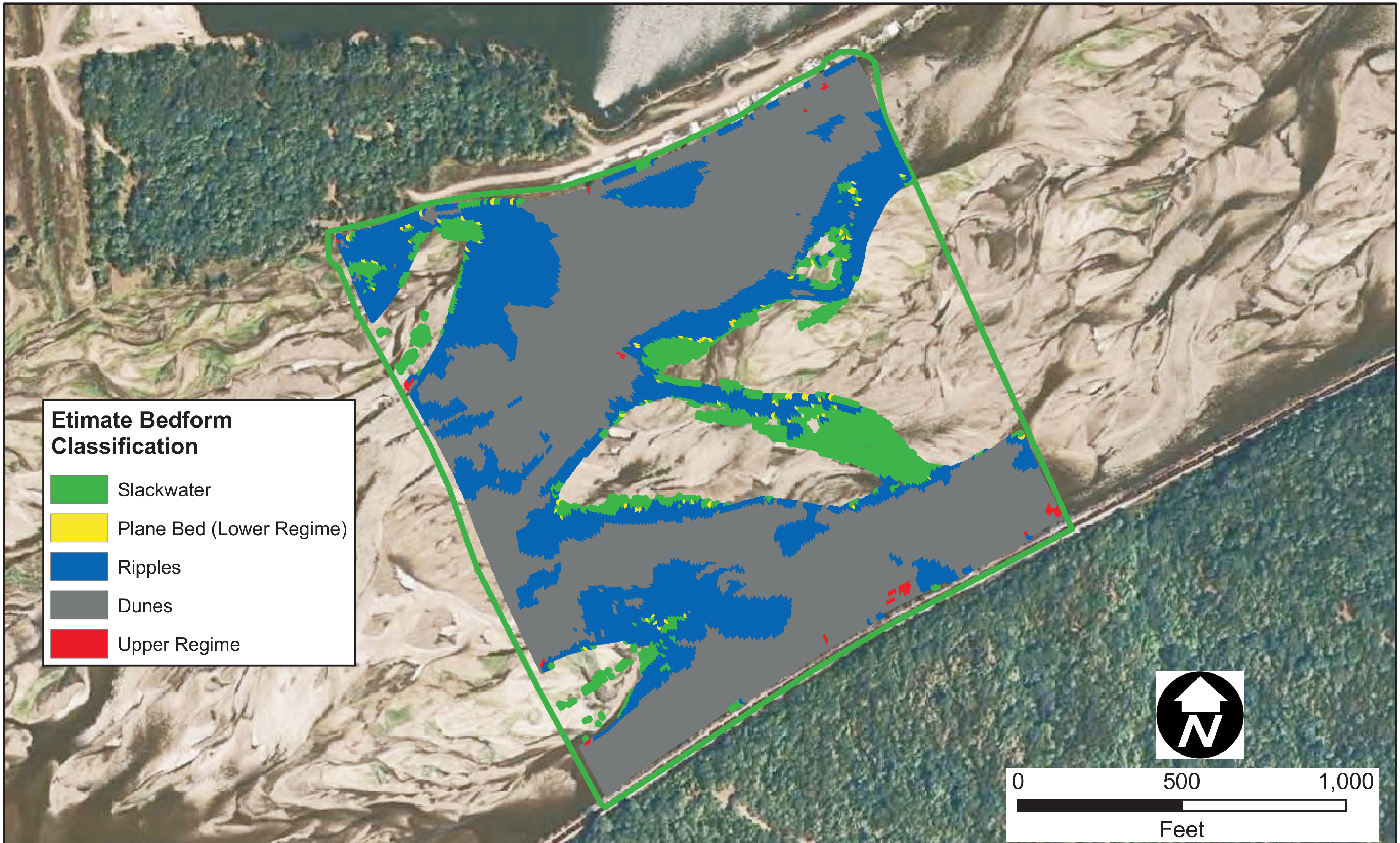
Figure: E1



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Estimated Bedform Classes at 4,300 cfs

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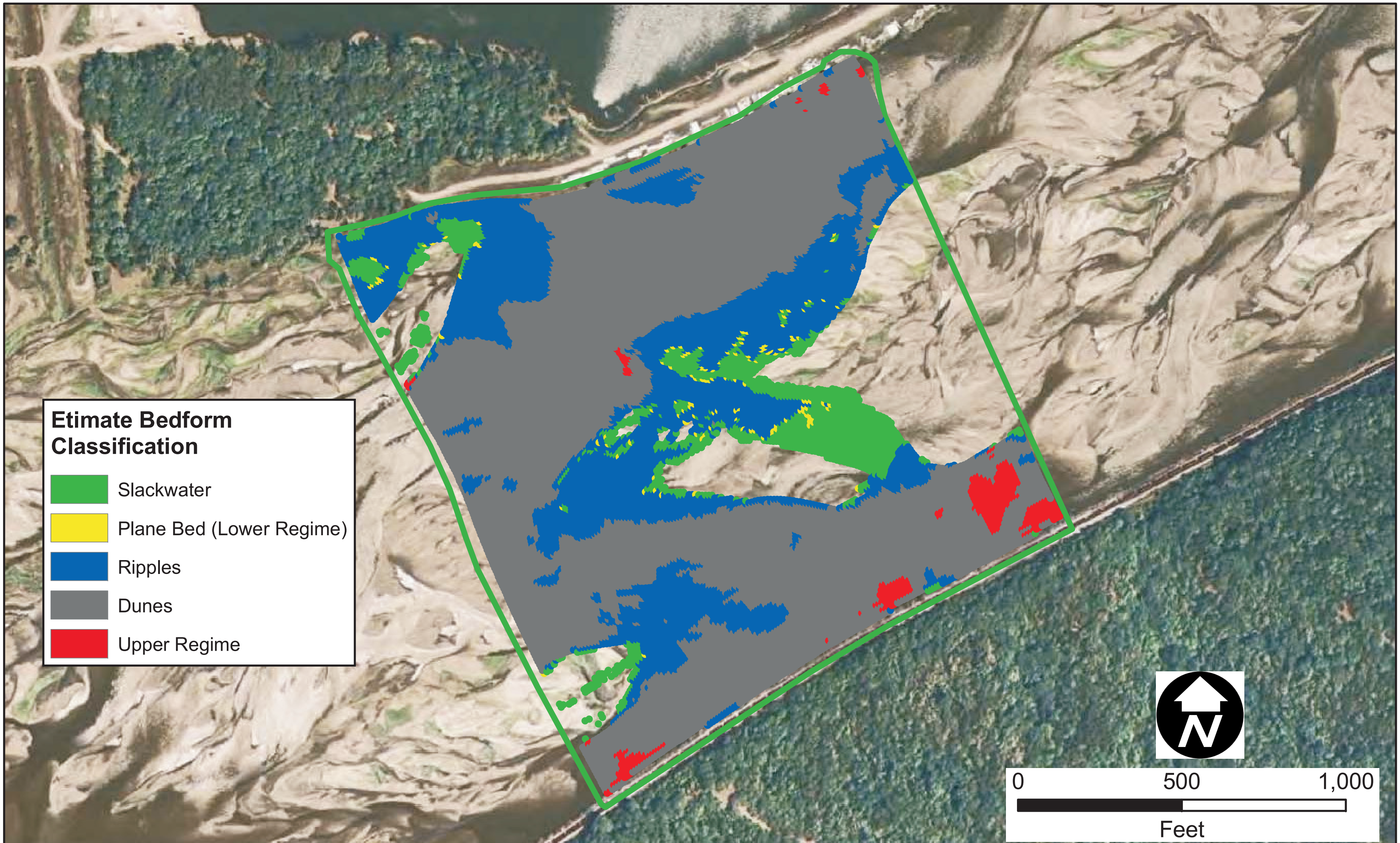
Figure: E2



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Estimated Bedform Classes at 6,000 cfs

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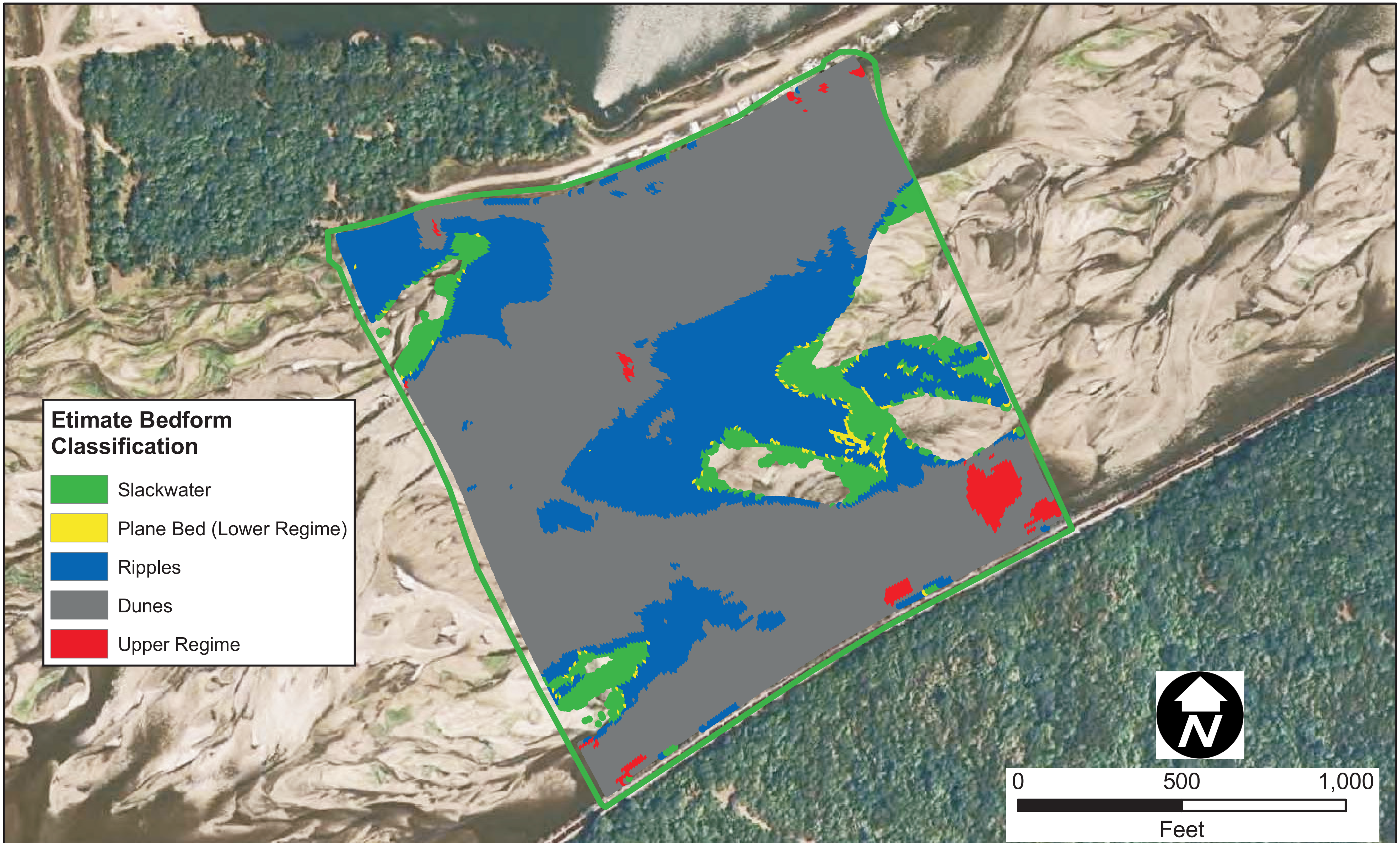
Figure: E3



Estimated Bedform Classes at 8,000 cfs

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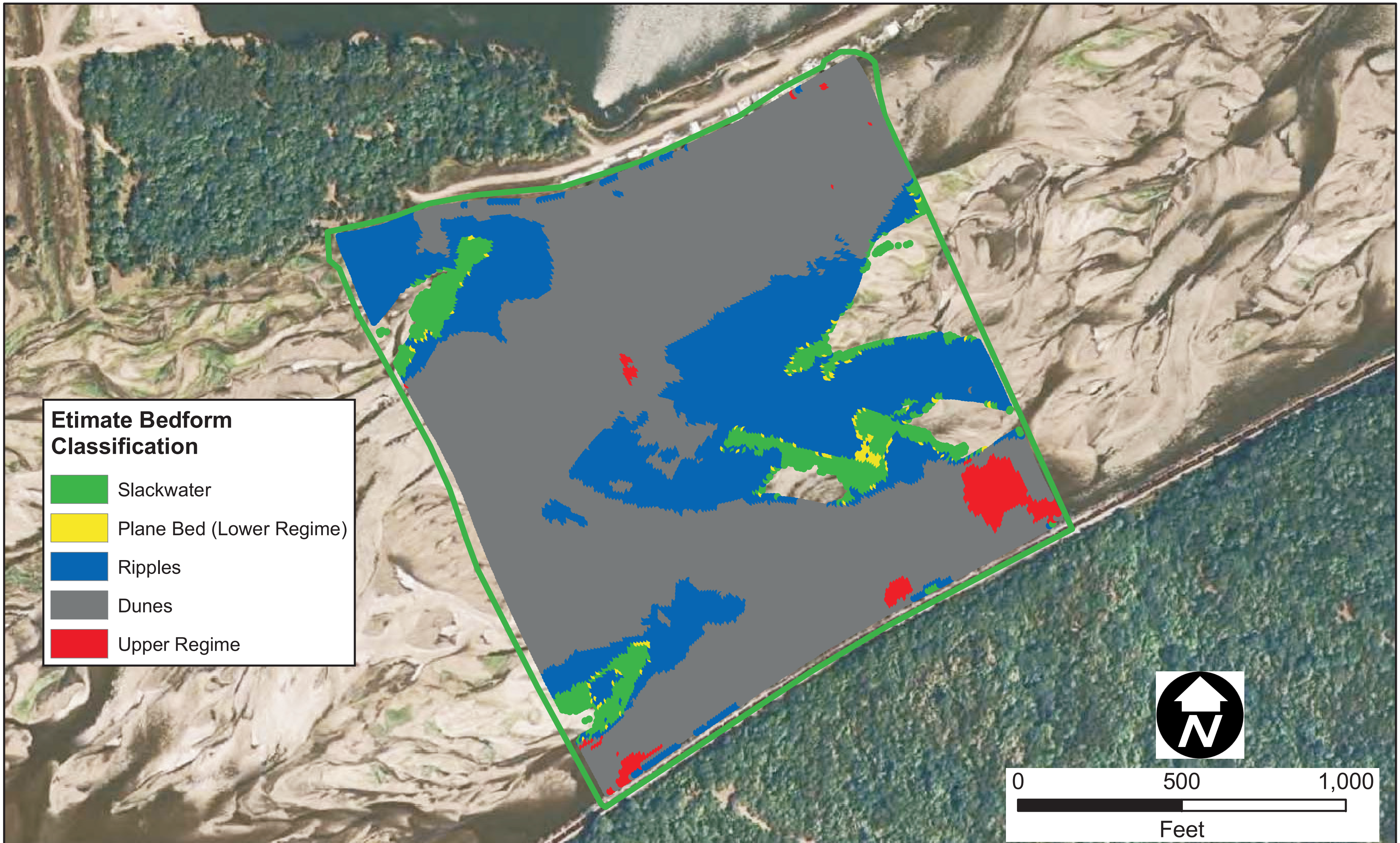
Figure: E4



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Estimated Bedform Classes at 10,000 cfs

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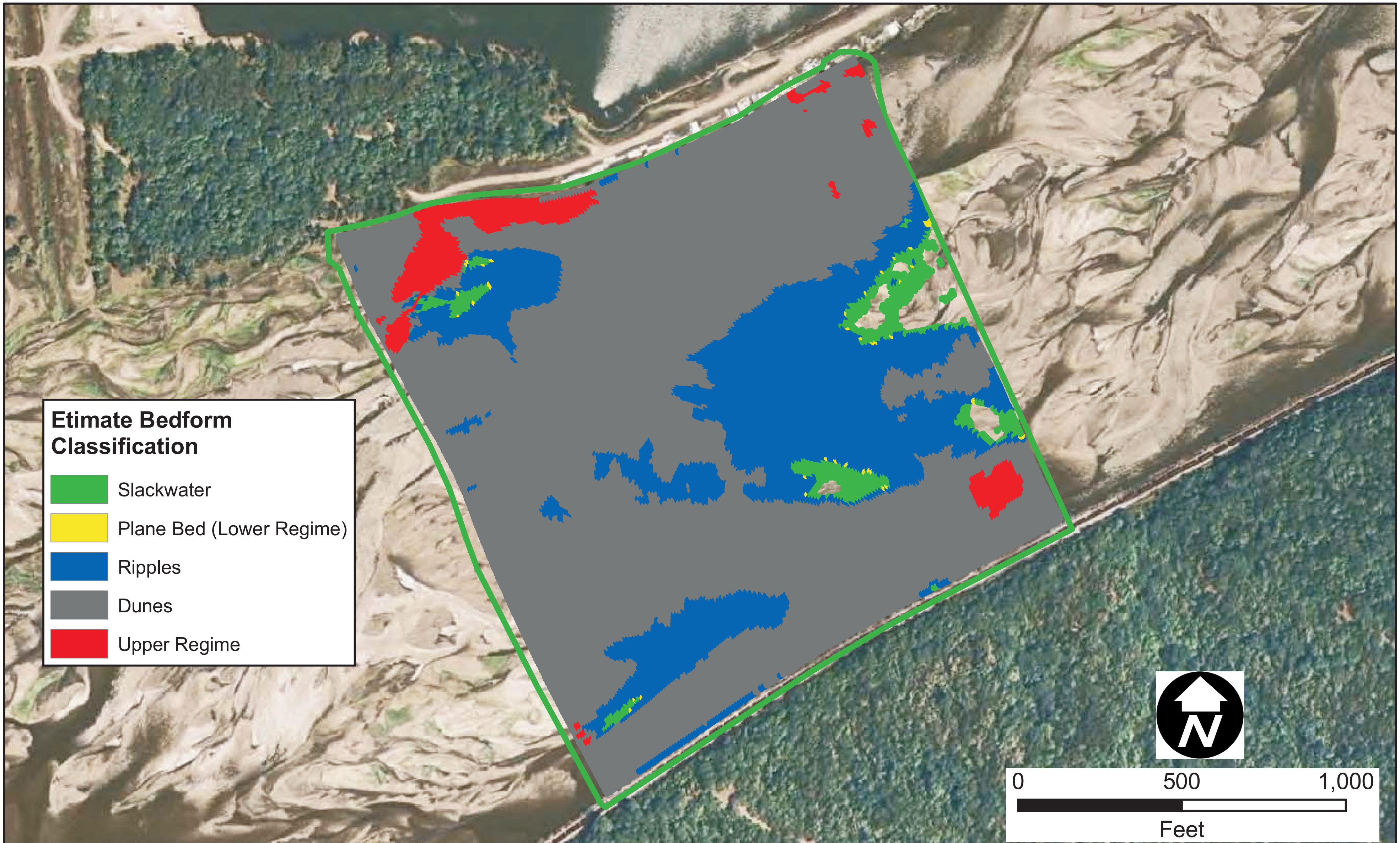
Figure: E5



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Estimated Bedform Classes at 14,000 cfs

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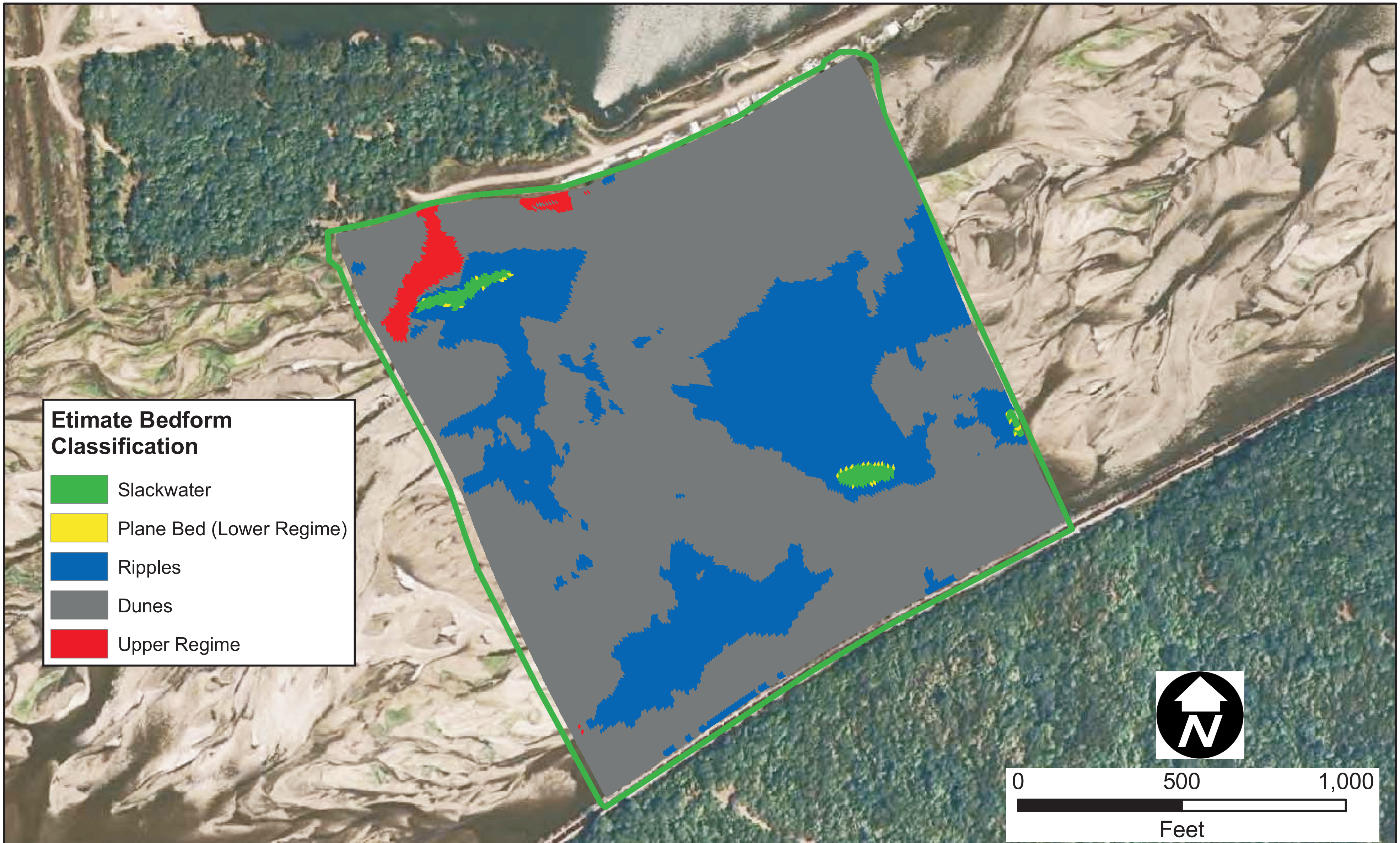
Figure: E6



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Estimated Bedform Classes at 20,000 cfs

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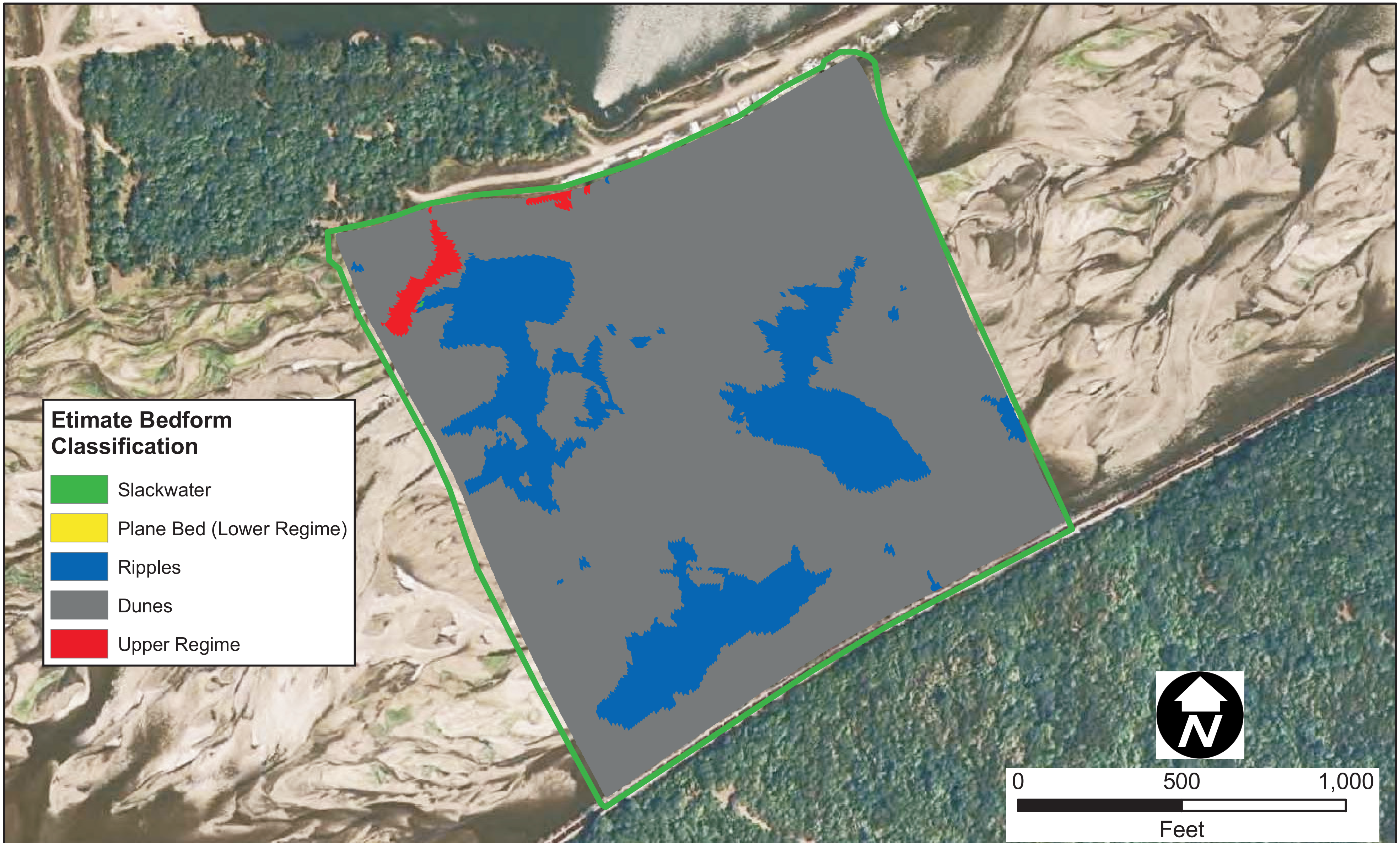
Figure: E7



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Estimated Bedform Classes at 30,000 cfs

Lower Platte River Stage Change Study
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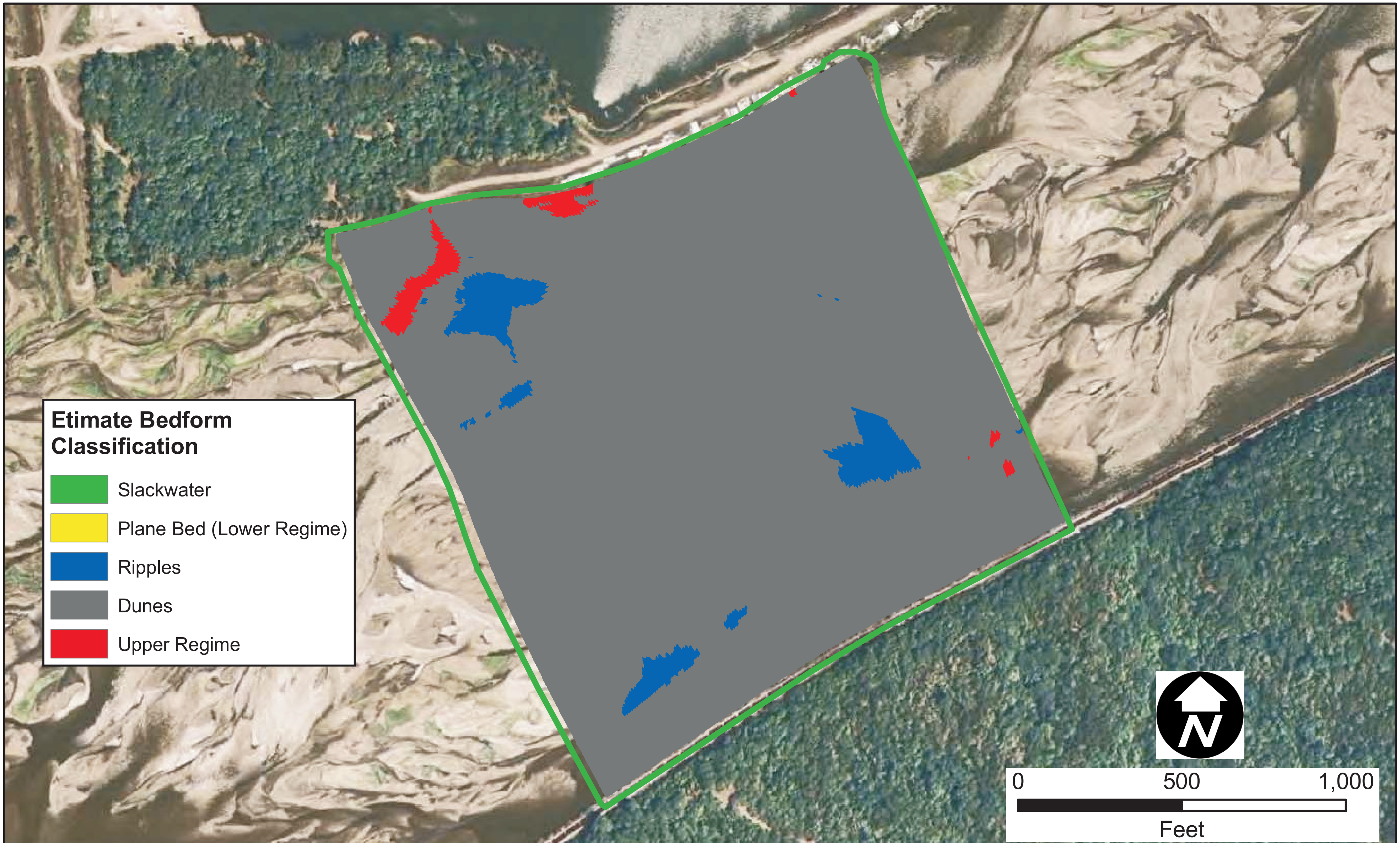
Figure:
E8



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Estimated Bedform Classes at 40,000 cfs

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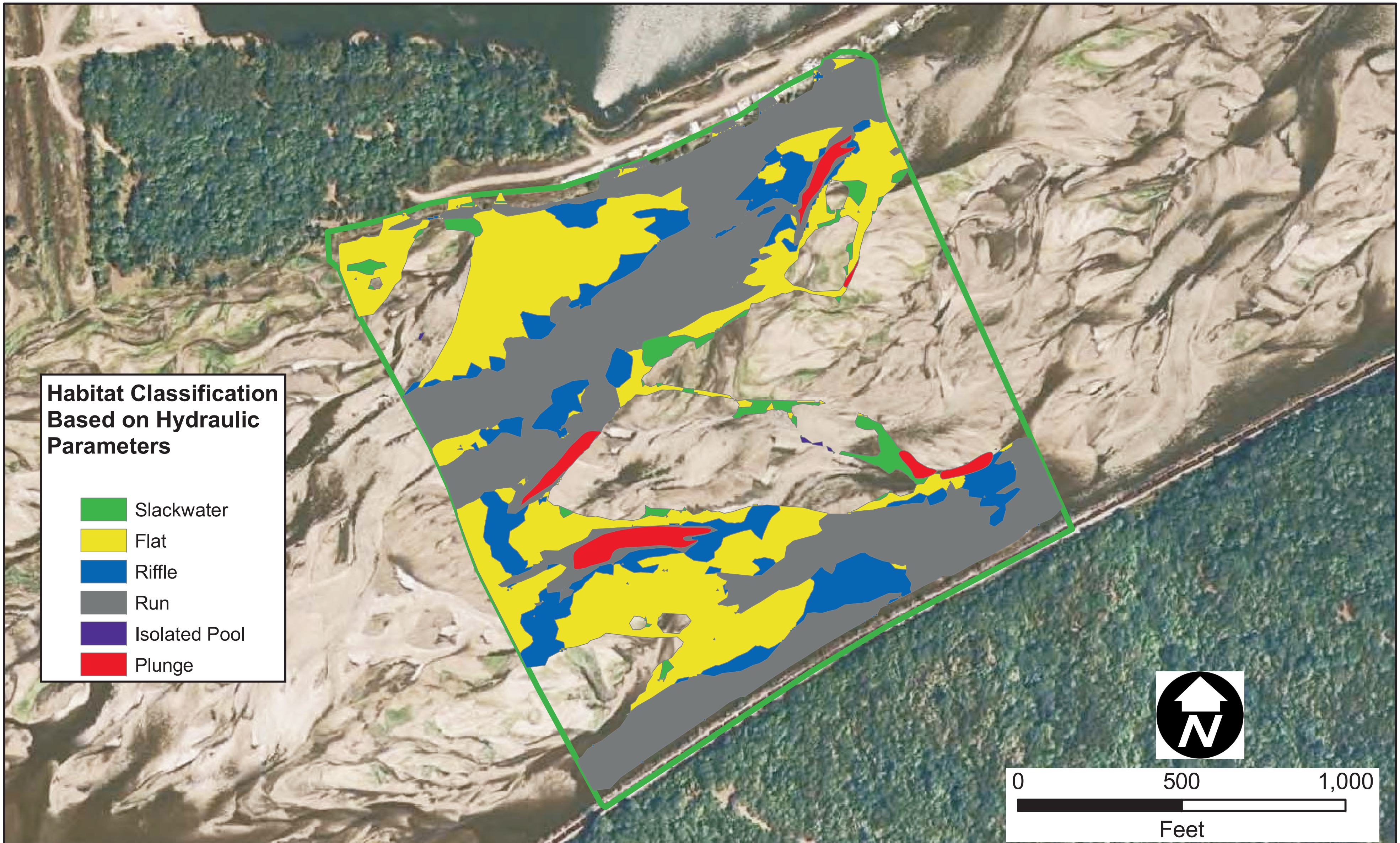
Figure: E9

Appendix F

Spatial Distribution Maps of Estimated Habitat Classes over a Range of Discharges between 3,700 and 40,000 cfs



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Estimated Habitat Classes at 3,700 cfs

Lower Platte River Stage Change Study
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Platte River Recovery Implementation Program

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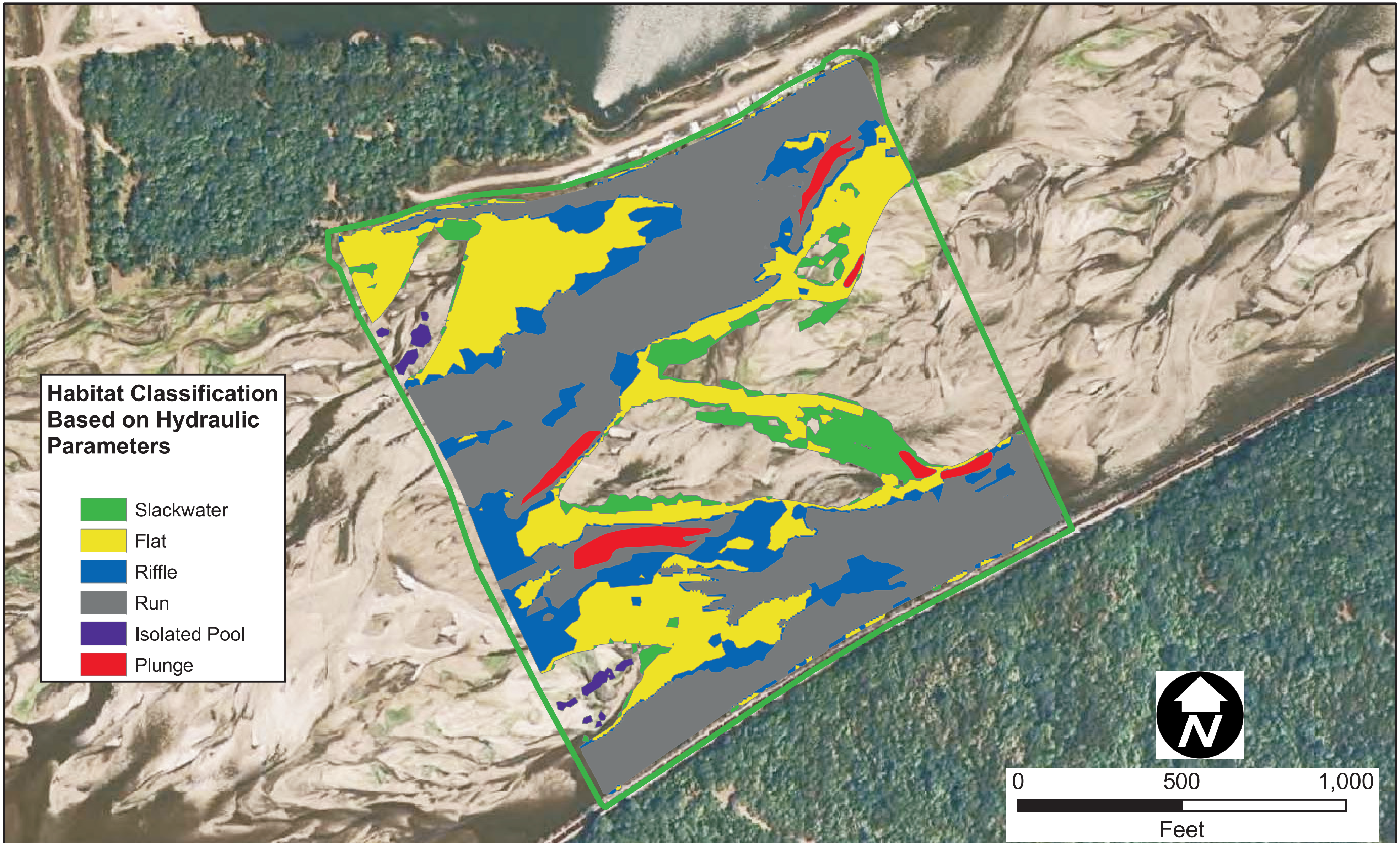
Figure: F1



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Estimated Habitat Classes at 4,300 cfs

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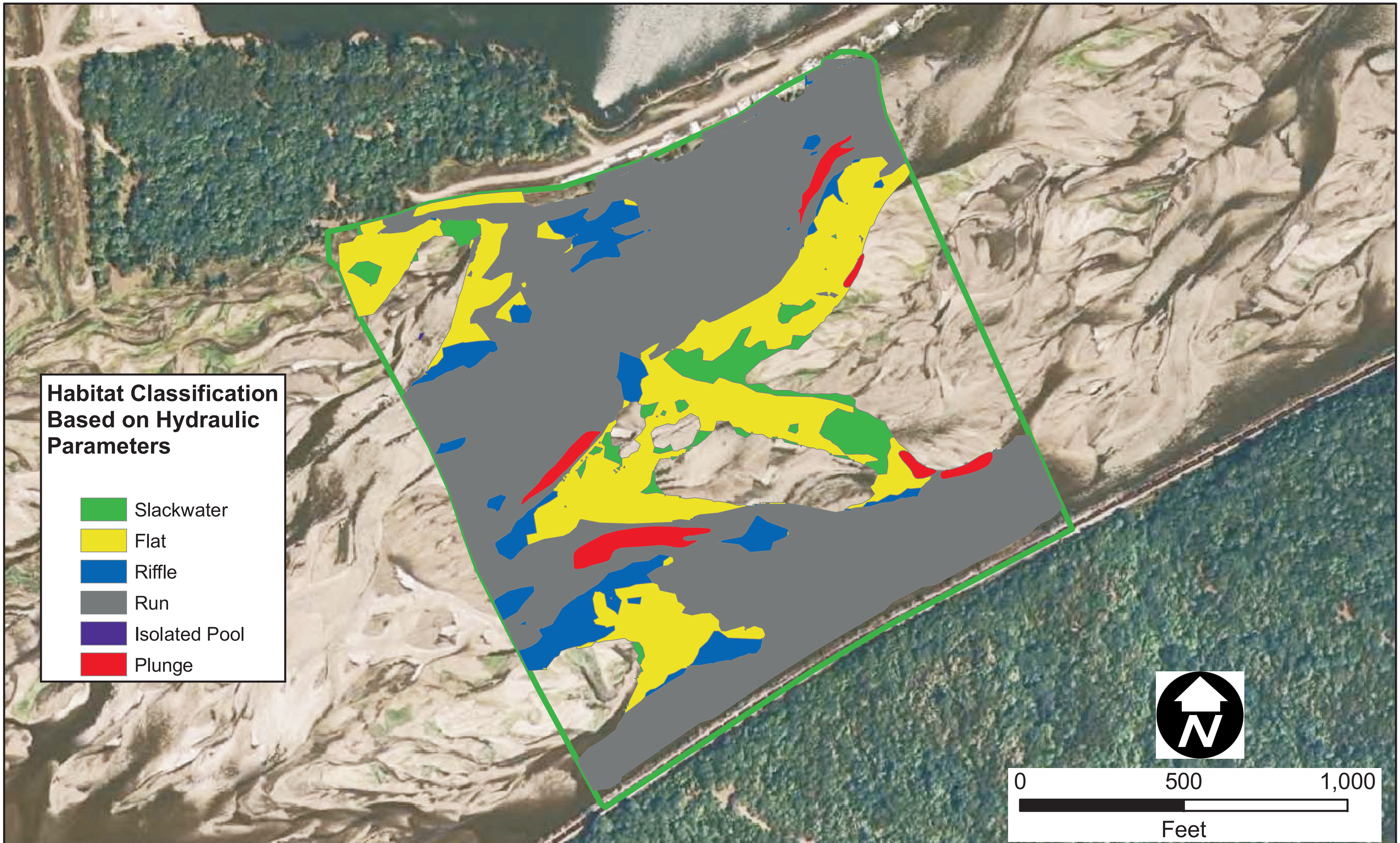
Figure:
F2



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Estimated Habitat Classes at 6,000 cfs

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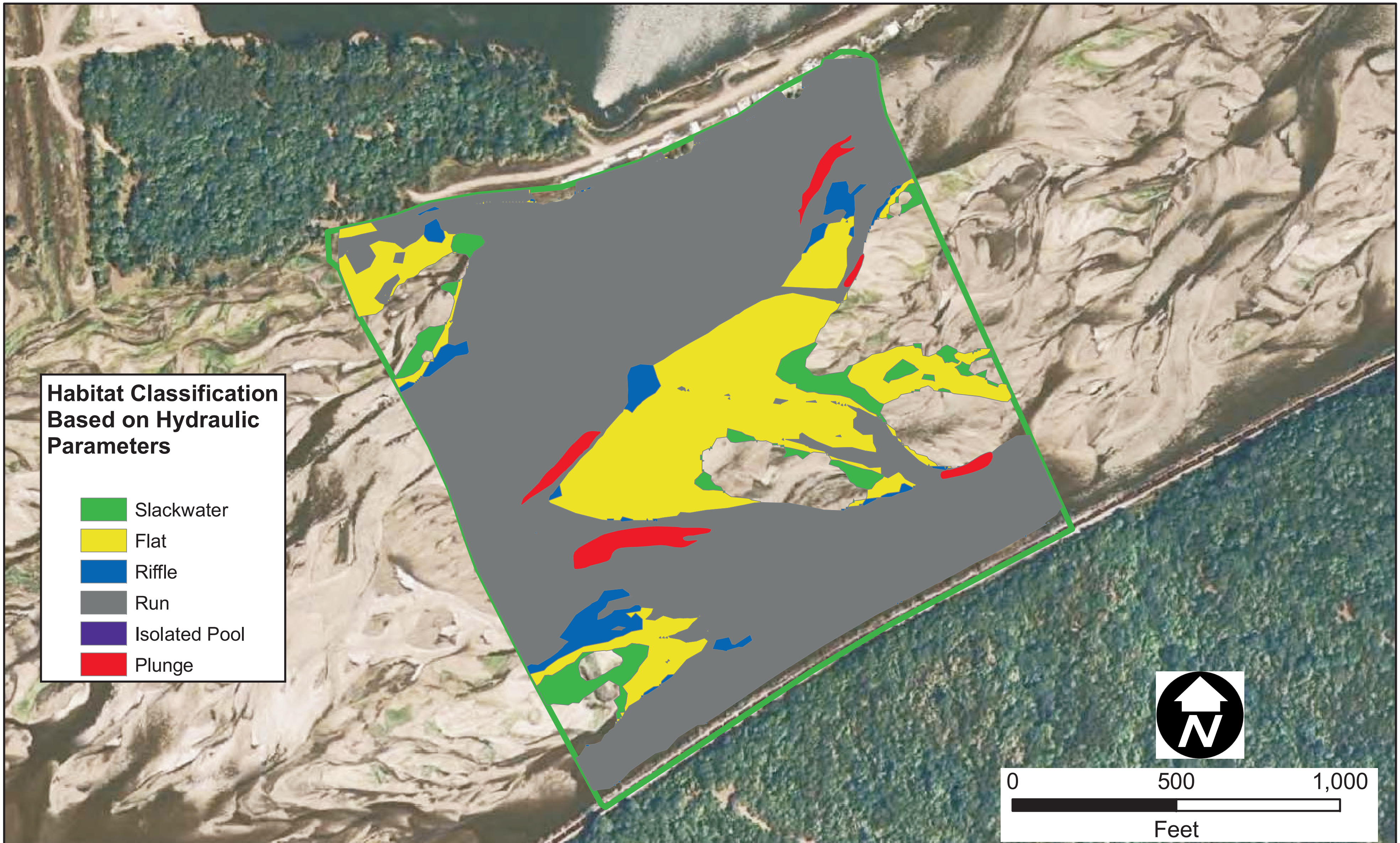
Figure:
F3



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MEI

Estimated Habitat Classes at 8,000 cfs

RECOVERY IMPLEMENTATION PROGRAM PLATTE RIVER

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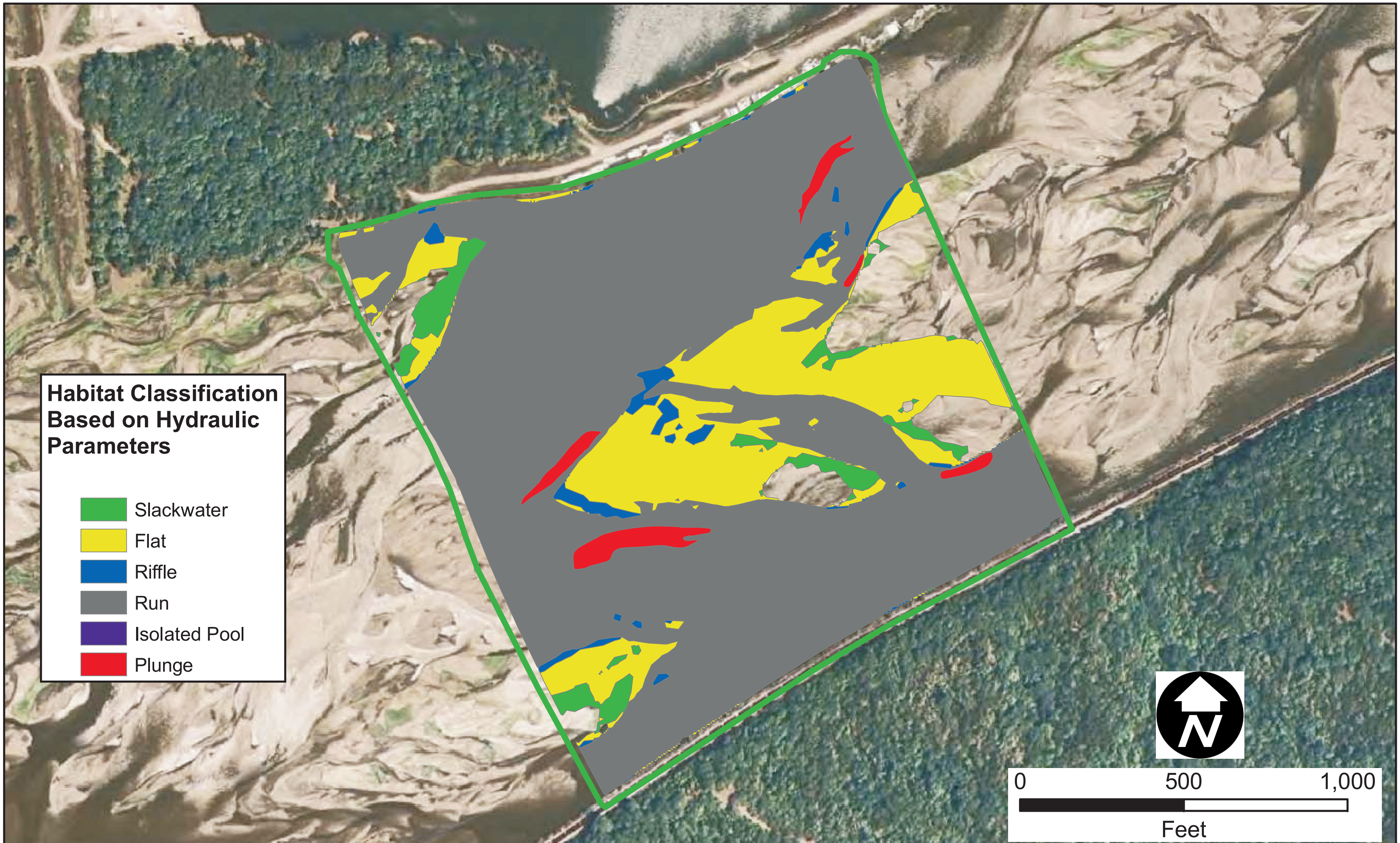
Figure: F4



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Estimated Habitat Classes at 10,000 cfs

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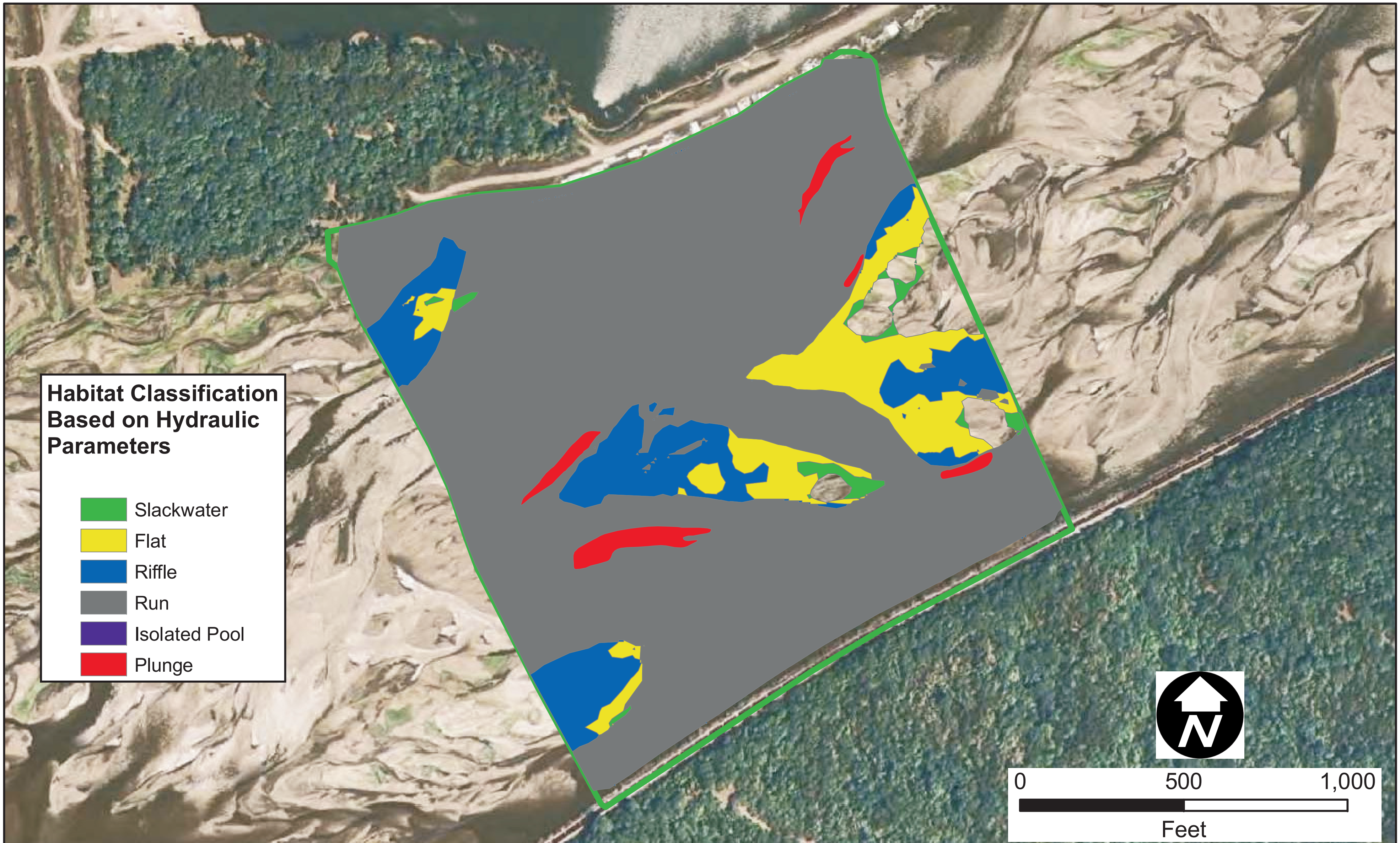
Figure:
F5



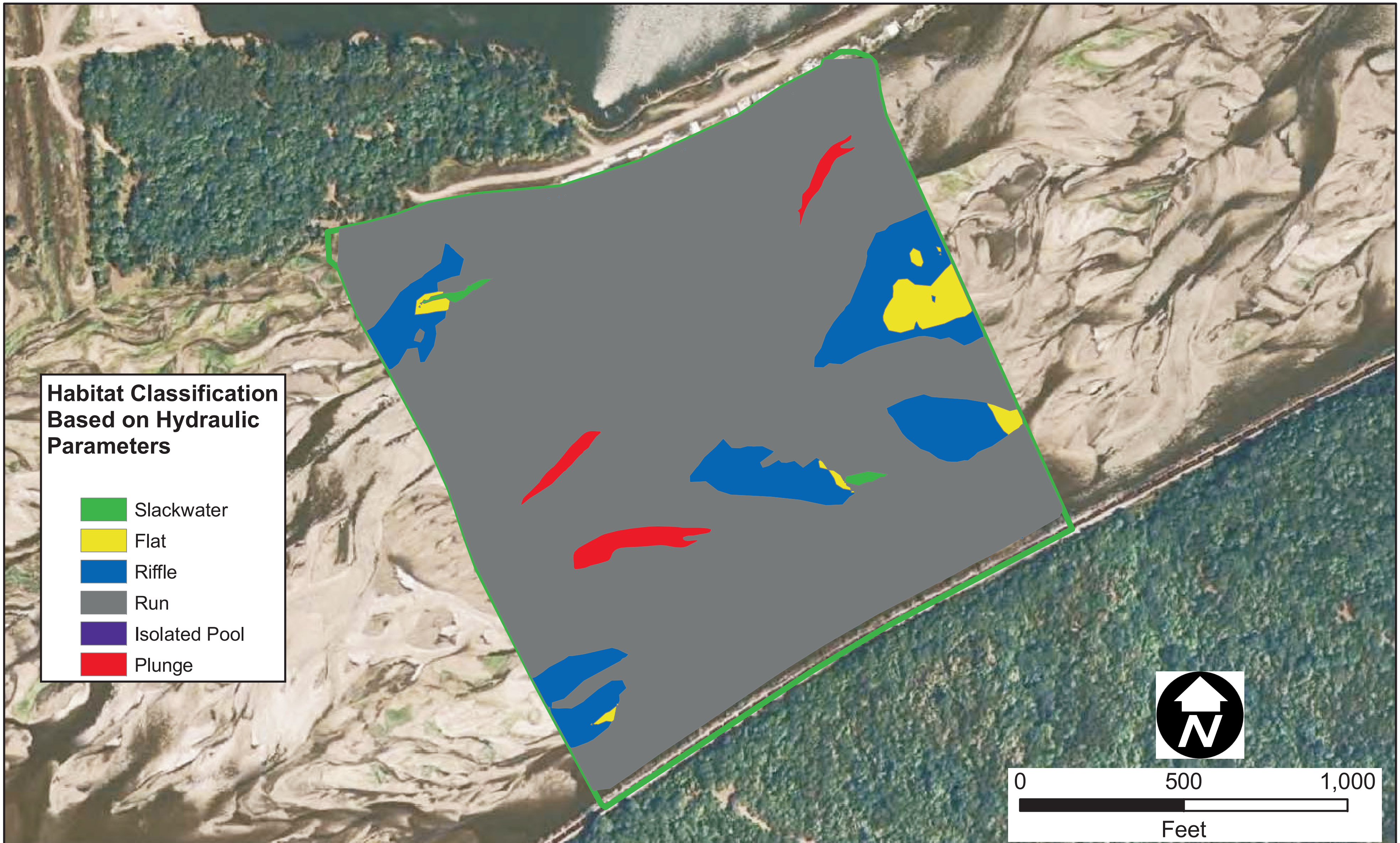
HDR
THE FLATWATER GROUP INC.
TETRA TECH
MEI

Estimated Habitat Classes at 14,000 cfs

Lower Platte River Stage Change Study
Final Protocol Implementation Report
Platte River Recovery Implementation Program

Date:
Dec. 2009

Figure:
F6



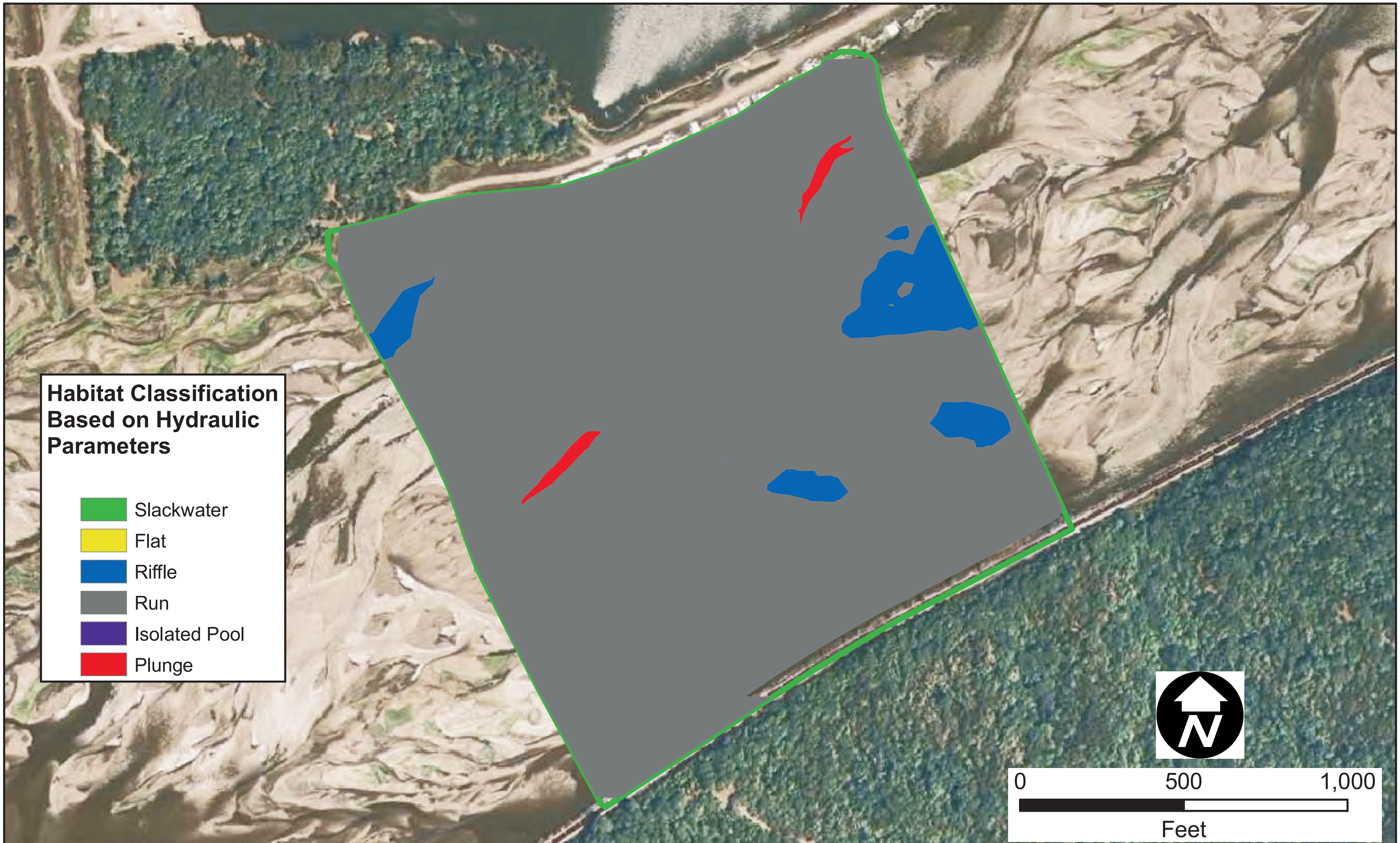
HDR
THE FLATWATER GROUP INC.
TETRA TECH
MEI

Estimated Habitat Classes at 20,000 cfs

Lower Platte River Stage Change Study
Final Protocol Implementation Report
Platte River Recovery Implementation Program

Date:
Dec. 2009

Figure:
F7



HDR
THE FLATWATER GROUP INC.
TETRA TECH
MEI

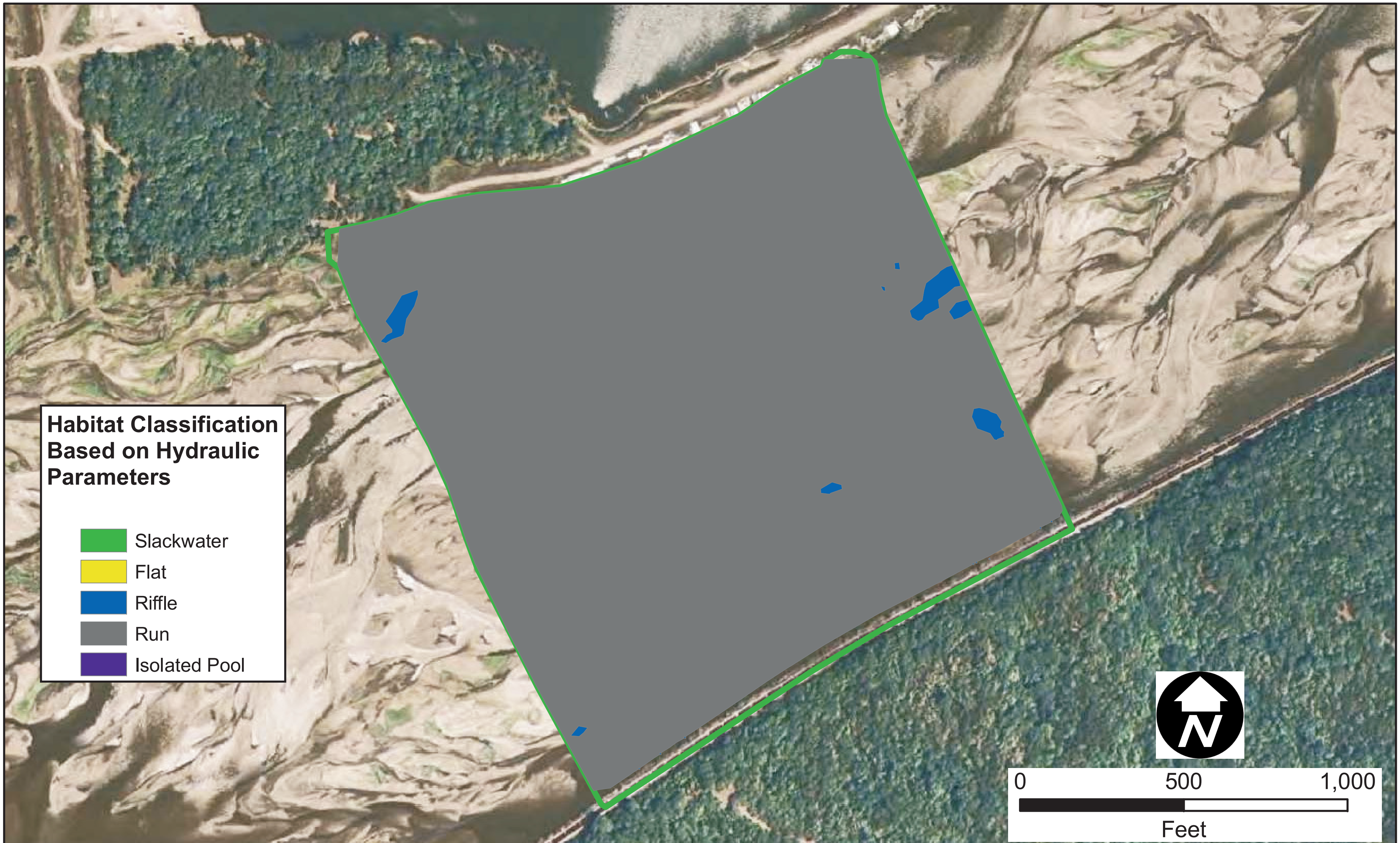
Estimated Habitat Classes at 30,000 cfs

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

Lower Platte River Stage Change Study
Final Protocol Implementation Report
Platte River Recovery Implementation Program

Date: Dec. 2009

Figure: F8



HDR
THE FLATWATER GROUP INC.
TETRA TECH
MEI

Estimated Habitat Classes at 40,000 cfs

Lower Platte River Stage Change Study
Final Protocol Implementation Report
Platte River Recovery Implementation Program

Date:
Dec. 2009

Figure:
F9

Appendix G

Lower Platte River Stage Change Study
Alternative Analysis of Program Activities
Technical Memorandum Presented to Program TAC Committee
Monday, November 23, 2009

Lower Platte River Stage Change Study
Alternative Analysis of Program Activities
Technical Memorandum
Presented to Program Technical Advisory Committee
Monday, November 23, 2009

HDR Engineering Inc., The Flatwater Group, Tetratech, Dr. Mark Pegg

Program activities may include regulating or trimming the hydrograph in the central Platte River which could affect flows in the lower Platte River (as measured at the Louisville gage). To estimate the impacts of this action, and the resultant change in stage, a hydrologic analysis was performed to evaluate a scenario during dry year hydrologic conditions. The analysis is based on Program target flows in the Platte River, the timing in which Program diversions would likely occur, and the system's diversion limitations.

The following tasks were performed: 1.) Determine the number of days that the target flows would be exceeded at Grand Island; 2.) Determine the magnitude of flow that could be diverted above the target flows, taking diversion limitations into consideration; 3.) Determine the impact that the diverted flow would have on the lower Platte River flow (Louisville gage); and 4.) Evaluate the impact of diverted flow on percent habitat classification area based on the analysis outlined in the Lower Platte River Stage Change Study Draft Protocol Implementation Report (Stage Change Report).

For purposes of this technical memorandum, the following assumptions were made: 1.) The Program would divert flows only during the months of March, April, October, and November; 2.) The Program would only divert flows in excess of Program target flows between Lexington and Chapman; and 3.) The maximum flow rate diverted above Grand Island is 4,000 cfs.

Table 1 shows the Program's target flows as set by the Governance Committee for the Lexington to Chapman reach. The gage at Grand Island was used for this analysis to determine the excess to target flows.

Table 1. Program Target Flows (cfs)

Period	Wet Year	Normal Year	Dry Year
February 15 – March 15	3,350	3,350	2,250
March 16 – March 22	1,800	1,800	1,200
March 23 – May 10	2,400	2,400	1,700
September 16 – September 30	1,000	1,000	600
October 1 – November 15	2,400	1,800	1,300
November 16 – December 31	1,000	1,000	600

A period of interest in the lower Platte River is when flows range between 4,000 and 6,000 cfs. It has been suggested in the literature that there are connectivity concerns at the lower end of this range. In addition, results of the Stage Change Study have shown this to be a range where the percent habitat classification area experiences a relatively high rate of change (see the Stage Change Report, Figure 38). Based on this, the gage data for the period of record at Louisville was sorted to catalog the events that were between 4,000 and 6,000 cfs for February 23 through May 5 (spring) and for September 25 through December 5 (fall). For those days at Louisville that had flow between 4,000 and 6,000 cfs, the corresponding flows at Grand Island were cataloged. Travel times of 4 days and 5 days for spring and fall, respectively, were used (USFWS, 2002). From that data set, days at Grand Island that exceeded the target flows were cataloged, and the amount of flow above the target flows (the flow that could be diverted by the Program) was determined. Assuming full translation, and accounting for travel time, the amount of flow diverted upstream of Grand Island was subtracted from the corresponding flow at Louisville. The results of the analysis are shown in Table 2.

Table 2. Excess to Target Flows at Grand Island vs. Flows at Louisville Between 4,000 and 6,000 cfs

Condition	# of Days for Period of Record	# of Days Between 4,000 and 6,000 cfs @ Louisville	# of Target Exceedences @ Grand Island	# of Days Below 4,000 cfs @ Louisville	Range of Flows Below 4,000 cfs @ Louisville	# of Consecutive Days Below 4,000 cfs
Spring	3,976	847	145	11	30 to 950	2 days (once)
Fall	4,017	1127	635	184	9 to 1380	2 days (16 times) 3 days (10 times) 4 days (3 times) 5 days (once) 6 days (2 times) 7 days (once) 8 days (3 times) 14 days (once)

For spring, target flows were exceeded on 145 days when the corresponding flow at Louisville was between 4,000 and 6,000 cfs. Assuming that the entire diverted flow (above target flows) at Grand Island was translated to Louisville (that is, did not account for reach losses), flow below 4,000 cfs would have been incurred on 11 days. Of those 11 days, only one instance would have lasted more than a day. The largest amount that could have been diverted for the sample set occurred on March 22, 1972. Flow at Grand Island was 3,190 cfs, thereby allowing the Program to divert 1,990 cfs above the target of 1,200 cfs. Based on the Stage Change Report, approximately 88 percent of the flow would have reached Louisville, which would have reduced the flow at Louisville from 5,040 cfs to 3,290 cfs. Based on the relationship shown in Figure 38 of the Stage Change Report, the Run habitat classification represents approximately 56 percent of the habitat area at 5,040 cfs and approximately 45 percent of the habitat area at 3,350 cfs, a decrease of 11 percent. It is noted that the lowest flow represented in Figure 38 is 3,700 cfs. Therefore, values relative to flows below that are reported as the values at 3,700 cfs. The Flat habitat classification represents approximately 25 and 35 percent of the habitat area at 5,040 and 3,290 cfs, respectively, a 10 percent increase. Finally, the Riffle habitat classification represents approximately 11 and 13 percent of the habitat area at 5,040 and 3,290 cfs, respectively, a 2 percent increase. In assessing the results of this example, it should be noted that the uncertainty in daily flow at the Louisville gage for the months of March and April is approximately 850 cfs (see the Stage Change Report, Table 5). Finally, the decrease in discharge does not move the conductivity, turbidity, temperature, or dissolved oxygen outside the typical range preferred by pallid sturgeon (see the Stage Change Report, Figures 42 and 43).

For fall, target flows were exceeded on 635 days when the corresponding flow at Louisville was between 4,000 and 6,000 cfs. Assuming that the entire diverted flow (above target flows) at Grand Island was translated to Louisville (that is, did not account for reach losses), flow below 4,000 cfs would have been incurred on 184 days. Of those 184 days, 37 instances would have lasted more than one day, ranging from 2 to 14 days, as shown in Table 2. The largest amount that could have been diverted for the sample set occurred on November 25, 1972. Flow at Grand Island was 2,550 cfs, thereby allowing the Program to divert 1,950 cfs above the target of 600 cfs. Based on the Stage Change Report, approximately 85 percent of the flow would have reached Louisville, which would have reduced the flow at Louisville from 5,860 cfs to 4,200 cfs. Based on the relationship shown in Figure 38 of the Stage Change Report, the Run habitat classification represents approximately 61 percent of the habitat area at 5,860 cfs and approximately 47 percent of the habitat area at 4,200 cfs, a decrease of 14 percent. The Flat habitat classification represents approximately 23 and 31 percent of the habitat area at 5,860 and 4,200 cfs, respectively, an 8 percent increase. Finally, the Riffle habitat classification represents approximately 9 and 14 percent of the habitat area at 5,860 and 4,200 cfs, respectively, a 5 percent increase. In assessing the results of this example, it should be noted that the uncertainty in daily flow at the Louisville gage for the months of October and November is approximately 500 cfs (see the Stage Change Report, Table 5). Finally, the decrease in discharge does not move the conductivity, turbidity, temperature, or dissolved oxygen outside the typical range preferred by pallid sturgeon (see the Stage Change Report, Figures 42 and 43).

Existing and new data collection efforts on the Platte River for sturgeon species (shovelnose and pallid) suggest that these species use the river during the spring and fall. Maintaining suitable habitat is critical for spawning (spring) and possibly for staging areas for overwintering or upcoming spawning movements (fall). Spring is likely the most critical period, so that should be protected as best possible. However, catch rates during fall 2009 sampling showed a significant pallid sturgeon presence in the Platte River. The issue at hand would likely be loss of habitat connectivity that prevents movements should flows be reduced significantly during spring and/or fall during diversion. Diversion of flows would likely be limited to one or a few days during any season given the information above. This duration of diversion would likely not have a long-term influence on habitat connectivity, although short-term connectivity could be problematic. However, these data suggest that proper monitoring of water levels in the lower Platte River and corrective actions implemented during diversion could prevent substantial negative impacts.

Reference

USFWS. 2002. "Summary Report on the Potential of Changes in Central Platte Flow Conditions to Affect Flows in the Lower Platte." Draft Report. U.S. Fish and Wildlife Service, Mountain-Prairie Region (Region 6). December.

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

EXHIBIT B

Stage Change Study Peer Review Results and PRRIP Responses to Peer Review Comments

ATKINS

Platte River Recovery Implementation Program
Lower Platte River Stage Change Study Peer Review

SUMMARY REPORT

I. Introduction

The Lower Platte Stage Change Study (Stage Change Study) was peer reviewed by five (5) panel members in September 2011 as requested by the Platte River Recovery Implementation Program (PRRIP). Each reviewer was tasked with reviewing the Stage Change Study from their particular area of expertise and to submit comments (both answering specific questions and submitting their own comments/inquiries) in writing to the Atkins North America (Atkins), who facilitated the peer review. Areas of expertise for the Stage Change Study included: (1) pallid sturgeon ecology; (2) riverine physical processes/geomorphology; (3) river engineering and hydraulic modelling; (4) hydrology and hydrologic analysis; and (5) ecological statistics. Peer reviewers for the Stage Change Study, including their affiliations and area of expertise, are listed in the table below.

Name	Affiliation	Area of Expertise
Christopher Guy	U.S. Geological Survey	Pallid Sturgeon Ecology
David Gaeuman	U.S. Bureau of Reclamation	Riverine Processes & Geomorphology
Larry Weber	University of Iowa	River Engineering/Hydraulics
Lee Wilson	Lee Wilson & Associates	Hydrology/Hydrologic Analysis
Dennis Helsel	Practical Stats	Ecological Statistics

II. Summary Report

Reviewers were asked to do the following tasks as part of the Stage Change Study Peer Review:

- Task 1 - Review the Stage Change Study from their area of expertise;
- Task 2 - Address the set of questions related to the Stage Change Study (as per the Scope of Work [SOW]);
- Task 3 - Provide general comments on scientific soundness, organization and clarity, conciseness, degree to which conclusions are supported by data, and cohesiveness of conclusions;
- Task 4 - Provide specific comments (as per the SOW) addressing presentation, methods, data presentation, statistical design and analyses, conclusions, errors, and citations (pee reviewers were to comment on these facets of the Stage Change Study if they significantly affected the peer reviewer's opinion); and
- Task 5 - Rate the Stage Change Study using the rating system provided in the SOW. See *Table 1* in *Section IV* below.
- Task 6 - Provide a recommendation (Accept, Accept with Revision, or Unacceptable) as it applies to the Stage Change Study.

This summary report provides an overview of the comments received from Task 3 (general comments), 5 (ratings) and 6 (recommendations) listed above. Comments received for Tasks 1, 2 and 4 are included in the *Lower Platte River Stage Change Study Peer Review Comment-Response Table* (*Attachment 1*). All comments have been inserted into a comment-response table as requested by the PRRIP so they can be easily referenced and tracked. Copies of the reviews are compiled in *Attachment 2*.

III. General Comments and Ratings

Reviewers were asked to provide comments on the Stage Change Study with respect to the following general categories[1]: (1) scientific soundness; (2) organization and clarity; (3) conciseness; (4) degree to which conclusions are supported by the data; and (5) cohesiveness of conclusions. Reviewers were to consider the major strengths and weakness of the document, its suitability for publication and/or use by the PRRIP, and its soundness in terms of both methods and scientific reasoning. A summary of responses for each category is included in subsequent sections. If specific examples or comments are cited, the reviewer's last name appears in parentheses following it.

<u>Scientific Soundness</u>

Reviewers indicated the scientific soundness of the Stage Change Study is *Good* (average rating of 2.8 = good; see ratings in *Table 1* in *Section IV*). Ratings ranged from 2 (very good) to 4 (fair). Most reviewers felt the technical aspects were generally good, excluding a few technical issues that were identified by specific comments. Of note were the following issues with scientific soundness.

1. Much of the study was based on analyses from unpublished FWS reports – results hinge on these results and some statement from the FWS should be included that verifies the analyses, spreadsheets etc., to ensure they are valid. The FWS reports do not discuss the methods that produced the conclusions or whatever product is being cited....the implication is the report is being accepted as truth (Helsel).
2. There is concern that most of the analyses and measures of variation represent pseudo-replication. A better way to determine the effects of PRRIP water activities on physical parameters that are thought to have significance to pallid sturgeon would be to conduct stage change studies in multiple reaches. It is a better way to represent available habitat for pallid sturgeon and the influence of PRRIP water activities on habitat (Guy).

<u>Degree to Which Conclusions are Supported by Data</u>

Reviewers indicated the degree to which conclusions are supported by data in the Stage Change Study is *Good/Very Good* (average rating of 2.6 = very good/good). There was a wide range of responses, from 1 (excellent) to 4 (fair) and thus perhaps an average rating is not the best means of evaluating this category. Three of the five reviewers felt the conclusions were well supported, particularly within their area of expertise (Gaeuman, Guy, and Weber). Although he believed the conclusions in the Stage Change Study are supported by the data, one reviewer suggested that the robustness of the data and the conclusions could be enhanced by a better experimental design (Guy). The remaining two reviewers felt the conclusions were not particularly well supported. One of the reviewers felt the water quality conclusions were not well supported (Helsel). The other reviewer felt that it was very difficult to determine how well supported the conclusions were without direct access to copies of the datasets, spreadsheets and models (Wilson).

<u>Organization and Clarity</u>

Reviewers indicated the organization and clarity of the Stage Change Study is *Good* (average rating of 3 = good). Ratings ranged from 1 (excellent) to 4 (fair). In terms of the document as a whole, reviewers felt it was relatively well organized and clear but could use standardization in terms of primary, secondary and tertiary headings, the addition of an executive summary, introductory

[1] Some reviewers rated "Importance to Objectives of the Program" even though the PRRIP document indicated that this category was for internal panel use only. Atkins assumed (as did several of the reviewers) that the internal panel was the PRRIP Governance Committee. Since some panelists rated it while others did not, ratings will not be included for this category. If clarification is needed, please provide it for use in future peer reviews.

section with background for context, and conclusions section, clarification to table and figure headings, and additional background information for clarity.

<u>Cohesiveness of Conclusions</u>
Reviewers indicated the cohesiveness of the conclusions in the Stage Change Study are *Good/Very Good* (average rating of 2.5 = good/very good). Ratings ranged from 2 (very good) to 4 (fair). One reviewer did not provide a rating for this category (it is marked as non-applicable [N/A] in *Table 1*). The rating may have been based on how willing the reviewer was to search for the conclusions within the Stage Change Study document. For example, one reviewer thought the conclusions were cohesive (rating of 2) but noted he had to search for them within the Discussion Section because they were interwoven (Weber). A conclusion section would have been helpful. Another reviewer suggested the addition of a conclusion section (Helsel) for ease of understanding. One reviewer even suggested that "much has been left unsaid in this study...and a stranger to this process might not be able to properly judge the end results (Wilson).

Comment [EBH1]: Atkins' deleted the ratin associated with this comment. Upon discuss with Lee Wilson, the rating and the comment were not linked.

Lee rated the document based on what he wa provided with (report, appendices, etc.). He made additional comments on how the report could be improved if it were revised.

Atkins mistakenly linked the ratings to the comments and that wasn't necessarily the intention of the reviewer.

<u>Conciseness</u>
Overall, reviewers indicated the conciseness of the Stage Change Study is *Very Good/Excellent* (average rating of 1.8 = very good/excellent). Most reviewers felt the document was well written and presented an appropriate amount of information in terms of breadth and depth.

IV. Ratings

Table 1 summarizes the ratings for each of the categories discussed in *Section III* (Task 5 in *Section II*). The ratings are organized by reviewer and an average rating is included as well. In most cases, average ratings tend to be a good representation of the overall sentiment of the reviewers. Exceptions are noted in *Section III* above.

	Reviewer	Gaeuman	Guy	Helsel	Weber	Wilson**	Average
Categories	Scientific soundness	4	3	3	2	2	**2.8**
	Degree to which conclusions are supported by the data	3	3	4	2	1	**2.6**
	Organization and clarity	4	4	4	1	2	**3**
	Cohesiveness of conclusions	N/A	2	4	2	2	**2.5**
	Conciseness	3	2	2	1	1	**1.8**

Table 1: Ratings given per each reviewer following the rating system: 1=excellent, 2=very good, 3=good, 4=fair, 5=poor.

**during the rating process, Lee Wilson inverted the rating system – he classified 5 = excellent and 1 = poor. Atkins was able to identify this reversal given that Lee's comments were counter to his ratings. Table 1 corrects for this. Atkins will verify this with Lee once he returns stateside in mid-October 2011.

Comment [EBH2]: Atkins verified that Lee Wilson did invert his ratings. Table 1 is correc as included in this report.

V. Recommendations

Reviewers were also asked to make a recommendation with respect to the document. They were given the following choices: (1) accept it; (2) accept it with revisions; or (3) deem it unacceptable. Before the recommendations can even be considered, it is important to note the confusion associated with this task. First, peer reviewers were unclear as to whether the Stage Change Study was a draft or final document – could it be revised? In some cases, the recommendation hinged on whether the reviewer felt it was feasible to make a specific recommendation given it may not be something that could be changed. Additionally, there may have been confusion amongst reviewers as to how the Stage Change Study was going to be used in the future – would it be published? Was it going to be used by the PRRIP and if so, how? Perhaps it would be useful to provide a one paragraph summary to peer reviewers (as they begin their peer review) that provides context for the study being reviewed and how it will be used by the PRRIP.

Given this, Weber and Wilson recommended the Stage Change Study be accepted. Gaeuman, Guy and Helsel recommended it be accepted with revisions (assuming it can be revised). In the case of Gaueman, he suggested a major revision but given its status as a final report, he would accept the general conclusion as being "qualitatively" correct.

ATTACHMENT 1

Lower Platte River Stage Change Study
Comment-Response Table

Lower Platte River Stage Change Peer Review Comment-Response Table						
Comment #	**Reviewer**	**Expertise**	**Section**	**Page**	**Comment**	**Response**
1	Gaeuman	Fluvial Geomorphology	SOW Question 1		Yes.	Comment noted.
2	Gaeuman	Fluvial Geomorphology	SOW Question 2		Yes. However, bedforms played a very minor role in this study. It's not clear how they were incorporated into the quantification of sturgeon habitat availability.	Comment noted.
3	Gaeuman	Fluvial Geomorphology	SOW Question 3		Yes, but I do not claim to be an expert in that subject.	Comment noted.
4	Gaeuman	Fluvial Geomorphology	SOW Question 4		No. A better evaluation of gaging errors is needed, as described in my comments above. I would also suggest that the idea of detectability be better defined. It seems that for a small water augmentation to be detected, one would have to know what the discharge would have been without the augmentation. How would the work? And what is the time scale over which the detection should occur? Detecting a small change on a particular day is a different matter than detecting a sustained small change over a month or a year.	If the Program elects to issue a final revised report, will add clarifying text similar to that in USFWS 2002 when discuss Table 5. Something like: "In other words, a change in daily flow of at least several hundred cfs would be needed under median flow conditions in any month for the Program-related change to be detectable (i.e., exceed gage uncertainty inherent in flow measurement). Program-related flow changes would need to be greater than about 450 cfs under median flow conditions from Jul through Sep to be detectable. Program-relted flow changes would need to be greater than about 150 cfs under low flow conditions (i.e., 90% exceedance) from Jul through Sep to be detectable. Based on an approximate travel time of 4 days from Grand Island to Louisville, Program-related flow changes will be assessed on an average daily flow basis. This will also average out the diurnal fluctuations at the Louisville Gage associated with releases from the Columbus Powerhouse, and facilitate isolation of effects of Program-related flows."
5	Gaeuman	Fluvial Geomorphology	SOW Question 5		N/A	Comment noted.
6	Gaeuman	Fluvial Geomorphology	SOW Question 6		yes	Comment noted.
7	Gaeuman	Fluvial Geomorphology	General		The scope of this study outlined in the RFP targets two related, but distinct, objectives: determining what measurable effect, if any, Program water delivered at upstream locations will have on discharge in the Platte River downstream from its confluence with the Elkhorn River, and quantifying how changes in discharge might translate to changes in hydraulic parameters and physical habitat characteristics in that stream segment.	Comment noted.
8	Gaeuman	Fluvial Geomorphology	General		The authors of the study approach these two objectives quite differently. With respect to how discharge affects habitat, the authors present an analysis based on numerical modeling of flow under existing geomorphic conditions. Although this modeling analysis neglects the potential for future flows to modify the current stream configuration and produce longer-term changes in habitat availability, it does address the question posed in the RFP. The question, the approach used to address it, and therefore the review of the analysis, is straight-forward. My review of that portion of the report is presented first.	Comment noted.
9	Gaeuman	Fluvial Geomorphology	General		For the question regarding the effect upstream Program water on downstream discharge, however, the authors opted to rely heavily on some earlier Fish and Wildlife Service analyses, which were incorporated in the report as Appendix A and Appendix B. In doing so, they implicitly endorse those reports and accept some level of responsibility for any problems with the methods and explanations presented in them. I found those reports quite difficult to interpret, so I'll save my comments on that portion of the Stage Change Study for last.	Comment noted.
10	Gaeuman	Fluvial Geomorphology	General		I note here that I have not attempted to systematically copy edit this report because, according to the title, this is a Final version. I take that to mean that typographic errors, unclear statements, and so on will not be corrected as might happen if this were a Draft version. Instead, my comments focus on the broader-scale "Specific Questions" identified in Review scope of Work and the "Specific Comments," "Rating," and "Recommendation" identified in the PRRIP Peer Review Guidelines. The questions from the Scope of Work and the Peer Review Guidelines are addressed explicitly following my free-form comments on the Hydraulics and Geomorphology section and the Hydrology section.	Comment noted.
11	Gaeuman	Fluvial Geomorphology	Hydraulics and Geomorphology	General	The approaches used to address the question posed in the RFP are appropriate. The general approach of modeling hydraulic parameters and using model output to classify habitat types is good. It could perhaps be improved by incorporating bedform types into the classification system, in addition to depth and velocity. Bedforms can have a large effect on flow velocities and turbulent structures near the bed, and so are likely very important components of physical habitat. The section on describing and predicting bedforms is good, but it's not clear whether or how that information was used to inform the final conclusions of the study.	Comment noted.
12	Gaeuman	Fluvial Geomorphology	General		The contractor appears to have an adequate understanding of the modeling tasks to produce credible results. However, the modeling analysis seems to include some mistakes and misinterpretations that might have the potential to affect the Study's conclusions and recommendations. Two problems with the model itself are worth highlighting: the 2d model domain lacks lead in and lead out sections and is generally too short (see comment 19), and the quantity of topographic data appears to be very small compared to the resolution of the model mesh (see comment 20). Both of these issues substantially degrade the accuracy of the model and the confidence that can be placed in its output. Two additional issues regarding the interpretation of the model results are worth mentioning: The sensitivity analysis regarding how model errors affect habitat classification may be flawed (see comment 31), and percentages in each habitat type are based on submerged area rather than total area (see comment 38). That said, I doubt that correcting these problems would materially change the Study's conclusions concerning how incremental changes in discharge alter habitat availability.	See responses to Comments 19, 20, 32, and 38.
13	Gaeuman	Fluvial Geomorphology		Page 9	"A hydraulic and geomorphologic analysis…" not sure what part of this is a geomorphologic analysis. It's mostly limited to hydraulic modeling.	The micro-scale bedform analysis portion of this is the geomorphologic portion of the analyses. Habitat classification was based on bedforms such as dunes, ripples, and upper regime bedforms.
14	Gaeuman	Fluvial Geomorphology		Page 9, last paragraph	"…trend over this period." Which period?	The 20 year period from the mid-1970s through 2001 period (i.e., same period as the available cross-section data stated in previous paragraph). Stated in the previous paragraph, and also later in this paragraph.
15	Gaeuman	Fluvial Geomorphology		Page 10, 2nd paragraph	refers to a 10-year model run. What does that mean?	The model run was a steady state run using the 10-year recurrence interval discharge. Sentence will be reworded if the Program elects to issue a revised final report.
16	Gaeuman	Fluvial Geomorphology		Page 10, 3rd paragraph	Not sure what's meant by the different model versions incorporating cross sections from different dates. The preceding sentence is about water surface elevations at the cross sections. Were different cross sections (geometry) used in the two model versions, or just different water surface elevations for validation?	Both. Surveyed geometry and WSE were used in the updated model to make it more applicable for recent topography and at lower flows relevant to flows considered for this study. 2nd sentence of this paragraph explains that surveyed cross sections replaced USACE-OD model sections.
17	Gaeuman	Fluvial Geomorphology	Table 7		Table headings are unclear and awkward. I'm not sure what an average maximum or average minimum is. Are these the extreme instantaneous values for a given day averaged over X number of days? Is "average mean" the average of X number of daily mean values, or the average of something else? The text on page 10 that references Table 7 doesn't help with this.	Editorial comment. Will be edited if Program elects to issue a revised final report.
18	Gaeuman	Fluvial Geomorphology		Page 11	The discussion of the models of different dates is poorly organized and confusing. It would help if the point of all this were explained at the outset. Much later in the text, in the section about bedforms I believe, it becomes apparent that the point is to account for differences in roughness due to differences in bedform regime at different flow levels.	Editorial comment. Will be edited if Program elects to issue a revised final report.

Comment #	Reviewer	Expertise	Section	Page	Comment	Response
19	Gaeuman	Fluvial Geomorphology		Page 12, 4th paragraph	Figures 19-20: The model mesh is 1,700 ft long. From the figures, it's seen that this corresponds to about 1 channel width. This is far too short of a model reach. First, it is a very small sample in term of area from which to generalize about the river segment. But more importantly, every point within the model is a short distance from the model boundaries. It is standard practice to extend the model mesh at least a few channel widths upstream and downstream of the reach of interest. That allows some space and time for any errors or imperfections in the boundary conditions to dissipate.	This is a relatively short reach. However, it has the characteristcs of the remainder of the reach of concern, including the variability seen up and downstream. The issue of "lead-in" and "tail-out" is only valid to the extent that the boundary conditions contain error. In our case, the downstream stage is assumed to be known from the 1D model. The upstream flow alignment and distribution may contain some error; however, considerable effort was made to insure that the flow distribution across the upstream boundary reasonable for all flows, and the boundary was established so that the flow direction was a perpendicular as possible to the boundary. Extending the model up- and downstream would require significantly more topographic data than we were able to collect within the time and budgetary constraints of the project. It is our opinion that any error introduced at the upstream boundary is relatively minor and does not propogate significantly into the remainder of the model domain.
20	Gaeuman	Fluvial Geomorphology		Page 12, last paragraph	refers to "detailed topographic and bathymetric data" used in the model. There is no indication in this report that detailed topographic data was collected. The onlydiscussion along those lines concerns collection of a relatively small number of cross sections. The 2d mesh is said to have a mesh resolution of 10 feet. This density is irrelevant unless the topo data mapped to the mesh is of similar resolution, as might be obtained with an intensive sonar survey using an array of transducers or a multi-beam. There is no indication that this was the case. The value of the fine mesh is, to a large extent, nullified if the topography was interpolated from cross sections.	6,638 topographic points were collected within the 49 acre 2D model domain This equates to one point every ~320 ft^2 or an average spacing of ~18'
21	Gaeuman	Fluvial Geomorphology		Page 12, last paragraph	It's not explained where the n values of 0.023 and 0.027 in the 2d model came from. Were these transferred from the 1d calibration in some way?	They were final calibrated n-values for the 2D model.
22	Gaeuman	Fluvial Geomorphology		Page 13, 4th paragraph	Figures 24-26: It is stated that the match between measured and modeled water surface elevation and water velocities is "good." This seems to be an overstatement. Plus or minus 0.5 ft in elevation does not seem especially good to me, and velocity errors seem to range up to around 50% (Figure 26).	+/-0.5' is pretty good for a river of this size. In fact, there's probably that much local variability in the WSEL when there are bedforms, etc.
23	Gaeuman	Fluvial Geomorphology		Pages 14-15	Nice overview on bedforms.	Comment noted.
24	Gaeuman	Fluvial Geomorphology		Page 16, 2nd paragraph	S'* is introduced, but not defined until it come up again on page 17. Same for SG in the equation given for d*.	If Program elects to issue a revised final report, the following clarification will be added. Definitions for S'* and SG under Eqn (2) on p. 17 will be added in 2nd paragraph on p. 16.
25	Gaeuman	Fluvial Geomorphology		Page 16, last paragraph	I think this should be the relation between the average shear stresses (as indicated in equation 1), rather than velocity.	Comment is correct. If Program elects to issue a revised final report, the sentence will be modified to indicate the relation is between shear stress (not velocity).
26	Gaeuman	Fluvial Geomorphology		Page 17	Some of the notation seems odd. ' is used in the definition of S'*, but is not defined (equation 1 introduces '0 and , but not '). Should it be just ? The shields parameter is denoted F* -- why not use * or like most everyone else? (SG-1) is often denoted by R, and SG itself is usually /s. I've usually seen transport stage denoted with T rather than S.	Notation in this report was essentially the same that Bennett (1995) used. Two differences should be noted: (1) SG was used for specific gravity rather than s, and (2) D50 was used rather than d50 for consistency with other related Program documents. Bennett used the same notation for the equation in the 3rd line after Eqtn (2), but it should clearly be tau0' in the context used here. If Program elects to issue a revised final report, tau0' will replace tau'.
27	Gaeuman	Fluvial Geomorphology		Page 17, 4th paragraph	the VBA script is said to solve for the "necessary values…" It's difficult to be sure what is being done here. I infer that is specified on the basis of model output, and equation 1 is solved for '0, but that's not clear from the text.	Some detail left out in the interest of readability, and will not be added to the report. However, the following clarification is provided here as a response. Total shear stress is based on 2D model predicted values. The VB program was then use to iteratively solve Equations (1) and (2) with an assumed starting value for shear stress due to grain resistance (T'o). First Equation 1 is solved for beform height using the assumed starting value for shear stress due to grain resistance. That calculated bedform height value is then used in Equation (2) to solve for sediment transport strength and subsequently shear stress due to grain resistance. This new value for shear stress due to grain resistance then replaces the originally assumed value in Equation (1), and Equations (1) and (2) are iteratively solved in this process until shear stress due to grain resistance used in Equation (1) matches the calculated shear stress due to grain resistance from Equation (2).
28	Gaeuman	Fluvial Geomorphology		Page 17, last paragraph	Discussion switches abruptly from bedform types to how much of the site is subaerially exposed. What's the connection?	Subaerially exposed (i.e., dry) areas are important because they are definitively not habitat for pallid sturgeon regarless of bedform type, and this is the difference between Figures 32 and 33. This discussion continues into 1st paragraph on p. 18 discussing the mix of bedforms for the remainder of the domain that is submerged.
29	Gaeuman	Fluvial Geomorphology		Pages 18-19	habitat evaluation: This seems like a good approach. Why are there no pools in this classification? Are especially deep scours and holes not relevant for sturgeon, or perhaps these environments are not present in the Platte?	Pools were included in the classification scheme (see Table 10). However, pools were not observed in the field survey, so are considered to be mostly absent from this section of the Platte. A very small area of isolated pools was however predicted in the final habitat classfication shown in Fig 37.
30	Gaeuman	Fluvial Geomorphology		Page 20	top: re-states that the model is well calibrated. See comment 22.	See response to Comment 22
31	Gaeuman	Fluvial Geomorphology		Page 20	numbered item 1: velocity units are given as ft.	Editorial comment. Will be edited if Program elects to issue a revised final report.
32	Gaeuman	Fluvial Geomorphology		Page 20	numbered item 2: Was the simulated error applied to each node independently? Or to put it another way, would adjacent nodes be assigned uncorrelated errors? That would clearly be incorrect – for example, if a given node had a large positive error in depth, all nearby nodes (and maybe every node in the model) would probably also have positive errors. Assigning each node an error that is independent of all the other errors would cause the random errors to cancel, and probably result in very little net change in the proportion of particular habitat types.	They were assigned independently. The criticism isn't necessarily valid. Acknowledging Comment 22 above, the model is well calibrated, so the error in the actual WSE should be relatively small. For purposes of this sensitivity analysis, we considered the calibrated model to be the baseline and evaluated the potential effect of uncertainty associated with local variability in topography and hydraulic conditions. The uncertainty in depths and velocities in this context stems primarily from variability in the local bed topography, and these would mostly be caused by micro-scale bedforms. As a result, the errors would not be correlated among nearby nodes in the model.
33	Gaeuman	Fluvial Geomorphology		Page 21	The text says that Table 11 shows variation among transects and among sample episodes, but it doesn't show that. Is a "sample episode" a day?	Table 11 shows variability among episodes, which are the 3 different dates in the table. Variation amoung transects is shown in Figs 39-41.

Comment #	Reviewer	Expertise	Section	Page	Comment	Response
34	Gaeuman	Fluvial Geomorphology	Table 12	Page 22	The table suggests that conductivity and turbidity behave in the same way with respect to different "phases" (what's the independent variable here, discharge maybe?). Meanwhile, Figure 42 shows that they behave in opposite ways. What point is being made with these statistics anyway?	Independent variable is the date, which essentially makes discharge the independent variable. Table 11 addresses whether WQ data are statistically different between the sampling events, or "Phases". It does not address direct or indirect relationships with discharge. Fig 42 addresses direct/indirect relationships with discharge. The point of Table 11 is that WQ for high flow event (July 2008), mid level flow (May 2009), and low flow (Sep 2008) are significantly different (i.e., are parameters influenced by flow). The point of Fig 42 is how WQ parameters change with flow (i.e., direct or indirect relationship).
35	Gaeuman	Fluvial Geomorphology		Page 22, 3rd paragraph	What is meant by "bottom velocity?" This must refer to some height above the bed.	Yes, peer-reviewed pallid sturgeon literature refers to bottom velocities as the velocity at a height of 0.5 m above the channel bottom. This is a relevant depth for pallid sturgeon spawning.
36	Gaeuman	Fluvial Geomorphology		Page 22, 3rd paragraph	The explanation for why run and plunge habitat is considered most suitable is not very convincing. Where are the sturgeon actually found? Do the cited publications refer to run and plunge habitats?	Discussion of habitat in report and development of habitat "categories" is based on peer-reviewed pallid sturgeon literature and best available information on pallid habitat use and occurrence.
37	Gaeuman	Fluvial Geomorphology		Page 23, 1st paragraph	The gaging error magnitudes defined in the hydrology sections are applied here. I suspect that the interpretation of gage errors may have a problem – see comment 46.	See response to Comments 46 and 4.
38	Gaeuman	Fluvial Geomorphology		Page 23-24	The actual changes in the availability of various habitat types may change more with discharge than is indicated. It appears that the percentages given for habitat types are the percents of the total submerged area. It would be more meaningful to report this in terms of actual area or as a percentage of the model domain area because the extent of the submerged area changes with discharge.	Percent changes are presented relative to submerged area as commenter suggests. This is more meaningful than % of total area, because dry areas are definitively not considered pallid sturgeon habitat.
39	Gaeuman	Fluvial Geomorphology	Hydraulics and Geomorphology	General	The hydrology studies presented in the two USFWS reports and incorporated into the Stage Change Study leave much to be desired in terms of both technical credibility and the clarity of the presentation. Some of the problems with the original reports are noted in the specific comments below. The authors of the Stage Change Study apparently reproduced the analyses described in the USFWS reports. That would require sorting out the details regarding what those analyses involved. Having done that, I would expect the authors of the Stage Change Study to provide a better description of what they did than simply referencing and copying text from the Appendices.	Beyond the scope of the study.
40	Gaeuman	Fluvial Geomorphology	Hydraulics and Geomorphology	General	The flow losses due to evaporation, transpiration, and seepage estimated in these reports are, in my opinion, unreliable. The reported total loss figures become more credible if they are considered to be generic losses, not attributable to any particular sink. Nonetheless, I agree with general conclusion that small discharge augmentations upstream of Grand Island of the magnitude discussed will not be very noticeable at Louisville. This is not so much related to gaging uncertainty (which I think is overestimated in the reports), but is instead due to the fact that the augmentation volumes discussed are small compared to everything else that is going on. Changes in flow on the order of 100 cfs would be difficult to distinguish even if the gages were perfectly accurate, because the changes can be swamped by much larger flow fluctuations caused by a variety of other factors.	Beyond the scope of the study.
41	Gaeuman	Fluvial Geomorphology		Page 2, end of 2nd paragraph	States that the selected flows are considered appropriate for modeling, but doesn't explain why. Does anything about pallid sturgeon habitat enter into this determination?	The range of flows considered in the hydraulic analysis (3,700 cfs to 40,000 cfs) covers the range of the median historic flows shown in the Louisville hydrograph (Figure 2). Additionally, the median discharge from April to June (months during pallid sturgeon migration and spawning) is approximately 7,000 cfs (as described in the Interpretation and Analysis section), which is well within the range modeled for this analysis.
42	Gaeuman	Fluvial Geomorphology	Table 2 and associated text		Meaning of the headings indicating time periods are unclear. These look like periods of record for the gages, but are not. Time periods listed for the Loup near Columbus include times when there are no gage records. It takes careful picking through the text to figure out how to interpret these dates. I'm unsure of what is meant by "period of analysis." This could refer to the period from which flow records were drawn to quantify the hydrologic characteristics of the gage site, which could then be extrapolated to other years, or it could mean that consideration of the gage site was entirely confined to that time period.	As indicated in the title of Table 2, the locations and periods of record are pertaining to the Historic Loss Analysis completed for this study. If a revised final report is issued, the text immediately preceding Table 2 will be clarified to indicate that the data in the table pertains to the historic loss analysis.
43	Gaeuman	Fluvial Geomorphology		Page 3, 3rd paragraph	This paragraph is very hard to follow. It does not clearly identify what is being estimated – language like "the USFWS analysis" and "these flows" do not identify the gages and dates for which flows were being reconstructed.	Editorial comment. Will be edited if Program elects to issue a revised final report.
44	Gaeuman	Fluvial Geomorphology		Page 3, last paragraph	A new gage can apparently supply better information about powerhouse return flows, but was not used. This information could have at least been used to check on the accuracy of the method in the USFWS analysis.	Beyond the scope of the study.
45	Gaeuman	Fluvial Geomorphology		Pages 4-5	The Study basically just sends the reader to Appendices A and B. There appears to have been little or no critical review of the USFWS reports by the Study authors.	Beyond the scope of the study.
46	Gaeuman	Fluvial Geomorphology		Page 5, last paragraph	This interpretation of gage accuracy seems overly simplistic. It is stated that the USGS considers 95% of the gage readings to be within 10% of the actual discharge. This report follows the USFWS reports in translating that into error bounds of plus or minus 10%. Assuming the errors are independent random variables, the actual error bound should be related to the number of samples used to generate an estimate. For example, the USGS error estimate could be interpreted as suggesting that the individual errors have a standard deviation of around 5% (because close to 95% of a normally-distributed population is within 2 standard deviations of the mean). Whether the standard deviation is 5% or something else, the standard error of the estimate is equal to the standard deviation divided by the square root of the sample size. If the estimate is monthly mean flow, the sample size is about 30. These numbers suggest that the error bound for the monthly mean might be around 2% at the 95% confidence level. I am not a statistician, and the details of this example may not be exactly correct. For example, the errors on sequential days are probably correlated to some degree. The point is simply that the 10% error bounds assumed in the reports need to be re-examined.	Beyond the scope of the study.
47	Gaeuman	Fluvial Geomorphology		Page 7	In repeating the USFWS reports, the Study incorporates an abundance of errors, confusing explanations, and obscure objectives. Page 7 discusses what happens to an incremental increase in flow at Grand Island by the time it reaches Louisville. The discharge increments considered seem arbitrary. It would be most helpful if the Study would explain why these particular increments are relevant, and more generally, what "Program water" or "First Increment water" is. After consulting the Biological Opinion, the Adaptive Management Plan, the Record of Decision, the Platte River Recovery Implementation Program Final Environmental Impact Statement, and the Platte River Recovery Implementation Program, I've determined that First Increment water refers to 130,000 to 150,000 acre-feet of water annually, perhaps in the form of baseflow discharge targets or (undefined?) pulse flows. Spread evenly across the full year, that volume of water is equivalent to about 200 cfs, which is in the range of increases being evaluated. I speculate that the documents I've consulted are ambiguous about Program water because it has not yet been fully determined how that water is to be used. If so, the hydrologic analyses in the Study seem to be putting the cart before the horse. They seem to ask: if the upstream flow is bumped by X, could it be detected downstream, and would it materially improve habitat? Would it not make more sense to go about it other way around? That is, to ask: How much of an increase in flow is needed in the lower river to materially improve habitat there, and how much discharge needs to be added to upstream flows to hit that downstream target? Perhaps this is how the question is being approach, but it's hard to tell from what's written.	Beyond the scope of the study.
48	Gaeuman	Fluvial Geomorphology		Page 7, 5th paragraph	The paragraph begins and ends describing evaporation trends, but refers to total volume lost in the middle. It's unclear whether this means total volume lost through evaporation, or total volume lost including seepage losses. It's also unclear whether evaporation here includes transpiration. More generally, the analysis contained here and in the USFWS reports is often muddled in this regard. Terms like evaporation and ET do not seem to be used in a consistent manner throughout. However, the distinction may be an unnecessary complication, given the methods used to estimate these losses. See comments on that later.	Beyond the scope of the study.
49	Gaeuman	Fluvial Geomorphology		Page 8	The section on hydrograph translation is difficult to interpret. It could be greatly improved by telling the reader more specifically what the EA flow was. Four paragraphs into the section it is noted that "the peak of the EA flow at Duncan is estimated to be approximately 2000 cfs above base flows." From this, a reader might infer that something like 2000 cfs was released from somewhere upstream or otherwise generated somehow. Is there some reason that what was done and where it was done can't be clearly stated?	Editorial comment. Will be edited if Program elects to issue a revised final report.
50	Gaeuman	Fluvial Geomorphology	Appendix A	Page 1	The report discusses evaporation and seepage losses. Are there no diversions or pumps to consider?	Peer review of this appendix beyond the scope of the review.

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51	Gaeuman	Fluvial Geomorphology	Appendix A	Page 2	The Figure 1 referenced here is missing. The same or a similar figure 1 is missing from Appendix B as well. The missing figures seem to be maps showing where all these gages, reaches, and tributaries are.	Peer review of this appendix beyond the scope of the review.
52	Gaeuman	Fluvial Geomorphology	Appendix A	Page 5	Estimated lag times are very crude. All are integer days, and variations in lag time with discharge are not considered. This component of the analysis deserves more attention than it was given.	Peer review of this appendix beyond the scope of the review.
53	Gaeuman	Fluvial Geomorphology	Appendix A	Page 5	Figure 2 referenced here is missing.	Peer review of this appendix beyond the scope of the review.
54	Gaeuman	Fluvial Geomorphology	Appendix A	Page 6-7	It would make sense to look at channel width during the time of year when evaporation losses are greatest. Seasonal trends in channel widths were considered indirectly through the application of "liberal" and "conservative" widths. Seasonal differences in width could be addressed more directly.	Peer review of this appendix beyond the scope of the review.
55	Gaeuman	Fluvial Geomorphology	Appendix A	Page 8	The use of pan evaporation rates to estimate river evaporation rates is a big leap. I suspect that the temperature of the pan is quite different than the temperature of the river. The pan coefficient might be intended to account for that, but no explanation or justification for the factor of 0.7 is given. The adjustment factors used for ET losses also lack explanation. These things need to be explained.	Peer review of this appendix beyond the scope of the review.
56	Gaeuman	Fluvial Geomorphology	Appendix A	Page 9-10	Seepage losses are calculated as the difference between the net inputs to a reach (inflows minus E/ET losses) and the outflow from the reach. This raises the question of why the analysis even bothers to estimate E/ET, because its magnitude is irrelevant to the result. If the estimate of E/ET was arbitrarily increased by 20 cfs, for example, the corresponding estimate of seepage loss would come out 20 cfs lower. The total loss, however, would remain the same regardless of what value was used for E/ET. It would be simpler and equally useful to simply define "losses" as the difference between inflows and outflows without regard to whether they are E/ET or seepage.	Peer review of this appendix beyond the scope of the review.
57	Gaeuman	Fluvial Geomorphology	Appendix A	Page 10	States that "Percent ungaged gains were not calculated, as this quantity is not relevant to this analysis." I'm not sure how to interpret this statement, but I do not agree that gains are irrelevant. It's also unclear whether "gain" refers to ungaged tributary input only, or to all gains (such as groundwater inflows and return flows from diversions).	Peer review of this appendix beyond the scope of the review.
58	Gaeuman	Fluvial Geomorphology	Appendix A	Page 11	Seepage loss estimates are called "conservative." It would be clearer to say the reported losses underestimate the actual losses. It would also be good to say something about the magnitude of underestimation.	Peer review of this appendix beyond the scope of the review.
59	Gaeuman	Fluvial Geomorphology	Appendix A	Bottom of Page 12	"Total estimated daily evaporation + ET losses" are given in units of cfs, that is, rate units instead of volume. And again on page 14. The figures referenced in this text give the losses in percent of flow.	Peer review of this appendix beyond the scope of the review.
60	Gaeuman	Fluvial Geomorphology	Appendix A	Page 18, 1st paragraph	This paragraph is unnecessarily confusing. The example discusses a reach, a subreach, a stream gage, and added Program water with no explanation of the geographic relationship between these elements. That difficulty would be partly relieved if Figure 1 wasn't missing from the report. It is stated that flow is 1000 cfs at Duncan on a particular day. It then refers to the "historic Platte River inflow," which, from the arithmetic that follows, appears to refer to the 1000 cfs at Duncan. Then, 200 cfs of Program water is introduced, although it's not clear how or where. Again, from the arithmetic, it seems that the Program water is also an inflow at the top of the reach, so that the flow at Duncan is actually 1200 cfs, not 1000 cfs. The presentation of the arithmetic is also overly complicated. It could be presented as three simple operations: determine the volume of inflows (including distance weighted gains), calculate the proportion of the inflows that are lost to E/ET (equal to losses/inflows), and multiply the Program water volume by that proportion.	Peer review of this appendix beyond the scope of the review.
61	Gaeuman	Fluvial Geomorphology	Appendix A,	Page 19, 5th paragraph	The sensitivity analysis for open water width needs more explanation. It seems to me that, according to how the total losses are calculated, changing the open water width would have zero effect on total losses because E/ET is subtracted from inflows before computing seepage losses. Could it be that the authors of this report applied 2 different estimates of E/ET to the same analysis? That is, did they subtract the original estimate of E/ET from inflows, then calculate seepage losses, then use those seepage losses with new, larger estimates of E/ET to arrive at new total losses? That would clearly be incorrect.	Peer review of this appendix beyond the scope of the review.
62	Gaeuman	Fluvial Geomorphology	Appendix A	Figures 9 and 10	Why do these graphs present different results than the similar graphs in Appendix C of the other USFWS report included as Appendix B (Page 17 in Appendix B)? Graph titles and axes labels are the same in both appendices, but the plotting positions differ.	Peer review of this appendix beyond the scope of the review.
63	Gaeuman	Fluvial Geomorphology	Appendix A	Page 23, 1st paragraph	States that there are no major diversions below Grand Island. What about numerous small diversions? Has that been evaluated?	Peer review of this appendix beyond the scope of the review.
64	Gaeuman	Fluvial Geomorphology	Appendix B	Page 5, 6th paragraph	Mentions a Tri-County supply canal system. I didn't see that mentioned anywhere else. I wonder where that is, and if it is, or should be, considered in the analysis presented in Appendix A.	Peer review of this appendix beyond the scope of the review.
65	Gaeuman	Fluvial Geomorphology	Appendix B, Table 2		Uncertainty is assumed to be 10% of the measured flow. See comment 46.	Peer review of this appendix beyond the scope of the review.
66	Gaeuman	Fluvial Geomorphology	Appendix B, Table 3		I'm wondering why the effect of First Increment Program activities is to cause negative changes in flow in some months. Here would be a good place to provide some explanation as to what First Increment Program activities include.	Peer review of this appendix beyond the scope of the review.
67	Gaeuman	Fluvial Geomorphology	Appendix B	Page 16	These travel times could be used to improve the Appendix A analysis.	Peer review of this appendix beyond the scope of the review.
68	Gaeuman	Fluvial Geomorphology	Appendix D	Page 18 of Appendix B and text on pages 9-10	Would be appropriate to define what the "OPSTUDY Model" is.	Peer review of this appendix beyond the scope of the review.
69	Guy	Fisheries Ecology and Aquatic resource Management	SOW Question 1		The Stage Change Study does address the overall objective of the RFP for a specific area in the Platte River. I believe that the study could have been more robust by extending the spatial extent of the study. The objective clearly states '…from the Elkhorn River confluence to the Missouri River confluence,' but the study was conducted on a reach from the Nebraska highway 50 bridge to the Chicago Rock Island and Pacific Railroad pedestrian bridge. I would agree that this reach is likely representative of much of the lower Platte River and is an area where pallid sturgeon have been located (Peters and Parham 2004); however, the Platte River at the confluence with the Missouri River is likely quite different and should have been included. The confluence is central to these analyses because much of the use of the Platte River by pallid sturgeon occurs near the confluence (Peters and Parham 2004). Had the investigators conducted measurements in at least two reaches (i.e., the current reach and one at the confluence), preferably more than two reaches (i.e., also include a reach near the Elkhorn River confluence), the precision, understanding of uncertainty, and inference space would have been greater with respect to Program water management activities. Further, the confluence reach is unique given that discharge in the Missouri River can influence the habitat dynamics in the Platte River which in turn will affect the results of Program water management activities, most likely different than the reach near Louisville, Nebraska. This criticism is especially relevant to the 2D modeling exercise which provides the most useful information for pallid sturgeon conservation. Understanding the effects of Program water management activities for additional reaches in the Platte River is instrumental if the Governance Committee is going to use this information to determine the effects of discharge on physical parameters thought to be important to pallid sturgeon. The effects of stage changes on physical parameters appears to be well studied for the reach near Louisville, Nebraska and should provide information needed to evaluate Program water management activities in that area. With that said, it would be beneficial if the investigators made it more clear regarding the discharges under which empirical data were collected, it is difficult to determine as currently written.	It is beyond the scope of this study to model several sections of the lower Platte River, and as a result the reach modeled was chosen because of its general representativeness of the lower Platte River. The study area is representative of the lower Platte River, including channel width and energy grade. The only exception would be areas influenced by unique hydraulic situations such as backwater effects like at the confluence with the Missouri. However, effects of Program flow changes on habitat classification would be even less detectable at areas with deeper flows like at the confluence with the Missouri. Considering that flow changes would not result in discernible changes to habitat area in the modeled reach, the same would likely be true at the confluence with the Missouri. Dates of empirical data collection are stated in 3rd paragraph on p. 1, and associated discharges for those dates are given in Table 7.
70	Guy	Fisheries Ecology and Aquatic resource Management	SOW Question 2		The selected physical parameters seem reasonable given the current state of knowledge regarding pallid sturgeon ecology. However, it is unclear what aspects of the pallid sturgeon life-history are targeted by Program water management activities. Providing habitat for adults is likely quite different than providing habitat for larvae. I realize this was not part of the scope of research for the investigators, but should be considered by the Governance Committee. This will help refine the effects of Program water management activities and how they relate to specific aspects in the conceptual models. Defining the life-history aspects of interest will also make the physical parameters more scientifically defensible. It is becoming clearer that habitat diversity and complexity are important to riverine fishes. Thus, combining metrics into a richness or diversity value and evaluating those data as a composite with varying Program water management activities might be more ecologically relevant than studying each parameter separately.	Primarily a hydrology study, not a study of pallid sturgeon life history or habitat use/occurrence.
71	Guy	Fisheries Ecology and Aquatic resource Management	SOW Question 3		The selected habitat classifications seem reasonable given the current state of knowledge regarding pallid sturgeon ecology. It may be implicit in some of the habitat classifications, but a more detailed analysis of the thalweg dynamics would have been informative (e.g., thalweg depth and migration under varying discharges). I believe understanding the dynamics of the thalweg given varying Program water management activities would be highly beneficial given that several studies indicate that pallid sturgeon are typically found in or near the thalweg. I recognize that the investigators are aware of the importance of this habitat type because they allude to it when they discuss run and plunge habitat. Again, it is important that the life-history aspect of interest is well defined because habitat use likely changes with ontogeny. As stated above, combining habitat classifications into metrics that describe the richness or diversity of habitat may be more ecologically meaningful.	Primarily a hydrology study, not a study of pallid sturgeon life history or habitat use/occurrence.
72	Guy	Fisheries Ecology and Aquatic resource Management	SOW Question 4		Yes, given the error associated with the Louisville gage and the results from the 100, 500, and 1,000 cfs additional Program water at Grand Island reaching Louisville as summarized in Figures 3, 4, and 4a. However, the amount detected varies temporally.	Comment noted.

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73	Guy	Fisheries Ecology and Aquatic resource Management	SOW Question 5		Yes, relative to stage and velocity, but not temperature, turbidity, substrate, or channel morphology because those are not measured by the gauging equipment. It is clear in the results that there is temporal variation in water quality metrics and that the variation can be detected given the sample sizes, but it is not clear how the variation in water quality metrics relate to Program water activities.	Primarily a hydrology study, so most important to consider stage and velocity. The purpose of the study was not to make a statement about the importance of water quality parameters such as turbidity and temperature for pallid sturgeon or to quantify the effects of Program actions on those parameters.
74	Guy	Fisheries Ecology and Aquatic resource Management	SOW Question 6		In general, I believe the conclusions are supported by the data, although the conclusions are not clearly articulated. I am concerned that most of the analyses and measures of variation represent pseudo-replication. This relates to my comments in the first question. I believe the best way to determine the effects of Program water activities on physical parameters that are thought to be of significance to pallid sturgeon would be to conduct the Stage Change Study in multiple reaches (i.e., the reaches are the experimental unit). Although one could argue that reaches are not independent, I surmise that it better represents available habitat for pallid sturgeon and the influence of Program water activities on that habitat. The most important aspect of having multiple reaches is that one will have a better understanding of the uncertainty of Program related water activities on pallid sturgeon habitat.	It is beyond the scope of this study to model several sections of the lower Platte River, and as a result the reach modeled was chosen because of its representativeness of the lower Platte River. The only exception would be areas influenced by unique hydraulic situations such as backwater effects like at the confluence with the Missouri. However, effects of Program flow changes on habitat classification would be even less detectable at areas with deeper flows like at the confluence with the Missouri. Considering that flow changes would not result in discernible changes to habitat area in the modeled reach, the same would likely be true at the confluence with the Missouri.
75	Guy	Fisheries Ecology and Aquatic resource Management		Page 1, 2nd paragraph	"*bed topography at low to intermediate flows*" Why not bed topography at high flow?	Bed topography was collected at low to intermediate flows to facilitate bed surveys (i.e., difficult to access and survey at high flows). This study focuses on hydraulics of the existing bed, and does not involve sediment transport and mobile bed dynamics, which have a much less significant influence on habitat classification that is primarily driven by hydraulics.
76	Guy	Fisheries Ecology and Aquatic resource Management		Page 1, 3rd paragraph	"*Within the Study Reach, depth, velocity, turbidity, water temperature, dissolved oxygen, and conductivity measurements, as well as bed topography, were obtained …*" Why not sediment transport or large woody debris?	Beyond the scope of the study.
77	Guy	Fisheries Ecology and Aquatic resource Management		Page 5, 4th paragraph	"*Water Quality Measures*" These are commonly measured, but why? What are your hypotheses related to these or how do they relate to a conceptual model	Parameters of importance to the Program.
78	Guy	Fisheries Ecology and Aquatic resource Management		Page 5, 4th paragraph	"Data collected from each phase of sampling were then used to conduct a power analysis to determine whether sample sizes were adequate…" This is true at one site, but wouldn't it be better to measure these at multiple reaches and treat those as the experimental unit?	Since the objective of the study was to determine whether Program changes to discharge could affect pallid sturgeon habitat, discharge was assumed to be the independent variable driving water quality. Changes in water quality between locations would not necessarily be related to Program changes to discharge (assuming all sites are downstream of the Program action).
79	Guy	Fisheries Ecology and Aquatic resource Management		Page 7, 3rd paragraph	"*The results, assuming 100, 500, and 1,000 cfs of additional Program water at Grand Island, are summarized in Figures 3, 4, and 4a, respectively*" Very informative.	Comment noted.
80	Guy	Fisheries Ecology and Aquatic resource Management		Page 7, 6th paragraph	"*Comparison with USFWS Analysis*" Was this part of the original RFP?	USFWS analysis was always considered as important for evaluation for the stage change study.
81	Guy	Fisheries Ecology and Aquatic resource Management		Page 11, 3rd paragraph	"These comparisons indicate that the low-flow channel or channels tended to deepen during the high spring flow events and tended to become shallower in response to periods of low flow..." I find this very informative given pallid sturgeon tend to use the main channel, i.e., thalweg. We have found that pallid sturgeon avoid shallow, small tributaries.	Comment noted.
82	Guy	Fisheries Ecology and Aquatic resource Management	Figure 23	Page 13	Why so few samples at high discharge? Also, does the variation in the number of samples collected influence the results?	Few samples at high discharge because of limited access to survey at higher discharge. Additionally, the "higher" discharge sample points were considered supplemental to the "lower" discharge sample points, due to the relatively small difference in WSE at this range of flow (range of 3,700 cfs to 6,000 cfs). Highest flow points shown in Fig 23 (25,000 and 37,000 cfs) were collected from other agencies and events not related to this study. Variation in WSE between samples did not affect model calibration.
83	Guy	Fisheries Ecology and Aquatic resource Management		Page 13, 4th paragraph	"in conjunction with the topographic data on which the hydraulic model is based (Figure 24)." Some statistics on the regression would help reduce this subjective statement. Why is one of the data points missing from this figure? It is the outlier in Figure 25. Am I missing something?	Editorial comment. Will be edited if Program elects to issue a revised final report.
84	Guy	Fisheries Ecology and Aquatic resource Management	Figure 26	Page 13	Seems like a lot of scatter, should you explain the variation?	Editorial comment. Will be edited if Program elects to issue a revised final report.
85	Guy	Fisheries Ecology and Aquatic resource Management		Page 16, 2nd paragraph	This paragraph and the following two paragraphs are difficult to read.	Editorial comment. Will be edited if Program elects to issue a revised final report.
86	Guy	Fisheries Ecology and Aquatic resource Management		Page 16, 2nd paragraph	"(d* = D50{(SG-1)g/v2}1/3)) " I think the parentheses are off a bit.	Editorial comment. Will be edited if Program elects to issue a revised final report.
87	Guy	Fisheries Ecology and Aquatic resource Management		Page 17, 2nd paragraph	"*is the sediment transport strength defined as (τ'/τcr-1)* " -I don't think this is defined?	T' should be T'o. Will be changed if revised final version is issued. Tcr is defined in the following sentence.
88	Guy	Fisheries Ecology and Aquatic resource Management		Page 17, 3rd paragraph	"*Based on six grab samples of the surface bed material*" -Is six good enough? Why six?	6 is adequate considering the relative uniformity of the bed material
89	Guy	Fisheries Ecology and Aquatic resource Management		Page 18, 1st paragraph	"Evaluation of the areas occupied by dunes indicates that the median predicted dune height increases from 0.45 feet (~5.4 inches) at 3,700 cfs to 0.81 feet (~10 inches)…" These data are very interesting. Especially from a fish ecology aspect because we believe fish use these as velocity refuge. Any measures of variation with these data?	Comment noted.
90	Guy	Fisheries Ecology and Aquatic resource Management		Page 18, Figure 34	Excellent figure!	Comment noted.
91	Guy	Fisheries Ecology and Aquatic resource Management		Page 18, 2nd paragraph	"Plunge areas represent a complex habitat that is characterized by not only a rapid change of depth, but also its spatial location relative to bars and banklines within the detailed study reach…" This information and the bullets below are a bit difficult to follow.	Editorial comment. Will be edited if Program elects to issue a revised final report.
92	Guy	Fisheries Ecology and Aquatic resource Management		Page 19, 1st paragraph	"*Slackwater, Riffles, and Runs*." Why caps now?	Editorial comment. Will be edited if Program elects to issue a revised final report.
93	Guy	Fisheries Ecology and Aquatic resource Management		Page 19, Figure 36	Excellent figure.	Comment noted.
94	Guy	Fisheries Ecology and Aquatic resource Management		Page 19, 2nd paragraph	"The procedure used to develop the uncertainty bands in Figures 38a-d are described in the next section..." This is good, but make it clear what uncertainty you are measuring. I don't think this is uncertainty related to Program water activities, which is the central question.	Editorial comment. Will be edited if Program elects to issue a revised final report.
95	Guy	Fisheries Ecology and Aquatic resource Management		Page 20, Figure 44a	Very useful information.	Comment noted.
96	Guy	Fisheries Ecology and Aquatic resource Management	Table 11	Page 21	Measures of variation?	Editorial comment. Will be edited if Program elects to issue a revised final report.
97	Guy	Fisheries Ecology and Aquatic resource Management		Page 22, 3rd paragraph	"*…it can be concluded that changes in habitat areas as a result of 100 or 500 cfs environmental releases would have a negligible influence on pallid sturgeon habitat in the lower Platte River.*" I agree. Nice work.	Comment noted.
98	Guy	Fisheries Ecology and Aquatic resource Management		Page 23, 1st paragraph	"Finally, the increase in discharge does not move the conductivity, turbidity, temperature, or dissolved oxygen outside the typical range preferred by pallid sturgeon (Figures 42 and 43)." Not sure we know what typical is for pallid. Can you reword to avoid 'typical' and 'preferred?'	If Program elects to issue a revised final report, this sentence will be re-worded to avoid "typical" and "preferred". Also waiting for input from mark Pegg as to whethere there is an identified range or ranges for these WQ parameters for pallids.
99	Guy	Fisheries Ecology and Aquatic resource Management		Page 23, 3rd paragraph	"*Based on this stage change study, the % habitat in the lower Platte River experiences a relatively high rate of change for flows ranging between 4,000 cfs to 6,000 cfs.* " Not true for all habitats see Figures 44 and 45.	The flat and the run habitat types experience the highest rate of change for these flows. Run habitat areas meet habitat criteria for pallid sturgeon (deep and swift flow), which is why this is emphasized.

Comment #	Reviewer	Expertise	Section	Page	Comment	Response
100	Guy	Fisheries Ecology and Aquatic resource Management		Page 24, 1st paragraph	"*The Flat classification would have been increased from approximately 30% (± 7%) to 40% (± 8%) of the habitat area…*" Do you mean ±9?	Editorial comment. Will be edited if Program elects to issue a revised final report.
101	Guy	Fisheries Ecology and Aquatic resource Management		Page 24, 1st paragraph	"*The decrease in discharge does not move the conductivity, turbidity, temperature, or dissolved oxygen outside the typical range preferred by pallid sturgeon (Figures 42 and 43)* ." see comment #24	Assume "comment #24" refers to overall comment #98 in this spreadsheet.
102	Guy	Fisheries Ecology and Aquatic resource Management		Page 24, 3rd paragraph	"*Spring is likely the most critical period so that should be protected as best possible.*" What does this mean? I don't think we can say this with much confidence.	Editorial comment. Will be edited if Program elects to issue a revised final report.
103	Guy	Fisheries Ecology and Aquatic resource Management		Page 25, 4th paragraph	"*Therefore, the results from this Study should be used as one part of a larger perspective on available habitat rather than an absolute factor in driving conclusions and decisions related to population dynamics.*" Yes, nice work!	Comment noted.
104	Helsel	Environmental Statistics	SOW Question 1		The Study adequately addresses the relative magnitude of stage change due to management activities in relation to existing flows and habitat of the pallid sturgeon. It does not discuss the proposed changes in light of existing appropriations and any current legal constraints on flow in the Platte River. In other words, if these diversions were implemented would they impact the water rights of existing rights owners? The method for extrapolation of miSSing record to the Loup River at Columbus is flawed, and so the resulting errors on the analysis are unknown.	Beyond the scope of the study.
105	Helsel	Environmental Statistics	SOW Question 2		The data themselves are presumably scientifically defensible. They are fairly routine parameters with established protocols for collection. The amount of data is adequate. Analysis ofthe data is not adequate, if the purpose is to determine whether proposed flow augmentation and withdrawals for storage will significantly affect those parameters.	Analysis is adequate for the scope of this study. Reviewer did not provide specific points for inadequacy of the analysis in this comment.
106	Helsel	Environmental Statistics	SOW Question 3		This is not my area of expertise.	Comment noted.
107	Helsel	Environmental Statistics	SOW Question 4		Yes. Given that equipment and gauging error is listed as 10% (presumably +5% and ·5%0, the Study determined that flow changes such as those on page 24, going from 5,040 cfs to 3,290 cfs, are expected to be much greater than 5% (the direction is known), and so will be detectable as different from base flow conditions.	Comment noted.
108	Helsel	Environmental Statistics	SOW Question 5		No. Determination ofdifferences in water quality parameters using Analysis of Variance is flawed because the serial correlation in the data was not accounted for. The current analysis is not sufficient to determine whether there are significant impacts for these parameters.	Flow and habitat conclusions are most important; water quality parameter conclusions less so.
109	Helsel	Environmental Statistics	SOW Question 6		The Study's conclusions in regards to flow are supported by the data and analysis. The conclusions in regards to water quality parameters are not. The conclusions in regards to effects on habitat. are beyond my area of expertise, but appear to be the most thoroughly supported portion due to the modeling work.	Flow and habitat conclusions are most important; water quality parameter conclusions less so.
110	Helsel	Environmental Statistics	General		One fundamental problem with the Study is that many analyses were based on two apparently unpublished reports by the USFWS (2002 a and b). Results hinge so much on these draft reports that some statement from the Service should be included that verifies that the analyses, spreadsheets, etc. in these reports are valid, and that they received peer review and were considered accurate, even though the reports were never published. Or if this is not the case, a statement to the effect that the analyses were never peer reviewed or verified. Citations in this Study to those two reports usually do not discuss the methods that produced the conclusions, or speadsheets, or whatever product is being cited. The citations imply that what was reported is accepted as truth. What were the quality of these methods? Are there any plans for reviewing, verifying and publishing these 10-year old reports?	Beyond the scope of the study.
111	Helsel	Environmental Statistics		Page 3	An example of the dependence on these two reports is the method used for extrapolation from one gage to another using regression. This procedure has for years been known to dampen variability in flows, as regression predicts mean values. So the predicted daily flows for 30 years at the Loup River at Columbus (1978-2008) relied upon in this report will not be as variable, high or low, as would have been the actual record ifit had been measured. Other methods for extrapolation (one is often called MOVE or LOC) are preferred when the probability ofhitting a high or low flow is at issue, which it is here. These probabilities of high and low events will be underestimated, as regression by design predicts values towards the center. Given that the referenced report was never taken beyond draft, methods in that report including this one may be less than 'industry standard'.	Beyond the scope of the study.
112	Helsel	Environmental Statistics		Page 4	Please make the method for estimating missing evaporation data more clear. Were simply long-term monthly averages used? That is what is implied in the text. Or were monthly temperatures for the period to be estimated incorporated as well, so an unusually hot June for example had higher evaporation than the long-term average for June?	Editorial comment. Will be edited if Program elects to issue a revised final report.
113	Helsel	Environmental Statistics		Page 4	Isn't the statement that "the effect of flow changes in the central Platte River for the magnitude currently envisioned under the Platte River Program are not likely to be detectable at Louisville, Nebraska" (USFWS, 2002b)" one ofthe questions that this Study is to answer? Why then cite the answer, from a draft report at that, here, with implied great authority? No background or insight into the method the USFWS used to make this conclusion is presented here. I'd suggest you delete this statement until later after you have presented your analysis ofthis question. From my reading of the analysis, the Study finds that the flow changes will certainly be detectable at Louisville, decreasing II ...the flow at Louisville from 5,040 cfs to 3,290 cfs" (from page 24). So if not deleting the statement, make sure it is clear that this report finds a different result.	Beyond the scope of the study.
114	Helsel	Environmental Statistics		Page 5	Data are not "illustrated" in a table such as Table 5. They are "listed". If they should be illustrated, draw a figure. Tables don't illustrate anything.	Editorial comment. Will be edited if Program elects to issue a revised final report.
115	Helsel	Environmental Statistics		Page 5	What is the objective of determining whether "water quality data can differentiate between flow conditions"? This implies that the flow data cannot differentiate, and that water quality might be needed to do this. Or do you mean "water quality is different at different flow conditions"? The latter is focused on water quality, rather than on using it to say something about flow. Clarify the objective for why this analysis is being undertaken.	Editorial comment. Will be edited if Program elects to issue a revised final report.
116	Helsel	Environmental Statistics		Page 5	Your title "Accuracy Assessment of USGS Stream Gage Measurements" is misleading. You aren't doing an assessment of the accuracy of their methods. No data were collected to do so. You are just using their own accuracy assessment to compute the magnitude of 10 percent of observed flows. You should rename this section. Then you compute tables of differences in uncertainty estimates (Tables 4 and 6) without stating what these are good for, or how they came about. Was the method used in the USFWS report different from yours, and therefore the differences? If so, what were the two methods and why do you think they differ? Or are these the same methods just applied to different time intervals, and no change in the physical system has occurred? If this is true, then discuss how this helps you and how the difference in flows between 1975-1994 and 1995-2008 produce the observed differences listed in Tables 4 and 6	Editorial comment. Will be edited if Program elects to issue a revised final report.
117	Helsel	Environmental Statistics		Page 8	I have no idea what "Program staff also provided some preliminary information evaluating the pulse flow event to the Grand Island gage" means. Please reword or delete if not important.	Editorial comment. Will be edited if Program elects to issue a revised final report.
118	Helsel	Environmental Statistics		Page 9	So your conclusions here are that a release of 13K AF upstream is not really discernable by the time it travels downstream to Louisville. What are the implications of this for your later findings, given that the later findings seem to disagree with this?	This conclusion is consistent with later findings. Hydrograph translation described on p. 9 indicates that the small "peak" from the 13k AF release may be within the "noise" of the Louisville gage and the peak is less than the accuracy of gage readings. This is the same conclusion in the 1st paragraph on p. 23 that states the flow change is approximately equal to the gage uncertainty, and thus would be difficult to accurately detect.
119	Helsel	Environmental Statistics	Modeling		You found that you have well-calibrated models, and that the Platte acts like most other rivers in scouring the bed during high flows, increasing channel depth. You have a handle on the types of bedforms and bars likely present at differing flow regimes. This was translated into models of the amount of habitat available for different flow regimes. You evaluate uncertainty in habitat computations based on differences between measured and modeled flows. However this underestimates the true error; as errors for calibration data are always smaller than verification data not used to calibrate the model. A verification step of some sort, possibly a cross-validation procedure, should be used to quantify uncertainties instead. Yours are very likely too small.	As described in the last paragraph on p. 20, a test run at 6,000 cfs indicated that uncertainty in modeled depth/velocity contributes a very small portion of the overall variability in habitat estimates, and that most of the variability is from the uncertainty in hydraulic criteria used to identify habitat types. Considering the minor uncertainty associated with modeled depth/velocity, the approach using variability between modeled and observed values is appropriate.
120	Helsel	Environmental Statistics		Page 21	These daily values are not independent. Analysis of variance (as well as other standard statistical tests) assume independence of observations, that there is no sequential correlation. There certainly is for day to day measures of temperature and water depth, and probably for the other parameters as well. The result is that sample sizes are incorrect, that 46 observations for September 2008 for example may have the equivalent information of 20 independent observations. Therefore the test should be run using n=20 rather than 46, and the differences between months may with reduced sample sizes actually not be significant. Because this was not considered, these tests do not prove that differences actually have occurred between months. The tests should be run by correcting for serial correlation, which can be done with more complex software, or by more simply computing the 'effective sample size' that is a function of the magnitude of correlation between observations in the time series.	The point of the water quality data is to determine a relationship between water quality and Q (e.g., that turbidity increases with Q). WQ data collected for this study were supplemented with USGS WQ data (Figs 42 and 43) for flows well above the bankfull Q of 40,000 cfs. The final dataset included WQ data for flows for the entire range of historical Q at Louisville (Fig 2). As a result, data independence was assumed for the wide range of data in Figs 42 and 43.

Comment #	Reviewer	Expertise	Section	Page	Comment	Response
121	Helsel	Environmental Statistics		Page 21	Serial correlation similarly invalidates standard power calculations. No detail on how power was calculated is given here. Standard ANOVA power calculations assume both independence and a normal distribution, and turbidity and depth data are probably not normally distributed (the others may be based on working with similar data). Much more detail should be given here on the procedure of the power calculations.	See response to previous comment. Due to the large WQ dataset that included USGS gaged water quality data, data independence was assumed.
122	Helsel	Environmental Statistics		Page 22	Even more importantly, the questions that the power analysis and ANOVA are addressing should be explicitly stated. What is the value in these analyses? State why you are performing them.	See response to previous 2 comments. Power and ANOVA analyses are somewhat irrelevant considering the large USGS gage dataset used to supplement WQ samples collected for this study. The total dataset shown in Figs 42 and 43 cover the range of historical Louisville Q, and as a result we have enough data to make predictions whether Program-related changes to Q would affect WQ.
123	Helsel	Environmental Statistics		Page 22	Figures 42 and 43 are stated as being composed of only the May 2009 data. Yet on page 23 they are used to compare to conditions at other additional times. This isn't valid, certainly for temperature. In addition, the data should be tagged and color coded by rising and falling stages of the hydro graph. Part of the large variation for similar discharges is due to differences between water quality when the storm is rising versus falling. Turbidity can certainly be expected to be very different for the same discharge depending on which limb of the hydro graph it occurs on.	Editorial comment. Will be edited if Program elects to issue a revised final report.
124	Helsel	Environmental Statistics		Page 23	The meaning of the statement" the magnitude ofthe change in discharge is subject to the same uncertainty as the overall flow" is unclear. Be more specific or delete this.	Editorial comment. Will be edited if Program elects to issue a revised final report.
125	Helsel	Environmental Statistics		Page 23	The statement" the increase in discharge does not move the conductivity, turbidity, temperature, or dissolved oxygen outside the typical range preferred by pallid sturgeon (Figures 42 and' 43)" is too broad and sweeping of a statement considering that the figures are based on data only from one month, and you've already stated that based on an ANOVA the levels of these parameters differ between months. Graphs of the relationship between these parameters and discharge should be based on data from all four months of interest where diversions are expected (note that May is not one of those months and so is incorrectly used for the data in these graphs), while considering variation due to rising vs falling hydrograph and to temperature effects. In short, you cannot use the current graphs to make the conclusion you are heading toward.	Editorial comment. Will be edited if Program elects to issue a revised final report.
126	Helsel	Environmental Statistics		Page 24	a typo? The Run classification would be reduced from 45% to 34%, a decrease of 1 %??? Plus, you report different values in Appx G. Please clarify.	Editorial comment. Will be edited if Program elects to issue a revised final report.
127	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling	SOW Question 1		The report does adequately address the overall objective as stated. The report is logically organized and compete, however, it would be helpful to include a background section early in the report that describes the type of flow conditions being considered to place the study in context.	Comment noted.
128	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling	SOW Question 2		Yes, the physical parameters are adequate and scientifically defensible. Clearly, the need for improved scientific understanding of selection and utilization of specific, local flow conditions (both hydrodynamics and water quality) and habitat-scale flow patterns that pallid sturgeon prefer is still needed, but outside of the scope of this project. The report does a very good job of describing available data and current understanding and utilizing this information to reach the conclusions.	Comment noted.
129	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling	SOW Question 3		Yes, the habitat classifications are adequate and scientifically defensible. In addition, to the uncertainty analysis and quantification of habitat areas by type, it would be helpful to include a broader discussion about the space-time utilization of individuals that may be residing or moving through the area. For instance, "what is known about adjacencies or distributions of habitat types", this may be important for habitat utilization and may be impacted by stage change. From the information it did not appear that distribution or adjacency would change, but would be good to include this in the discussion.	Comment noted.
130	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling	SOW Question 4		Yes, the report clearly addresses the detectability of the stage change from Program Water activities. It would be helpful, within the discussion section to refer to the stage discharge curves for the reach.	Comment noted.
131	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling	SOW Question 5		Yes, the report addresses the impact of the stage change on the river parameters listed. It would be helpful to list other parameters that may be important, such as flow shear lines, and eddy structures, however, less is know about these features than the parameters given. With that said, some acknowledgement that the parameters considered may not be the only flow features that determine habitat function and utilization would be useful. The second to last paragraph of the report provides some comments towards this, but could be expanded.	Comment noted.
132	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling	SOW Question 6		Yes, the findings of the study and conclusions reached are supported by data and sound engineering and scientific analysis. It would be beneficial to include an executive summary of the report and a clear conclusions / summary section in the report	Comment noted.
133	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling	General		Scientific Soundness – The methods and approaches were based on sound engineering and science. Unfortunately, although there is literature and past studies that describe general habitat preferences and utilization, there is little available information from a first-principles understanding of specific habitat needs for the species of interest. This short-coming is, however, common in most aquatic restoration and management programs. The project report uses sound, available engineering and science to address this inherent uncertainty in its habitat evaluation. Although further studies and fundamental research could improve this understanding, it is clearly outside of the scope of this project.	Beyond the scope of the study.
134	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling	General		Organization and Clarity – The report logically presents the engineering analysis of the hydrologic conditions of the study reach; data collection programs; hydraulic model construction, calibration and utilization; geomorphic assumptions and analysis, flow habitat assumptions and habitat discrimination technique; and conclusions. Uncertainties of methods, models and approaches are adequately described throughout the report.	Comment noted.
135	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling	General		Conciseness – The report is well written and presents an appropriate amount (both depth and breadth) of information. The report also, includes relevant information in the appendices and adequately sites previous and related published work.	Comment noted.
136	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling	General		Degree to which the conclusions are supported by the data – The report provides a logical progression from hydrologic conditions of the study reach through final conclusions, including the uncertainty of information utilized in the decision process.	Comment noted.
137	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling	General		Cohesiveness of conclusions – The formulation of the conclusions is based on sound engineering and science. The conclusions/summary statements should have been explicitly organized in a closing, Conclusion or Summary section in the report rather than simply woven into the Discussion section.	Comment noted.
138	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling			In the discussion of minimum and maximum flow selection, a flow recurrence /exceedance plot would be helpful to place the selected flows in context, rather than referring to figure 2. Also the period of record should be stated for this analysis in the Study Flows section.	Editorial comment. Will be edited if Program elects to issue a revised final report.
139	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling	Figure 2		x-axis of figure 2 should use the first day of the month for each major grid line and label	Editorial comment. Will be edited if Program elects to issue a revised final report.
140	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling			A better location map would be helpful to locate the study reach within the state and along the Platte River Stream network.	Editorial comment. Will be edited if Program elects to issue a revised final report.
141	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling			It would be helpful to explicitly state that the 2D SRH model is a fixed bed model andthis geometry is used throughout for all simulations. How this impacts the local flow conditions for higher flows should be addressed.	Editorial comment. Will be edited if Program elects to issue a revised final report.
142	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling			Figures 24, 25 and 26 are useful data plots, however, it would be helpful to see the distribution of the difference between model and field data on a spatial image of the study area. This would be helpful to understand the performance of the model, but likely does not negatively impact the use of the model results.	Editorial comment. Will be edited if Program elects to issue a revised final report.
143	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling		Page 24, first paragraph after table 13	….45% (+8%) of the habitat area to approximately 34% (+8%) of the habitat area, a decrease of 1%. The "1%" should be "11%".	Editorial comment. Will be edited if Program elects to issue a revised final report.

Comment #	Reviewer	Expertise	Section	Page	Comment	Response
144	Weber	River Hydraulics and Mechanics, River Restoration, and Computational Modeling	Discussion		In addition to the text description, it would be helpful to tabulate the changes to habitat classification in the discussion section. This to compare across conditions of interest, and to show the impact of the management actions.	Editorial comment. Will be edited if Program elects to issue a revised final report.
145	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	SOW Question 1		Yes, subject to comments	Comment noted.
146	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	SOW Question 2		Yes, to the extent that they can actually be meaningfully evaluated by the methods used.	Comment noted.
147	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	SOW Question 3		This is a good example of a subject that can't be evaluated if one considers the report in isolation, because habitats get minimal attention in this report.	Primarily a hydrology study; no intention to focus on habitat.
148	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	SOW Question 4		Yes and No. Yes the study answered the question; no, program activities (as to flow) cannot be detected. Effects of other activities (sediment mobilization for example) were not assessed.	Comment noted.
149	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	SOW Question 5		N/A	Comment noted.
150	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	SOW Question 6		Yes, especially given the conclusion is "did not find".	Comment noted.
151	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		I consider the core elements of the study to be technically sound and useful. With some exceptions noted below, the work satisfied the scientific and technical scrutiny that was within my expertise to apply, and within the peer review budget to investigate. The study report appears to satisfy the objectives of the RFP.	Comment noted.
152	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		In my experience, a role of peer review is to focus on potential weaknesses or limitations in a study. Thus the critical nature of my comments should not be taken to suggest the study is seriously flawed, but rather as my effort to provide constructive input to future work. In the specific comments, I observe the following aspects of the study that I thought might be in most need of improvement or of further evaluation.	Comment noted.
153	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		For purposes of organization and clarity, it would be beneficial to provide an introduction that puts the study in context. See specific comments on p. 1.	Editorial comment. Will be edited if Program elects to issue a revised final report.
154	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		I suggest reconsidering the methodology and results of the loss analysis. See specific comments on p. 2.	Further input on this topic from this reviewer is in Comment #171 below. The loss approach used in this analysis is based on the common mass balance technique using known input and outputs and gaged flow between 2 points. The alternative approach suggested by reviewer in Comment #171 (i.e., modeling the flow exchange between surface and ground water based on ground water heads) is beyond the scope of this study.
155	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		The effects of flow modification by hydropower appear to be potentially profound and need further evaluation. See specific comments on p. 8.	Beyond the scope of the study.
156	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		The apparent rigor of certain of the analyses does not fully capture the uncertainty in the bottom line results. See specific comments on p. 20.	Specific comment referenced here is overall Comment #184 below. This boils down to an editorial comment suggesting that a full acknowledgement of unertainties and limitations be added to the report. This will be added if the Program elects to issue a revised final version of the report.
157	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		*Scientific soundness*. The technical aspects of the document were generally good, with possible exceptions noted under Specific Comments.	Comment noted.
158	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		Organization and clarity. The Specific Comments (especially regarding Pages 1 and 9) identify ways the organization and clarity of the report could have been improved by providing additional background discussion. That being said, within what was actually presented, the report was well organized and well written.	Comment noted.
159	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		*Conciseness*. Good.	Comment noted.
160	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		*Degree to which conclusions are supported by the data*. Hard to say without copies of the data sets, spreadsheets, and models.	Comment noted.
161	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		*Cohesiveness of conclusions*. Ok within the context of the report. But there is so much unsaid, that a stranger to the process might not be able to properly judge the end results.	Comment noted.
162	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		*Presentation: Is a tightly reasoned argument evident throughout? Does the manuscript wander from the central purpose?* The true central purpose is never stated. Within the organization as presented, the report does a good job of walking through the methods, data and results without any wandering.	Comment noted.
163	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		*Methods: Are they appropriate? Current? Described clearly and with sufficient detail so that someone else could repeat the work?* Except for the evaluation of losses, the methods are appropriate and current. The level of detail in methods is good. I don't know enough about the models to know if one could repeat the work, but I suspect it would be necessary to get the actual model I/O files to do so.	Comment noted.
164	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		*Data presentation: When results are stated in the text of the manuscript, can you easily verify them by examining tables and figures? Are any of the results counterintuitive? Are all tables and figures clearly labeled? Well planned? Too complex? Necessary?*Good marks on all of this.	Comment noted.
165	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		*Statistical design and analyses: Are they appropriate and correct? Can the reader readily discern which measurements or observations are independent of which other measurements or observations? Are replicates correctly identified? Are significance statements justified?* A lot of attention is paid to statistical determinations, but there is a fair amount more that could and probably should have been said. See comments on P. 20.	Comment noted.
166	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		*Conclusions: Has the author(s) drawn conclusions from insufficient evidence? Are the interpretations of the data logical, reasonable, and based on the application of relevant and generally accepted scientific principles? Has the author(s) overlooked alternative hypotheses?*I found the overall results acceptable, since they agreed with what was fairly evident even without the study, that no significant relationships can be quantitatively established.	Comment noted.
167	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		*Errors: Point out any errors in technique, fact, calculation, interpretation, or style.* My review was not in depth, but I found nothing of concern except for the loss analysis (see comments on P. 2).	Comment noted.
168	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology	General		*Citations: Are all (and only) pertinent references cited? Are they provided for all assertions of fact not supported by the data in the manuscript?* It's a good reference list.	Comment noted.
169	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Page 1	In my first paragraph of general comments, I said the study appears to satisfy the objectives of the RFP. I used the word "appears" because neither the RFP nor report does a good job of placing the study objectives into context, i.e. explaining to what ultimate purpose the work was being done. To understand the work, I relied on the Biological Opinion and the limited discussion in the Protocol. I don't fault the authors for this necessarily, as it isn't clear from the RFP that they were tasked to provide context in the report. Nonetheless, the lack of context made reading and evaluating the report much more difficult than it should have been (at least for me). The standard organization for a scientific paper includes an introduction that presents the background knowledge necessary for the reader to understand the findings of the paper. This is especially important when, as here, there is no executive summary to bring everything together. In this case the following would have been useful in providing the reader with important background knowledge: 1) A brief synopsis of the nexus between stage and sturgeon as it is now understood. Note that the fact that this paper is about pallid sturgeon isn't even mentioned until halfway through the report (p. 14). 2) One or more hypotheses about how the Program could impact that nexus (including a "non-detect" hypothesis). This would disclose the current thinking about why the study reach is important to sturgeon, and why we are interested in predicting impacts to depth, velocity, bedforms, topography and the like. 3) A clear and succinct statement of the methodological approach to evaluating the hypotheses. This might be a flow chart indicating that first we have to route Program flows to the reach; then model their impact on the parameters of interest; which means very complex hydraulic models and interpretations relating especially to bedforms; and finally translate that to impacts to sturgeon habitats. It may seem obvious, but that doesn't mean the report shouldn't be clear about what is being done.	Editorial comment. Will be edited if Program elects to issue a revised final report.

Comment #	Reviewer	Expertise	Section	Page	Comment	Response
170	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Pages 1 and 2	Figure 1 would benefit from an inset location map.	Editorial comment. Will be edited if Program elects to issue a revised final report.
171	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Page 2	The loss analysis is an update of a FWS study provided in Appendix A. It is difficult to fully evaluate the method without a copy of the spreadsheet. Nonetheless, I was very surprised about the results, and wonder if the Program is approaching this important issue correctly. I did not review Appendix A in sufficient detail to know for sure that my concerns are valid, so please consider this discussion accordingly. My two primary concerns are as follows. Some of the loss rates reported are much higher than I have seen, even in arid western rivers. If it has not been done, I strongly recommend each element of the loss be independently verified. For example, analytical methods using groundwater head data can be used to independently estimate seepage losses. It appears that the method calculates Program losses in proportion to flows. An alternative (and in my experience more appropriate) approach is to calculate them on an incremental basis. If the current procedure has not been affirmatively deemed more appropriate than an incremental approach, the incremental method should be To illustrate my concern, consider the result of the accounting done by the Bureau of Reclamation for the loss of water imported into the Rio Grande Basin (this loss rate is important for quantification of endangered species impacts as well as available water supplies). Based on quantification conducted by the Rio Grande Compact Commission, a loss rate has been calculated for the reach from Heron Reservoir (near the Colorado border on a tributary of the Rio Chama) to Albuquerque (a distance roughly comparable to Grand Island-Louisville). The loss rate applies to the flow added to natural flow by imported water. There are elements of the rate calculation that are not entirely apples-apples to that made for the Lower Platte, but these would have a modest effect at most. The Rio Grande loss rate is 2%. Given this result, it is difficult for me to understand loss rats as high as 90% in eastern Nebraska.The subject of losses above Grand Island is not considered, but it would be of interest to know the Louisville flow as compared to an upstream reservoir release. The following comment is not related to the above, but to the reference to selection of “appropriate” flows on page 2. Appropriate how? With no discussion of matters such as sturgeon habitat, the reader cannot know. It is also confusing to indicate that a flow of 39,000 cfs is of “primary interest”, without explaining why it was then appropriate to use 8,000 cfs as the high end of flows selected.	Beyond the scope of the study.
172	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Page 3	I did not understand how the study made use of two different periods of record for extended analysis.	Editorial comment. Will be edited if Program elects to issue a revised final report.
173	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Page 4	The new spreadsheet analysis probably should be provided in an Appendix.	Editorial comment. Will be edited if Program elects to issue a revised final report.
174	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Page 5	The power analysis probably should be provided in an Appendix.	Editorial comment. Will be edited if Program elects to issue a revised final report.
175	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Page 6	The focus on gage uncertainty may cause readers to overlook the uncertainty in the USFWS spreadsheet which estimates impacts of Program flows.	Comment noted.
176	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Page 7	In addition to the plots in Figures 3, 4 and 4a, it would be interesting to see the data plotted as flow duration curves.	Editorial comment. Will be edited if Program elects to issue a revised final report.
177	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Page 8	This page presents Figure 5 and makes note of the “obvious” intraday flow variation. The discussion focuses on how to smooth that out so the pulse can be translated from Grand Island to Louisville, which is certainly appropriate. However there is no discussion whatsoever about the fact that the hydropower effect causes a 1 foot diurnal change in stage, which is far greater than the transformed impact of the pulse. The implied premise of the study is that stage impacts habitat, through effects on velocity, depth and bedforms. If so, how is it that the effects of such a large and rapid stage change are not considered at all? Had the study found that Program releases did impact habit in the study reach, that conclusion would have been called into question because the interday flow variation was not considered and could be such that it swamped out any Program impact.	Diurnal flow variations in Fig 5 are a result of Loup River hydropower production, and are not related to Program actions. The large & rapid change in stage associated with Loup River hydropower production may have an impact on pallid sturgeon habitat, but assessing those impacts is not a Program responsibility and is beyond the scope of this study.
178	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Page 9	Another aspect of context that wasn't effectively presented was the cause-effect relationship being studied. The stated objective puts “stage” as the focal point, whereas after reading the report, I perceive the operational objective was to evaluate the impact of flow (cfs) as it directly impacts water depth and velocity, and the consequent effects on sediment, bedforms and habitat. Stage as such seemed not to be that much of a consideration, or a particularly good surrogate, especially in terms of assessing velocity and its consequences. The lack of hypotheses was surprising given the nature of the Adaptive Management Plan.	Beyond the scope of the study.
179	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Page 10	Given that stage is the focus of the study, are two water surface data points sufficient for the cross-sections?	Two water surface data points are adequate for validation of a 1-dimensional model, which assumes that water surface elevation is constant at a given cross section.
180	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Page 11	It would be useful to have an assessment of the change in roughness with flow, and especially whether it is reasonable to interpolate values.	Editorial comment. Will be edited if Program elects to issue a revised final report.
181	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Page 12	I did not follow the explanation of the very low n values for the 2D model.	Editorial comment. Will be edited if Program elects to issue a revised final report.
182	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Page 15	The entire bedform discussion would benefit from illustrations.	Editorial comment. Will be edited if Program elects to issue a revised final report.
183	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Page 19	I found Figure 36 hard to interpret.	Editorial comment. Will be edited if Program elects to issue a revised final report.
184	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Page 20	The use of a Monte Carlo analysis to assess uncertainty gives an impression of statistical rigor to the results. Certain other aspects of the work give a similar impression. However if one starts at the very beginning of the work, i.e. an increment of flow at Grand Island (with unstated uncertainty), and carries it through to the end, many other issues become apparent – the loss estimates, hydrograph translation, error bars on model inputs (median grain size is a good example), and more. This cascade of uncertainties would have undermined the results had a positive relationship been found. As the bottom line of the report did not assert any relationships had been statistically demonstrated, these issues are perhaps not critical. Still, I would have liked to see (in the discussion section) a recap of all the assumptions, limitations and uncertainties in the work.	Editorial comment. A summary of assumptions, limitations, and uncertainties will be added to the report if Program elects to issue a revised final report.
185	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Page 22	Of interest given prior discussion, the models are (correctly) said to evaluate depth and velocity, not “stage change”. One question not posed previously: why is the release being evaluated so small?	Potential Program releases as per the Program document were evaluated.
186	Wilson	Hydrology, Environmental Impact Assessment, Geomorphology		Page 25	Perhaps emphasize that lack of statistical significance does not equal lack of effect. In fact, qualitatively one can say that a release probably does have at least marginal benefit (this is a bit more affirmative than “no additional stress”).	Editorial comment. Will be edited if Program elects to issue a revised final report.

ATTACHMENT 2

Lower Platte River Stage Change Study
Peer Review Submissions

Reviewer #1

Dr. David Gaeuman

Expertise: Fluvial Geomorphology

Review of:
Lower Platte River Stage Change Study Final Protocol Implementation Report

The scope of this study outlined in the RFP targets two related, but distinct, objectives: determining what measurable effect, if any, Program water delivered at upstream locations will have on discharge in the Platte River downstream from its confluence with the Elkhorn River, and quantifying how changes in discharge might translate to changes in hydraulic parameters and physical habitat characteristics in that stream segment.

The authors of the study approach these two objectives quite differently. With respect to how discharge affects habitat, the authors present an analysis based on numerical modeling of flow under existing geomorphic conditions. Although this modeling analysis neglects the potential for future flows to modify the current stream configuration and produce longer-term changes in habitat availability, it does address the question posed in the RFP. The question, the approach used to address it, and therefore the review of the analysis, is straight-forward. My review of that portion of the report is presented first.

For the question regarding the effect upstream Program water on downstream discharge, however, the authors opted to rely heavily on some earlier Fish and Wildlife Service analyses, which were incorporated in the report as Appendix A and Appendix B. In doing so, they implicitly endorse those reports and accept some level of responsibility for any problems with the methods and explanations presented in them. I found those reports quite difficult to interpret, so I'll save my comments on that portion of the Stage Change Study for last.

I note here that I have not attempted to systematically copy edit this report because, according to the title, this is a Final version. I take that to mean that typographic errors, unclear statements, and so on will not be corrected as might happen if this were a Draft version. Instead, my comments focus on the broader-scale "Specific Questions" identified in Review scope of Work and the "Specific Comments," "Rating," and "Recommendation" identified in the PRRIP Peer Review Guidelines. The questions from the Scope of Work and the Peer Review Guidelines are addressed explicitly following my free-form comments on the Hydraulics and Geomorphology section and the Hydrology section.

Hydraulics and Geomorphology

General Comments and Recommendation on Hydraulics and Geomorphology Section

The approaches used to address the question posed in the RFP are appropriate. The general approach of modeling hydraulic parameters and using model output to classify habitat types is good. It could perhaps be improved by incorporating bedform types into the classification system, in addition to depth and velocity. Bedforms can have a large effect on flow velocities and turbulent structures near the bed, and so are likely very important components of physical habitat. The section on describing and predicting bedforms is good, but it's not clear whether or how that information was used to inform the final conclusions of the study.

The contractor appears to have an adequate understanding of the modeling tasks to produce credible results. However, the modeling analysis seems to include some mistakes and misinterpretations that might have the potential to affect the Study's conclusions and recommendations. Two problems with the model itself are worth highlighting: the 2d model domain lacks lead in and lead out sections and is generally too short (see comment 7), and the quantity of topographic data appears to be very small compared to the resolution of the model mesh (see comment 8). Both of these issues substantially degrade the accuracy of the model and the confidence that can be placed in its output. Two additional issues regarding the interpretation of the model results are worth mentioning: The sensitivity analysis regarding how model errors affect habitat classification may be flawed (see comment 20), and percentages in each habitat type are based on submerged area rather than total area (see comment 26). That said, I doubt that correcting these problems would materially change the Study's conclusions concerning how incremental changes in discharge alter habitat availability.

Specific Comments on Hydraulics and Geomorphology Section

1. Page 9: "A hydraulic and geomorphologic analysis…" not sure what part of this is a geomorphologic analysis. It's mostly limited to hydraulic modeling.

2. Page 9, last paragraph: "…trend over this period." Which period?

3. Page 10, 2nd paragraph refers to a 10-year model run. What does that mean?

4. Page 10, 3rd paragraph: Not sure what's meant by the different model versions incorporating cross sections from different dates. The preceding sentence is about water surface elevations at the cross sections. Were different cross sections (geometry) used in the two model versions, or just different water surface elevations for validation?

5. Table 7: Table headings are unclear and awkward. I'm not sure what an average maximum or average minimum is. Are these the extreme instantaneous values for a given day averaged over X number of days? Is "average mean" the average of X number of daily mean values, or the average of something else? The text on page 10 that references Table 7 doesn't help with this.

6. Page 11: The discussion of the models of different dates is poorly organized and confusing. It would help if the point of all this were explained at the outset. Much later in the text, in the section about bedforms I believe, it becomes apparent that the point is to account for differences in roughness due to differences in bedform regime at different flow levels.

7. Page 12, 4th paragraph, Figures 19-20: The model mesh is 1,700 ft long. From the figures, it's seen that this corresponds to about 1 channel width. This is far too short of a model reach. First, it is a very small sample in term of area from which to generalize about the river segment. But more importantly, every point within the model is a short distance from the model boundaries. It is standard practice to extend the model mesh at least a few channel widths upstream and downstream of the reach of interest. That allows some space and time for any errors or imperfections in the boundary conditions to dissipate.

8. Page 12, last paragraph refers to "detailed topographic and bathymetric data" used in the model. There is no indication in this report that detailed topographic data was collected. The only

discussion along those lines concerns collection of a relatively small number of cross sections. The 2d mesh is said to have a mesh resolution of 10 feet. This density is irrelevant unless the topo data mapped to the mesh is of similar resolution, as might be obtained with an intensive sonar survey using an array of transducers or a multi-beam. There is no indication that this was the case. The value of the fine mesh is, to a large extent, nullified if the topography was interpolated from cross sections.

9. Page 12, last paragraph: It's not explained where the n values of 0.023 and 0.027 in the 2d model came from. Were these transferred from the 1d calibration in some way?

10. Page 13, 4th paragraph, Figures 24-26: It is stated that the match between measured and modeled water surface elevation and water velocities is "good." This seems to be an overstatement. Plus or minus 0.5 ft in elevation does not seem especially good to me, and velocity errors seem to range up to around 50% (Figure 26).

11. Pages 14-15: Nice overview on bedforms.

12. Page 16, 2nd paragraph: S'* is introduced, but not defined until it come up again on page 17. Same for SG in the equation given for d*.

13. Page 16, last paragraph: I think this should be the relation between the average shear stresses (as indicated in equation 1), rather than velocity.

14. Page 17: Some of the notation seems odd. τ' is used in the definition of S'*, but is not defined (equation 1 introduces τ'_0 and τ, but not τ'). Should it be just τ? The shields parameter is denoted F* -- why not use τ^* or θ like most everyone else? (SG-1) is often denoted by *R*, and SG itself is usually ρ/ρ_s. I've usually seen transport stage denoted with T rather than S.

15. Page 17, 4th paragraph: the VBA script is said to solve for the "necessary values…" It's difficult to be sure what is being done here. I infer that τ is specified on the basis of model output, and equation 1 is solved for τ'_0, but that's not clear from the text.

16. Page 17, last paragraph: Discussion switches abruptly from bedform types to how much of the site is subaerially exposed. What's the connection?

17. Pages 18-19, habitat evaluation: This seems like a good approach. Why are there no pools in this classification? Are especially deep scours and holes not relevant for sturgeon, or perhaps these environments are not present in the Platte?

18. Page 20, top: re-states that the model is well calibrated. See comment 10.

19. Page 20, numbered item 1: velocity units are given as ft.

20. Page 20, numbered item 2: Was the simulated error applied to each node independently? Or to put it another way, would adjacent nodes be assigned uncorrelated errors? That would clearly be incorrect – for example, if a given node had a large positive error in depth, all nearby nodes

(and maybe every node in the model) would probably also have positive errors. Assigning each node an error that is independent of all the other errors would cause the random errors to cancel, and probably result in very little net change in the proportion of particular habitat types.

21. Page 21: The text says that Table 11 shows variation among transects and among sample episodes, but it doesn't show that. Is a "sample episode" a day?

22. Table 12 and top of page 22: The table suggests that conductivity and turbidity behave in the same way with respect to different "phases" (what's the independent variable here, discharge maybe?). Meanwhile, Figure 42 shows that they behave in opposite ways. What point is being made with these statistics anyway?

23. Page 22, 3rd paragraph: What is meant by "bottom velocity?" This must refer to some height above the bed.

24. Page 22, 3rd paragraph: The explanation for why run and plunge habitat is considered most suitable is not very convincing. Where are the sturgeon actually found? Do the cited publications refer to run and plunge habitats?

25. Page 23, 1st paragraph: The gaging error magnitudes defined in the hydrology sections are applied here. I suspect that the interpretation of gage errors may have a problem – see comment 32.

26. Page 23-24: The actual changes in the availability of various habitat types may change more with discharge than is indicated. It appears that the percentages given for habitat types are the percents of the total submerged area. It would be more meaningful to report this in terms of actual area or as a percentage of the model domain area because the extent of the submerged area changes with discharge.

Hydrology

General Comments and Recommendation on the Hydrology Section

The hydrology studies presented in the two USFWS reports and incorporated into the Stage Change Study leave much to be desired in terms of both technical credibility and the clarity of the presentation. Some of the problems with the original reports are noted in the specific comments below. The authors of the Stage Change Study apparently reproduced the analyses described in the USFWS reports. That would require sorting out the details regarding what those analyses involved. Having done that, I would expect the authors of the Stage Change Study to provide a better description of what they did than simply referencing and copying text from the Appendices.

The flow losses due to evaporation, transpiration, and seepage estimated in these reports are, in my opinion, unreliable. The reported total loss figures become more credible if they are considered to be generic losses, not attributable to any particular sink. Nonetheless, I agree with general conclusion that small discharge augmentations upstream of Grand Island of the magnitude discussed will not be very noticeable at Louisville. This is not so much related to gaging uncertainty (which I think is overestimated in the reports), but is instead due to the fact that the augmentation volumes discussed are small compared to everything else that is going on. Changes in flow on the order of 100 cfs would be difficult to distinguish even if the gages were perfectly accurate, because the changes can be swamped by much larger flow fluctuations caused by a variety of other factors.

Specific Comments on the Hydrology Section

27. Page 2, end of second paragraph: States that the selected flows are considered appropriate for modeling, but doesn't explain why. Does anything about pallid sturgeon habitat enter into this determination?

28. Table 2 and associated text: Meaning of the headings indicating time periods are unclear. These look like periods of record for the gages, but are not. Time periods listed for the Loup near Columbus include times when there are no gage records. It takes careful picking through the text to figure out how to interpret these dates. I'm unsure of what is meant by "period of analysis." This could refer to the period from which flow records were drawn to quantify the hydrologic characteristics of the gage site, which could then be extrapolated to other years, or it could mean that consideration of the gage site was entirely confined to that time period.

29. Page 3, 3rd paragraph: This paragraph is very hard to follow. It does not clearly identify what is being estimated – language like "the USFWS analysis" and "these flows" do not identify the gages and dates for which flows were being reconstructed.

30. Page 3, last paragraph: A new gage can apparently supply better information about powerhouse return flows, but was not used. This information could have at least been used to check on the accuracy of the method in the USFWS analysis.

31. Pages 4-5: The Study basically just sends the reader to Appendices A and B. There appears to have been little or no critical review of the USFWS reports by the Study authors.

32. Page 5, last paragraph: This interpretation of gage accuracy seems overly simplistic. It is stated that the USGS considers 95% of the gage readings to be within 10% of the actual discharge. This report follows the USFWS reports in translating that into error bounds of plus or minus 10%. Assuming the errors are independent random variables, the actual error bound should be related to the number of samples used to generate an estimate. For example, the USGS error estimate could be interpreted as suggesting that the individual errors have a standard deviation of around 5% (because close to 95% of a normally-distributed population is within 2 standard deviations of the mean). Whether the standard deviation is 5% or something else, the standard error of the estimate is equal to the standard deviation divided by the square root of the sample size. If the estimate is monthly mean flow, the sample size is about 30. These numbers suggest that the error bound for the monthly mean might be around 2% at the 95% confidence level. I am not a statistician, and the details of this example may not be exactly correct. For example, the errors on sequential days are probably correlated to some degree. The point is simply that the 10% error bounds assumed in the reports need to be re-examined.

33. Page 7: In repeating the USFWS reports, the Study incorporates an abundance of errors, confusing explanations, and obscure objectives. Page 7 discusses what happens to an incremental increase in flow at Grand Island by the time it reaches Louisville. The discharge increments considered seem arbitrary. It would be most helpful if the Study would explain why these particular increments are relevant, and more generally, what “Program water” or “First Increment water” is.

After consulting the Biological Opinion, the Adaptive Management Plan, the Record of Decision, the Platte River Recovery Implementation Program Final Environmental Impact Statement, and the Platte River Recovery Implementation Program, I’ve determined that First Increment water refers to 130,000 to 150,000 acre-feet of water annually, perhaps in the form of baseflow discharge targets or (undefined?) pulse flows. Spread evenly across the full year, that volume of water is equivalent to about 200 cfs, which is in the range of increases being evaluated.

I speculate that the documents I’ve consulted are ambiguous about Program water because it has not yet been fully determined how that water is to be used. If so, the hydrologic analyses in the Study seem to be putting the cart before the horse. They seem to ask: if the upstream flow is bumped by X, could it be detected downstream, and would it materially improve habitat? Would it not make more sense to go about it other way around? That is, to ask: How much of an increase in flow is needed in the lower river to materially improve habitat there, and how much discharge needs to be added to upstream flows to hit that downstream target? Perhaps this is how the question is being approach, but it’s hard to tell from what’s written.

34. Page 7, 5th paragraph: The paragraph begins and ends describing evaporation trends, but refers to total volume lost in the middle. It’s unclear whether this means total volume lost through evaporation, or total volume lost including seepage losses. It’s also unclear whether evaporation here includes transpiration.

More generally, the analysis contained here and in the USFWS reports is often muddled in this regard. Terms like evaporation and ET do not seem to be used in a consistent manner throughout. However, the distinction may be an unnecessary complication, given the methods used to estimate these losses. See comments on that later.

35. Page 8: The section on hydrograph translation is difficult to interpret. It could be greatly improved by telling the reader more specifically what the EA flow was. Four paragraphs into the section it is noted that “the peak of the EA flow at Duncan is estimated to be approximately 2000 cfs above base flows.” From this, a reader might infer that something like 2000 cfs was released from somewhere upstream or otherwise generated somehow. Is there some reason that what was done and where it was done can’t be clearly stated?

36. Appendix A, page 1: The report discusses evaporation and seepage losses. Are there no diversions or pumps to consider?

36. Appendix A, page 2: The Figure 1 referenced here is missing. The same or a similar figure 1 is missing from Appendix B as well. The missing figures seem to be maps showing where all these gages, reaches, and tributaries are.

37. Appendix A, Page 5: Estimated lag times are very crude. All are integer days, and variations in lag time with discharge are not considered. This component of the analysis deserves more attention than it was given.

37. Appendix A, Page 5: Figure 2 referenced here is missing.

38. Appendix A, Page 6-7: It would make sense to look at channel width during the time of year when evaporation losses are greatest. Seasonal trends in channel widths were considered indirectly through the application of "liberal" and "conservative" widths. Seasonal differences in width could be addressed more directly.

39: Appendix A, Page 8: The use of pan evaporation rates to estimate river evaporation rates is a big leap. I suspect that the temperature of the pan is quite different than the temperature of the river. The pan coefficient might be intended to account for that, but no explanation or justification for the factor of 0.7 is given. The adjustment factors used for ET losses also lack explanation. These things need to be explained.

40: Appendix A, Page 9-10: Seepage losses are calculated as the difference between the net inputs to a reach (inflows minus E/ET losses) and the outflow from the reach. This raises the question of why the analysis even bothers to estimate E/ET, because its magnitude is irrelevant to the result. If the estimate of E/ET was arbitrarily increased by 20 cfs, for example, the corresponding estimate of seepage loss would come out 20 cfs lower. The total loss, however, would remain the same regardless of what value was used for E/ET. It would be simpler and equally useful to simply define "losses" as the difference between inflows and outflows without regard to whether they are E/ET or seepage.

41: Appendix A, Page 10: States that "Percent ungaged gains were not calculated, as this quantity is not relevant to this analysis." I'm not sure how to interpret this statement, but I do not agree that gains are irrelevant. It's also unclear whether "gain" refers to ungaged tributary input only, or to all gains (such as groundwater inflows and return flows from diversions).

42: Appendix A, Page 11: Seepage loss estimates are called "conservative." It would be clearer to say the reported losses underestimate the actual losses. It would also be good to say something about the magnitude of underestimation.

43. Appendix A, bottom of Page 12: "Total estimated daily evaporation + ET losses" are given in units of cfs, that is, rate units instead of volume. And again on page 14. The figures referenced in this text give the losses in percent of flow.

44. Appendix A, Page 18, 1st paragraph: This paragraph is unnecessarily confusing. The example discusses a reach, a subreach, a stream gage, and added Program water with no explanation of the geographic relationship between these elements. That difficulty would be partly relieved if Figure 1 wasn't missing from the report. It is stated that flow is 1000 cfs at Duncan on a particular day. It then refers to the "historic Platte River inflow," which, from the arithmetic that follows, appears to refer to the 1000 cfs at Duncan. Then, 200 cfs of Program water is introduced, although it's not clear how or where. Again, from the arithmetic, it seems that the

Program water is also an inflow at the top of the reach, so that the flow at Duncan is actually 1200 cfs, not 1000 cfs. The presentation of the arithmetic is also overly complicated. It could be presented as three simple operations: determine the volume of inflows (including distance weighted gains), calculate the proportion of the inflows that are lost to E/ET (equal to losses/inflows), and multiply the Program water volume by that proportion.

45. Appendix A, Page 19, 5th paragraph: The sensitivity analysis for open water width needs more explanation. It seems to me that, according to how the total losses are calculated, changing the open water width would have zero effect on total losses because E/ET is subtracted from inflows before computing seepage losses. Could it be that the authors of this report applied 2 different estimates of E/ET to the same analysis? That is, did they subtract the original estimate of E/ET from inflows, then calculate seepage losses, then use those seepage losses with new, larger estimates of E/ET to arrive at new total losses? That would clearly be incorrect.

46. Appendix A, Figures 9 and 10: Why do these graphs present different results than the similar graphs in Appendix C of the other USFWS report included as Appendix B (Page 17 in Appendix B)? Graph titles and axes labels are the same in both appendices, but the plotting positions differ.

47. Appendix A, Page 23, 1st paragraph: States that there are no major diversions below Grand Island. What about numerous small diversions? Has that been evaluated?

48. Appendix B, Page 5, 6th paragraph: Mentions a Tri-County supply canal system. I didn't see that mentioned anywhere else. I wonder where that is, and if it is, or should be, considered in the analysis presented in Appendix A.

49. Appendix B, Table 2: Uncertainty is assumed to be 10% of the measured flow. See comment 32.

50. Appendix B, Table 3: I'm wondering why the effect of First Increment Program activities is to cause negative changes in flow in some months. Here would be a good place to provide some explanation as to what First Increment Program activities include.

51. Appendix B (page 16) of Appendix B: These travel times could be used to improve the Appendix A analysis.

52. Appendix D (page 18) of Appendix B and text on pages 9-10: Would be appropriate to define what the “OPSTUDY Model” is.

Reply to Specific Questions in the Review Scope of Work

1) Does the Stage Change Study adequately address the **overall objective** of the RFP, which is *"…to develop information needed to evaluate the effects of Program water management activities, including new activities covered by state or federal depletion plans, on water stage and how those stage changes affect physical parameters in the reach of the lower Platte River from the Elkhorn River confluence to the Missouri River confluence"*?

Yes

2) Are the physical parameters and measured data considered in the study (flow quantity, depth, velocity, temperature, turbidity, sediment, and sandbars and bedforms at selected sites throughout the study reach) adequate and scientifically defensible for the purposes of the study?

Yes. However, bedforms played a very minor role in this study. It's not clear how they were incorporated into the quantification of sturgeon habitat availability.

3) Are the habitat classifications considered in the study (slackwater, flat, riffle, run, isolated pool, and plunge) adequate and scientifically defensible for the purposes of the study?

Yes, but I do not claim to be an expert in that subject.

4) Is the Stage Change Study sufficient to determine if First Increment Program water activities can be detected (statistically significant beyond the error of the gauging equipment) from base flow conditions?

No. A better evaluation of gaging errors is needed, as described in my comments above. I would also suggest that the idea of detectability be better defined. It seems that for a small water augmentation to be detected, one would have to know what the discharge would have been without the augmentation. How would the work? And what is the time scale over which the detection should occur? Detecting a small change on a particular day is a different matter than detecting a sustained small change over a month or a year.

5) If "yes" to Question #4 above, is the Stage Change Study sufficient to detect if First Increment Program water activities have an impact (statistically significant beyond the error of the gauging equipment) on stage, velocity, temperature, turbidity, substrate, or channel morphology?

6) Are the findings of the stage change study and the conclusions reached in the report supported by the data and analysis?

Yes.

Reply to Specific Questions in the PRRIP Peer Review Guidelines

1. Presentation: Is a tightly reasoned argument evident throughout? Does the manuscript wander from the central purpose?

The manuscript stays on task well. It addresses the questions posed in the RFP.

2. Methods: Are they appropriate? Current? Described clearly and with sufficient detail so that someone else could repeat the work?

General methods are appropriate, but the description of methods in the hydrology section is poorly organized and difficult to follow. Methods in both the hydrology and hydraulic sections are deficient in certain details, as is described in my comments above.

3. Data presentation: When results are stated in the text of the manuscript, can you easily verify them by examining tables and figures? Are any of the results counterintuitive? Are all tables and figures clearly labeled? Well planned? Too complex? Necessary?

Many of the tables contain headings that are difficult to decipher, especially in the Hydrology section. Instances of this are pointed out above.

4. Statistical design and analyses: Are they appropriate and correct? Can the reader readily discern which measurements or observations are independent of which other measurements or observations? Are replicates correctly identified? Are significance statements justified?

There is little in the way of formal statistics in this study. An instance in which error margins on gage records may be misinterpreted is pointed out in my comments above.

5. Conclusions: Has the author(s) drawn conclusions from insufficient evidence? Are the interpretations of the data logical, reasonable, and based on the application of relevant and generally accepted scientific principles? Has the author(s) overlooked alternative hypotheses?

The general conclusions of the study are reasonable.

6. Errors: Point out any errors in technique, fact, calculation, interpretation, or style.

I have done that in my comments above.

7. Citations: Are all (and only) pertinent references cited? Are they provided for all assertions of fact not supported by the data in the manuscript?

The citations given seem reasonable, but additional supporting discussion and references is needed in some parts of the study. For example, the reasoning and sources used to choose values for evaporation and transpiration coefficients are not given. See detailed comments above.

Rating

Scientific soundness – 4
Degree to which conclusions are supported by the data – 3
Organization and clarity – 3 (hydraulics) and 5 (hydrology)
Conciseness – 3

Recommendation – If this were a draft to be revised I'd recommend major revision. But it seems to be a final report, so my recommendation is to accept its general conclusions as being qualitatively correct.

Reviewer #2

Dr. Christopher S. Guy

Expertise: Fisheries Ecology and Aquatic Resource Management

Lower Platte Stage Change Study Peer Review Questions

1) Does the Stage Change Study adequately address the **overall objective** of the RFP, which is "…to develop information needed to evaluate the effects of Program water management activities, including new activities covered by state or federal depletion plans, on water stage and how those stage changes affect physical parameters in the reach of the lower Platte River from the Elkhorn River confluence to the Missouri River confluence?"

   The Stage Change Study does address the overall objective of the RFP for a specific area in the Platte River. I believe that the study could have been more robust by extending the spatial extent of the study. The objective clearly states '…from the Elkhorn River confluence to the Missouri River confluence,' but the study was conducted on a reach from the Nebraska highway 50 bridge to the Chicago Rock Island and Pacific Railroad pedestrian bridge. I would agree that this reach is likely representative of much of the lower Platte River and is an area where pallid sturgeon have been located (Peters and Parham 2004); however, the Platte River at the confluence with the Missouri River is likely quite different and should have been included. The confluence is central to these analyses because much of the use of the Platte River by pallid sturgeon occurs near the confluence (Peters and Parham 2004). Had the investigators conducted measurements in at least two reaches (i.e., the current reach and one at the confluence), preferably more than two reaches (i.e., also include a reach near the Elkhorn River confluence), the precision, understanding of uncertainty, and inference space would have been greater with respect to Program water management activities. Further, the confluence reach is unique given that discharge in the Missouri River can influence the habitat dynamics in the Platte River which in turn will affect the results of Program water management activities, most likely different than the reach near Louisville, Nebraska. This criticism is especially relevant to the 2D modeling exercise which provides the most useful information for pallid sturgeon conservation. Understanding the effects of Program water management activities for additional reaches in the Platte River is instrumental if the Governance Committee is going to use this information to determine the effects of discharge on physical parameters thought to be important to pallid sturgeon.

   The effects of stage changes on physical parameters appears to be well studied for the reach near Louisville, Nebraska and should provide information needed to evaluate Program water management activities in that area. With that said, it would be beneficial if the investigators made it more clear regarding the discharges under which empirical data were collected, it is difficult to determine as currently written.

2) Are the physical parameters and measured data considered in the study (flow quantity, depth, velocity, temperature, turbidity, sediment, and sandbars and bedforms at selected sites throughout the study reach) adequate and scientifically defensible for the purposes of the study?

The selected physical parameters seem reasonable given the current state of knowledge regarding pallid sturgeon ecology. However, it is unclear what aspects of the pallid sturgeon life-history are targeted by Program water management activities. Providing habitat for adults is likely quite different than providing habitat for larvae. I realize this was not part of the scope of research for the investigators, but should be considered by the Governance Committee. This will help refine the effects of Program water management activities and how they relate to specific aspects in the conceptual models. Defining the life-history aspects of interest will also make the physical parameters more scientifically defensible. It is becoming clearer that habitat diversity and complexity are important to riverine fishes. Thus, combining metrics into a richness or diversity value and evaluating those data as a composite with varying Program water management activities might be more ecologically relevant than studying each parameter separately.

3) Are the habitat classifications considered in the study (slackwater, flat, riffle, run, isolated pool, and plunge) adequate and scientifically defensible for the purposes of the study?

   The selected habitat classifications seem reasonable given the current state of knowledge regarding pallid sturgeon ecology. It may be implicit in some of the habitat classifications, but a more detailed analysis of the thalweg dynamics would have been informative (e.g., thalweg depth and migration under varying discharges). I believe understanding the dynamics of the thalweg given varying Program water management activities would be highly beneficial given that several studies indicate that pallid sturgeon are typically found in or near the thalweg. I recognize that the investigators are aware of the importance of this habitat type because they allude to it when they discuss run and plunge habitat. Again, it is important that the life-history aspect of interest is well defined because habitat use likely changes with ontogeny. As stated above, combining habitat classifications into metrics that describe the richness or diversity of habitat may be more ecologically meaningful.

4) Is the Stage Change Study sufficient to determine if First Increment Program water activities can be detected (statistically significant beyond the error of the gauging equipment) from base flow conditions?

   Yes, given the error associated with the Louisville gage and the results from the 100, 500, and 1,000 cfs additional Program water at Grand Island reaching Louisville as summarized in Figures 3, 4, and 4a. However, the amount detected varies temporally.

5) If "yes" to Question #4 above, is the Stage Change Study sufficient to detect if First Increment Program water activities have an impact (statistically significant beyond the error of the gauging equipment) on stage, velocity, temperature, turbidity, substrate, or channel morphology?

   Yes, relative to stage and velocity, but not temperature, turbidity, substrate, or channel morphology because those are not measured by the gauging equipment. It is clear in the results that there is temporal variation in water quality metrics and that the variation can be detected given the sample sizes, but it is not clear how the variation in water quality metrics relate to Program water activities.

6) Are the findings of the stage change study and the conclusions reached in the report supported by the data and analysis?

In general, I believe the conclusions are supported by the data, although the conclusions are not clearly articulated. I am concerned that most of the analyses and measures of variation represent pseudo-replication. This relates to my comments in the first question. I believe the best way to determine the effects of Program water activities on physical parameters that are thought to be of significance to pallid sturgeon would be to conduct the Stage Change Study in multiple reaches (i.e., the reaches are the experimental unit). Although one could argue that reaches are not independent, I surmise that it better represents available habitat for pallid sturgeon and the influence of Program water activities on that habitat. The most important aspect of having multiple reaches is that one will have a better understanding of the uncertainty of Program related water activities on pallid sturgeon habitat.

If the answer to any of the questions above is "no", please suggest possible remedies to data collection methodologies, analysis, or other study tasks.

General Comments:
1. Scientific soundness

See comments above regarding replication.

2. Organization and clarity

I believe the report could be more clearly organized. One thing that would help is standardization with primary, secondary, and tertiary headings. Executive summary and conclusion sections would also be helpful.

3. Conciseness

The report is concise.

4. Degree to which conclusions are supported by the data

Again, see comments above. Overall, I believe the conclusions are supported by the data, but the robustness of the data and conclusions could be enhanced by a better experimental design.

5. Cohesiveness of conclusions

Specific Comments:
Please support your general comments with specific evidence and literature. You may write directly on the manuscript, but please summarize your handwritten remarks separately. Comment on any of the following matters that significantly affected your opinion of the manuscript:
1. Presentation: Is a tightly reasoned argument evident throughout? Does the manuscript wander from the central purpose?

I believe the authors could do a better job of organizing the methods, results, and discussion by question being addressed.

2. Methods: Are they appropriate? Current? Described clearly and with sufficient detail so that someone else could repeat the work?

See above.

3. Data presentation: When results are stated in the text of the manuscript, can you easily verify them by examining tables and figures? Are any of the results counterintuitive? Are all tables and figures clearly labeled? Well planned? Too complex? Necessary?

Data presentation is excellent and can verify the results with the tables and figures. Some of the figure captions could be expanded to provide more substantive information.

4. Statistical design and analyses: Are they appropriate and correct? Can the reader readily discern which measurements or observations are independent of which other measurements or observations? Are replicates correctly identified? Are significance statements justified?

See above. This is the major shortcoming of the study. That is, I believe the measurements for most analyses are not independent (i.e., true replicates). I would encourage the authors to clarify their experimental units and replicates and explain how they are relevant to the inference space described in the RFP.

5. Conclusions: Has the author(s) drawn conclusions from insufficient evidence? Are the interpretations of the data logical, reasonable, and based on the application of relevant and generally accepted scientific principles? Has the author(s) overlooked alternative hypotheses?

See above.

6. Errors: Point out any errors in technique, fact, calculation, interpretation, or style.

See above.

7. Citations: Are all (and only) pertinent references cited? Are they provided for all assertions of fact not supported by the data in the manuscript?

RATING:
Please score each aspect of this manuscript using the following rating system: 1=excellent, 2=very good, 3=good, 4=fair, 5=poor.

Rating
Scientific soundness _3__
Degree to which conclusions are supported by the data _3__
Organization and clarity _4__
Cohesiveness of conclusions _3__
Conciseness __2_
Importance to objectives of the Program _2__
(For use by internal review panel only)
RECOMMENDATION (check one)
Accept ___
Accept after revision __x_
Unacceptable ___

Reviewer #3

Dr. Dennis R. Helsel

Expertise: Environmental Statistics

TECHNICAL REVIEW OF
" Lower Platte River Stage Change Study Final Protocol Implementation Report, Version 1.0", dated December 2009

A. Lower Platte Stage Change Study Peer Review Questions

1) Does the Stage Change Study adequately address the overall objective of the RFP, which is "…to develop information needed to evaluate the effects of Program water management activities, including new activities covered by state or federal depletion plans, on water stage and how those stage changes affect physical parameters in the reach of the lower Platte River from the Elkhorn River confluence to the Missouri River confluence?"

   The Study adequately addresses the relative magnitude of stage change due to management activities in relation to existing flows and habitat of the pallid sturgeon. It does not discuss the proposed changes in light of existing appropriations and any current legal constraints on flow in the Platte River. In other words, if these diversions were implemented would they impact the water rights of existing rights owners? The method for extrapolation of missing record to the Loup River at Columbus is flawed, and so the resulting errors on the analysis are unknown.

2) Are the physical parameters and measured data considered in the study (flow quantity, depth, velocity, temperature, turbidity, sediment, and sandbars and bedforms at selected sites throughout the study reach) adequate and scientifically defensible for the purposes of the study?

   The data themselves are presumably scientifically defensible. They are fairly routine parameters with established protocols for collection. The amount of data is adequate. Analysis of the data is not adequate, if the purpose is to determine whether proposed flow augmentation and withdrawals for storage will significantly affect those parameters.

3) Are the habitat classifications considered in the study (slackwater, flat, riffle, run, isolated pool, and plunge) adequate and scientifically defensible for the purposes of the study?

   This is not my area of expertise.

4) Is the Stage Change Study sufficient to determine if First Increment Program water activities can be detected (statistically significant beyond the error of the gauging equipment) from base flow conditions?

   Yes. Given that equipment and gauging error is listed as 10% (presumably +5% and -5%0, the Study determined that flow changes such as those on page 24, going from 5,040 cfs to 3,290 cfs, are expected to be much greater than 5% (the direction is known), and so will be detectable as different from base flow conditions.

5) If "yes" to Question #4 above, is the Stage Change Study sufficient to detect if First Increment Program water activities have an impact (statistically significant beyond the error of the gauging equipment) on stage, velocity, temperature, turbidity, substrate, or channel morphology?

   No. Determination of differences in water quality parameters using Analysis of Variance is flawed because the serial correlation in the data was not accounted for. The current analysis is not sufficient to determine whether there are significant impacts for these parameters.

6) Are the findings of the stage change study and the conclusions reached in the report supported by the data and analysis?

   The Study's conclusions in regards to flow are supported by the data and analysis. The conclusions in regards to water quality parameters are not. The conclusions in regards to effects on habitat are beyond my area of expertise, but appear to be the most thoroughly supported portion due to the modeling work.

B. Specific Comments, by page

One fundamental problem with the Study is that many analyses were based on two apparently unpublished reports by the USFWS (2002 a and b). Results hinge so much on these draft reports that some statement from the Service should be included that verifies that the analyses, spreadsheets, etc. in these reports are valid, and that they received peer review and were considered accurate, even though the reports were never published. Or if this is not the case, a statement to the effect that the analyses were never peer reviewed or verified. Citations in this Study to those two reports usually do not discuss the methods that produced the conclusions, or speadsheets, or whatever product is being cited. The citations imply that what was reported is accepted as truth. What were the quality of these methods? Are there any plans for reviewing, verifying and publishing these 10-year old reports?

Page 3. An example of the dependence on these two reports is the method used for extrapolation from one gage to another using regression. This procedure has for years been known to dampen variability in flows, as regression predicts mean values. So the predicted daily flows for 30 years at the Loup River at Columbus (1978-2008) relied upon in this report will not be as variable, high or low, as would have been the actual record if it had been measured. Other methods for extrapolation (one is often called MOVE or LOC) are preferred when the probability of hitting a high or low flow is at issue, which it is here. These probabilities of high and low events will be underestimated, as regression by design predicts values towards the center. Given that the referenced report was never taken beyond draft, methods in that report including this one may be less than 'industry standard'.

Page 4. Please make the method for estimating missing evaporation data more clear. Were simply long-term monthly averages used? That is what is implied in the text. Or were monthly temperatures for the period to be estimated incorporated as well, so an unusually hot June for example had higher evaporation than the long-term average for June?

Page 4. Isn't the statement that "the effect of flow changes in the central Platte River for the magnitude currently envisioned under the Platte River Program are not likely to be detectable at Louisville, Nebraska" (USFWS, 2002b)" one of the questions that this Study is to answer? Why then cite the answer, from a draft report at that, here, with implied great authority? No background or insight into the method the USFWS used to make this conclusion is presented here. I'd suggest you delete this statement until later after you have presented your analysis of this question. From my reading of the analysis, the Study finds that the flow changes will certainly be detectable at Louisville, decreasing "...the flow at Louisville from 5,040 cfs to 3,290 cfs" (from page 24). So if not deleting the statement, make sure it is clear that this report finds a different result.

page 5. Data are not "illustrated" in a table such as Table 5. They are "listed". If they should be illustrated, draw a figure. Tables don't illustrate anything.

Page 5. What is the objective of determining whether "water quality data can differentiate between flow conditions"? This implies that the flow data cannot differentiate, and that water quality might be needed to do this. Or do you mean "water quality is different at different flow conditions"? The latter is focused on water quality, rather than on using it to say something about flow. Clarify the objective for why this analysis is being undertaken.

Page 5. Your title "Accuracy Assessment of USGS Stream Gage Measurements" is misleading. You aren't doing an assessment of the accuracy of their methods. No data were collected to do so. You are just using their own accuracy assessment to compute the magnitude of 10 percent of observed flows. You should rename this section. Then you compute tables of differences in uncertainty estimates (Tables 4 and 6) without stating what these are good for, or how they came about. Was the method used in the USFWS report different from yours, and therefore the differences? If so, what were the two methods and why do you think they differ? Or are these the same methods just applied to different time intervals, and no change in the physical system has occurred? If this is true, then discuss how this helps you and how the difference in flows between 1975-1994 and 1995-2008 produce the observed differences listed in Tables 4 and 6

Page 8. I have no idea what "Program staff also provided some preliminary information evaluating the pulse flow event to the Grand Island gage" means. Please reword or delete if not important.

Page 9. So your conclusions here are that a release of 13K AF upstream is not really discernable by the time it travels downstream to Louisville. What are the implications of this for your later findings, given that the later findings seem to disagree with this?

Modeling section. You found that you have well-calibrated models, and that the Platte acts like most other rivers in scouring the bed during high flows, increasing channel depth. You have a handle on the types of bedforms and bars likely present at differing flow regimes. This was translated into models of the amount of habitat available for different flow regimes. You evaluate uncertainty in habitat computations based on differences between measured and modeled flows. However this underestimates the true error, as errors for calibration data are always smaller than verification data not used to calibrate the model. A verification step of some sort, possibly a cross-validation procedure, should be used to quantify uncertainties instead. Yours are very likely too small.

Page 21. These daily values are not independent. Analysis of variance (as well as other standard statistical tests) assume independence of observations, that there is no sequential correlation. There certainly is for day to day measures of temperature and water depth, and probably for the other parameters as well. The result is that sample sizes are incorrect, that 46 observations for September 2008 for example may have the equivalent information of 20 independent observations. Therefore the test should be run using n=20 rather than 46, and the differences between months may with reduced sample sizes actually not be significant. Because this was not considered, these tests do not prove that differences actually have occurred between months. The tests should be run by correcting for serial correlation, which can be done with more complex software, or by more simply computing the 'effective sample size' that is a function of the magnitude of correlation between observations in the time series.

page 21. Serial correlation similarly invalidates standard power calculations. No detail on how power was calculated is given here. Standard ANOVA power calculations assume both independence and a normal distribution, and turbidity and depth data are probably not normally distributed (the others may be based on working with similar data). Much more detail should be given here on the procedure of the power calculations.

Page 22. Even more importantly, the questions that the power analysis and ANOVA are addressing should be explicitly stated. What is the value in these analyses? State why you are performing them.

Page 22. Figures 42 and 43 are stated as being composed of only the May 2009 data. Yet on page 23 they are used to compare to conditions at other additional times. This isn't valid, certainly for temperature. In addition, the data should be tagged and color coded by rising and falling stages of the hydrograph. Part of the large variation for similar discharges is due to differences between water quality when the storm is rising versus falling. Turbidity can certainly be expected to be very different for the same discharge depending on which limb of the hydrograph it occurs on.

Page 23. The meaning of the statement " the magnitude of the change in discharge is subject to the same uncertainty as the overall flow" is unclear. Be more specific or delete this.

Page 23. The statement " the increase in discharge does not move the conductivity, turbidity, temperature, or dissolved oxygen outside the typical range preferred by pallid sturgeon (Figures 42 and 43)" is too broad and sweeping of a statement considering that the figures are based on data only from one month, and you've already stated that based on an ANOVA the levels of these parameters differ between months. Graphs of the relationship between these parameters and discharge should be based on data from all four months of interest where diversions are expected (note that May is not one of those months and so is incorrectly used for the data in these graphs), while considering variation due to rising vs falling hydrograph and to temperature effects. In short, you cannot use the current graphs to make the conclusion you are heading toward.

page 24, a typo? The Run classification would be reduced from 45% to 34%, a decrease of 1%??? Plus, you report different values in Appx G. Please clarify.

C. Rating

Please score each aspect of this manuscript using the following rating system:
1=excellent, 2=very good, 3=good, 4=fair, 5=poor.

	Rating	
Scientific soundness	___3____	sections vary
Degree to which conclusions are supported by the data	___4___	
Organization and clarity	___4___	
Cohesiveness of conclusions	___4___	
Conciseness	___2___	
Importance to objectives of the Program	___3___	

RECOMMENDATION	Check One
Accept	________
Accept after revision	___X____
Unacceptable	________

Reviewer #4

Dr. Larry J. Weber

Expertise: River Hydraulics and Mechanics, River Restoration, and Computational Modeling

Larry J. Weber

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September 16, 2011

Eliza Hines
Senior Scientist, Integrated Water Resources
ATKINS
701 San Marco Blvd Suite #1201
Jacksonville, FL 32207

Contract: Platte River Stage Change Peer Review

Dear Ms. Hines,

I have completed my peer review of the Platte River Stage Change study as defined in the scope of work document transmitted to me 16 August 2011. In particular, I have reviewed all of the documents provided including the original project RFP, the Protocol Development Report, the Final Implementation Report, and all appendices and associated documents. My review report includes answers to the *Peer Review Questions* and responses to the *Guidelines for Peer Reviewers*. Although my comments will include all technical aspects of the report, my primary expertise in the context of this work relate to hydraulic modeling and river hydrodynamics.

__Peer Review Questions__

1) Does the Stage Change Study adequately address the **overall objective** of the RFP, which is "...to develop information needed to evaluate the effects of Program water management activities, including new activities covered by state or federal depletion plans, on water stage and how those stage changes affect physical parameters in the reach of the lower Platte River from the Elkhorn River confluence to the Missouri River confluence?"

   The report does adequately address the overall objective as stated. The report is logically organized and compete, however, it would be helpful to include a background section early in the report that describes the type of flow conditions being considered to place the study in context.

2) Are the physical parameters and measured data considered in the study (flow quantity, depth, velocity, temperature, turbidity, sediment, and sandbars and bedforms at selected sites throughout the study reach) adequate and scientifically defensible for the purposes of the study?

   Yes, the physical parameters are adequate and scientifically defensible. Clearly, the need for improved scientific understanding of selection and utilization of specific, local flow conditions (both hydrodynamics and water quality) and habitat-scale flow patterns that pallid sturgeon prefer is still needed, but outside of the scope of this project. The report does a very good job of describing available data and current understanding and utilizing this information to reach the conclusions.

3) Are the habitat classifications considered in the study (slackwater, flat, riffle, run, isolated pool, and plunge) adequate and scientifically defensible for the purposes of the study?

   Yes, the habitat classifications are adequate and scientifically defensible. In addition, to the uncertainty analysis and quantification of habitat areas by type, it would be helpful to include a broader discussion about the space-time utilization of individuals that may be residing or moving through the area. For instance, "what is known about adjacencies or distributions of habitat types", this may be important for habitat utilization and may be impacted by stage change. From the information it did not appear that distribution or adjacency would change, but would be good to include this in the discussion.

4) Is the Stage Change Study sufficient to determine if First Increment Program water activities can be detected (statistically significant beyond the error of the gauging equipment) from base flow conditions?

   Yes, the report clearly addresses the detectability of the stage change from Program Water activities. It would be helpful, within the discussion section to refer to the stage discharge curves for the reach.

5) If "yes" to Question #4 above, is the Stage Change Study sufficient to detect if First Increment Program water activities have an impact (statistically significant beyond the error of the gauging equipment) on stage, velocity, temperature, turbidity, substrate, or channel morphology?

   Yes, the report addresses the impact of the stage change on the river parameters listed. It would be helpful to list other parameters that may be important, such as flow shear lines, and eddy structures, however, less is know about these features than the parameters given. With that said, some acknowledgement that the parameters considered may not be the only flow features that determine habitat function and utilization would be useful. The second to last paragraph of the report provides some comments towards this, but could be expanded.

6) Are the findings of the stage change study and the conclusions reached in the report supported by the data and analysis?

   Yes, the findings of the study and conclusions reached are supported by data and sound engineering and scientific analysis. It would be beneficial to include an executive summary of the report and a clear conclusions / summary section in the report

General Comments

1) Scientific Soundness – The methods and approaches were based on sound engineering and science. Unfortunately, although there is literature and past studies that describe

general habitat preferences and utilization, there is little available information from a first-principles understanding of specific habitat needs for the species of interest. This short-coming is, however, common in most aquatic restoration and management programs. The project report uses sound, available engineering and science to address this inherent uncertainty in its habitat evaluation. Although further studies and fundamental research could improve this understanding, it is clearly outside of the scope of this project.

2) Organization and Clarity – The report logically presents the engineering analysis of the hydrologic conditions of the study reach; data collection programs; hydraulic model construction, calibration and utilization; geomorphic assumptions and analysis, flow habitat assumptions and habitat discrimination technique; and conclusions. Uncertainties of methods, models and approaches are adequately described throughout the report.

3) Conciseness – The report is well written and presents an appropriate amount (both depth and breadth) of information. The report also, includes relevant information in the appendices and adequately sites previous and related published work.

4) Degree to which the conclusions are supported by the data – The report provides a logical progression from hydrologic conditions of the study reach through final conclusions, including the uncertainty of information utilized in the decision process.

5) Cohesiveness of conclusions – The formulation of the conclusions is based on sound engineering and science. The conclusions/summary statements should have been explicitly organized in a closing, *Conclusion* or *Summary* section in the report rather than simply woven into the *Discussion* section.

Specific Comments

1) In the discussion of minimum and maximum flow selection, a flow recurrence / exceedance plot would be helpful to place the selected flows in context, rather than referring to figure 2. Also the period of record should be stated for this analysis in the Study Flows section.
2) x-axis of figure 2 should use the first day of the month for each major grid line and label
3) A better location map would be helpful to locate the study reach within the state and along the Platte River Stream network.
4) It would be helpful to explicitly state that the 2D SRH model is a fixed bed model and this geometry is used throughout for all simulations. How this impacts the local flow conditions for higher flows should be addressed.
5) Figures 24, 25 and 26 are useful data plots, however, it would be helpful to see the distribution of the difference between model and field data on a spatial image of the study area. This would be helpful to understand the performance of the model, but likely does not negatively impact the use of the model results.
6) Page 24, first paragraph after table 13. ….45% ($\pm$8%) of the habitat area to approximately 34% ($\pm$8%) of the habitat area, a decrease of 1%. The "1%" should be "11%".

7) Discussion section. In addition to the text description, it would be helpful to tabulate the changes to habitat classification in the discussion section. This to compare across conditions of interest, and to show the impact of the management actions.

Rating (1=excellent, 5=poor)

Scientific soundness	2
Degree to which conclusions are supported by the data	2
Organization and clarity	1
Cohesiveness of conclusions	2
Conciseness	1

Comment: Overall this is a very good study report, providing insight and comprehensive summarization of multiple data sets. My decision not to use ratings of '1' is primarily a result of the inability to basic first-principles understanding and analysis, which is currently unavailable for this complex project. I have no hesitation in recommending acceptance of the report

Recommendation

Based on my review of the materials provided, it is my recommendation to accept the Final Protocol Implementation Report and its conclusions.

Please do not hesitate to contact me if I can be of any further assistance.

Sincerely,

Larry J. Weber

Reviewer #5

Dr. Lee Wilson

Expertise: Hydrology, Environmental Impact Assessment, Geomorphology

In accordance with my contract, I have conducted a peer review of the Lower Platte River Stage Change Study. The review is organized according to my understanding of the peer review guidelines, as follows.

1. General comments.
2. Specific comments.
3. Response to questions.
4. Ratings.

I will be on travel until mid-October, after which I will be available to answer any questions on this submittal.

I appreciate being selected to be part of the peer review team, and in that way to contribute to the Platte River Recovery Implementation Program.

1. General comments

I consider the core elements of the study to be technically sound and useful. With some exceptions noted below, the work satisfied the scientific and technical scrutiny that was within my expertise to apply, and within the peer review budget to investigate. The study report appears to satisfy the objectives of the RFP.

In my experience, a role of peer review is to focus on potential weaknesses or limitations in a study. Thus the critical nature of my comments should not be taken to suggest the study is seriously flawed, but rather as my effort to provide constructive input to future work. In the specific comments, I observe the following aspects of the study that I thought might be in most need of improvement or of further evaluation.

- For purposes of organization and clarity, it would be beneficial to provide an introduction that puts the study in context. See specific comments on p. 1.
- I suggest reconsidering the methodology and results of the loss analysis. See specific comments on p. 2.
- The effects of flow modification by hydropower appear to be potentially profound and need further evaluation. See specific comments on p. 8.
- The apparent rigor of certain of the analyses does not fully capture the uncertainty in the bottom line results. See specific comments on p. 20.

The following are responses to particular considerations posed in the peer review guidelines ("guidelines"), under the heading of general comments.

- *Scientific soundness*. The technical aspects of the document were generally good, with possible exceptions noted under Specific Comments.
- *Organization and clarity*. The Specific Comments (especially regarding Pages 1 and 9) identify ways the organization and clarity of the report could have been improved by providing additional background discussion. That being said, within what was actually presented, the report was well organized and well written.
- *Conciseness*. Good.
- *Degree to which conclusions are supported by the data*. Hard to say without copies of the data sets, spreadsheets, and models.
- *Cohesiveness of conclusions*. Ok within the context of the report. But there is so much unsaid, that a stranger to the process might not be able to properly judge the end results.

2. <u>Specific comments</u>

My specific comments are provided in two parts. First, I respond to considerations set out in the guidelines. Then I go through the document and present comments that are specific to particular pages. For Pages 1, 2, 3, 9, and 20 these include expanded discussions of the bullet points presented in my general comments above.

1. *Presentation: Is a tightly reasoned argument evident throughout? Does the manuscript wander from the central purpose*? The true central purpose is never stated. Within the organization as presented, the report does a good job of walking through the methods, data and results without any wandering.

2. *Methods: Are they appropriate? Current? Described clearly and with sufficient detail so that someone else could repeat the work*? Except for the evaluation of losses, the methods are appropriate and current. The level of detail in methods is good. I don't know enough about the models to know if one could repeat the work, but I suspect it would be necessary to get the actual model I/O files to do so.

3. *Data presentation: When results are stated in the text of the manuscript, can you easily verify them by examining tables and figures? Are any of the results counterintuitive? Are all tables and figures clearly labeled? Well planned? Too complex? Necessary?* Good marks on all of this.

4. *Statistical design and analyses: Are they appropriate and correct? Can the reader readily discern which measurements or observations are independent of which other measurements or observations? Are replicates correctly identified? Are significance statements justified?* A lot of attention is paid to statistical determinations, but there is a fair amount more that could and probably should have been said. See comments on P. 20.

5. Conclusions: Has the author(s) drawn conclusions from insufficient evidence? Are the interpretations of the data logical, reasonable, and based on the application of relevant and generally accepted scientific principles? Has the author(s) overlooked alternative hypotheses? I found the overall results acceptable, since they agreed with what was fairly evident even without the study, that no significant relationships can be quantitatively established.

6. *Errors: Point out any errors in technique, fact, calculation, interpretation, or style*. My review was not in depth, but I found nothing of concern except for the loss analysis (see comments on P. 2).

7. *Citations: Are all (and only) pertinent references cited? Are they provided for all assertions of fact not supported by the data in the manuscript*? It's a good reference list.

Page 1. In my first paragraph of general comments, I said the study appears to satisfy the objectives of the RFP. I used the word "appears" because neither the RFP nor report does a good job of placing the study objectives into context, i.e. explaining to what ultimate purpose the work was being done. To understand the work, I relied on the Biological Opinion and the limited discussion in the Protocol. I don't fault the authors for this necessarily, as it isn't clear from the RFP that they were tasked to provide context in the report.

Nonetheless, the lack of context made reading and evaluating the report much more difficult than it should have been (at least for me). The standard organization for a scientific paper includes an introduction that presents the background knowledge necessary for the reader to understand the findings of the paper. This is especially important when, as here, there is no executive summary to bring everything together.

In this case the following would have been useful in providing the reader with important background knowledge.

- A brief synopsis of the nexus between stage and sturgeon as it is now understood. Note that the fact that this paper is about pallid sturgeon isn't even mentioned until halfway through the report (p. 14).
- One or more hypotheses about how the Program could impact that nexus (including a "non-detect" hypothesis). This would disclose the current thinking about why the study reach is important to sturgeon, and why we are interested in predicting impacts to depth, velocity, bedforms, topography and the like.
- A clear and succinct statement of the methodological approach to evaluating the hypotheses. This might be a flow chart indicating that first we have to route Program flows to the reach; then model their impact on the parameters of interest; which means very complex hydraulic models and interpretations relating especially to bedforms; and finally translate that to impacts to sturgeon habitats. It may seem obvious, but that doesn't mean the report shouldn't be clear about what is being done.

In between pages 1 and 2. Figure 1 would benefit from an inset location map.

Page 2. The loss analysis is an update of a FWS study provided in Appendix A. It is difficult to fully evaluate the method without a copy of the spreadsheet. Nonetheless, I was very surprised about the results, and wonder if the Program is approaching this important issue correctly. I did not review Appendix A in sufficient detail to know for sure that my concerns are valid, so please consider this discussion accordingly.

My two primary concerns are as follows.

- Some of the loss rates reported are much higher than I have seen, even in arid western rivers. If it has not been done, I strongly recommend each element of the loss be independently verified. For example, analytical methods using groundwater head data can be used to independently estimate seepage losses.
- It appears that the method calculates Program losses in proportion to flows. An alternative (and in my experience more appropriate) approach is to calculate them on an incremental basis. If the current procedure has not been affirmatively deemed more appropriate than an incremental approach, the incremental method should be

To illustrate my concern, consider the result of the accounting done by the Bureau of Reclamation for the loss of water imported into the Rio Grande Basin (this loss rate is important for quantification of endangered species impacts as well as available water supplies). Based on quantification conducted by the Rio Grande Compact Commission, a loss rate has been calculated for the reach from Heron Reservoir (near the Colorado border on a tributary of the Rio Chama) to Albuquerque (a distance roughly comparable to Grand Island-Louisville). The loss rate applies to the flow added to natural flow by imported water. There are elements of the rate calculation that are not entirely apples-apples to that made for the Lower Platte, but these would have a modest effect at most. The Rio Grande loss rate is 2%. Given this result, it is difficult for me to understand loss rats as high as 90% in eastern Nebraska.

The subject of losses above Grand Island is not considered, but it would be of interest to know the Louisville flow as compared to an upstream reservoir release

The following comment is not related to the above, but to the reference to selection of “appropriate” flows on page 2. Appropriate how? With no discussion of matters such as sturgeon habitat, the reader cannot know. It is also confusing to indicate that a flow of 39,000 cfs is of “primary interest”, without explaining why it was then appropriate to use 8,000 cfs as the high end of flows selected.

Page 3. I did not understand how the study made use of two different periods of record for extended analysis.

Page 4. The new spreadsheet analysis probably should be provided in an Appendix.

Page 5. The power analysis probably should be provided in an Appendix.

Page 6. The focus on gage uncertainty may cause readers to overlook the uncertainty in the USFWS spreadsheet which estimates impacts of Program flows.

Page 7. In addition to the plots in Figures 3, 4 and 4a, it would be interesting to see the data plotted as flow duration curves.

Page 8. This page presents Figure 5 and makes note of the "obvious" intraday flow variation. The discussion focuses on how to smooth that out so the pulse can be translated from Grand Island to Louisville, which is certainly appropriate. However there is no discussion whatsoever about the fact that the hydropower effect causes a 1 foot diurnal change in stage, which is far greater than the transformed impact of the pulse.

The implied premise of the study is that stage impacts habitat, through effects on velocity, depth and bedforms. If so, how is it that the effects of such a large and rapid stage change are not considered at all? Had the study found that Program releases did impact habit in the study reach, that conclusion would have been called into question because the interday flow variation was not considered and could be such that it swamped out any Program impact.

Page 9. Another aspect of context that wasn't effectively presented was the cause-effect relationship being studied. The stated objective puts "stage" as the focal point, whereas after reading the report, I perceive the operational objective was to evaluate the impact of flow (cfs) as it directly impacts water depth and velocity, and the consequent effects on sediment, bedforms and habitat. Stage as such seemed not to be that much of a consideration, or a particularly good surrogate, especially in terms of assessing velocity and its consequences. The lack of hypotheses was surprising given the nature of the Adaptive Management Plan.

Page 10. Given that stage is the focus of the study, are two water surface data points sufficient for the cross-sections?

Page 11. It would be useful to have an assessment of the change in roughness with flow, and especially whether it is reasonable to interpolate values.

Page 12. I did not follow the explanation of the very low n values for the 2D model.

Page 15. The entire bedform discussion would benefit from illustrations.

Page 19. I found Figure 36 hard to interpret.

Page 20. The use of a Monte Carlo analysis to assess uncertainty gives an impression of statistical rigor to the results. Certain other aspects of the work give a similar impression. However if one starts at the very beginning of the work, i.e. an increment of flow at Grand Island (with unstated uncertainty), and carries it through to the end, many other issues become apparent – the loss estimates, hydrograph translation, error bars on model inputs (median grain size is a good example), and more. This cascade of uncertainties would have undermined the results had a positive relationship been found. As the bottom line of the report did not assert any relationships had been statistically demonstrated, these issues are perhaps not critical. Still, I would have liked to see (in the discussion section) a recap of all the assumptions, limitations and uncertainties in the work.

Page 22. Of interest given prior discussion, the models are (correctly) said to evaluate depth and velocity, not "stage change". One question not posed previously: why is the release being evaluated so small?

Page 25. Perhaps emphasize that lack of statistical significance does not equal lack of effect. In fact, qualitatively one can say that a release probably does have at least marginal benefit (this is a bit more affirmative than "no additional stress").

3. Response to questions

1) *Does the Stage Change Study adequately address the overall objective of the RFP, which is "…to develop information needed to evaluate the effects of Program water management activities, including new activities covered by state or federal depletion plans, on water stage and how those stage changes affect physical parameters in the reach of the lower Platte River from the Elkhorn River confluence to the Missouri River confluence?"* Yes, subject to comments above.

2) *Are the physical parameters and measured data considered in the study (flow quantity, depth, velocity, temperature, turbidity, sediment, and sandbars and bedforms at selected sites throughout the study reach) adequate and scientifically defensible for the purposes of the study? Yes, to the extent that they can actually be meaningfully evaluated by the methods used.*

3) *Are the habitat classifications considered in the study (slackwater, flat, riffle, run, isolated pool, and plunge) adequate and scientifically defensible for the purposes of the study? This is a good example of a subject that can't be evaluated if one considers the report in isolation, because habitats get minimal attention in this report.*

4) *Is the Stage Change Study sufficient to determine if First Increment Program water activities can be detected (statistically significant beyond the error of the gauging equipment) from base flow conditions?* Yes and No. Yes the study answered the question; no, program activities (as to flow)

cannot be detected. Effects of other activities (sediment mobilization for example) were not assessed.

5) *If "yes" to Question #4 above, is the Stage Change Study sufficient to detect if First Increment Program water activities have an impact (statistically significant beyond the error of the gauging equipment) on stage, velocity, temperature, turbidity, substrate, or channel morphology*? No.

6) *Are the findings of the stage change study and the conclusions reached in the report supported by the data and analysis*? Yes, especially given the conclusion is "did not find".

4. Rating

RATING:
Please score each aspect of this manuscript using the following rating system: 1=excellent, 2=very good, 3=good, 4=fair, 5=poor.

Scientific soundness: 4
Degree to which conclusions are supported by the data: 5
Organization and clarity: 4
Cohesiveness of conclusions: 4
Conciseness : 5
Importance to objectives of the Program: 3

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

EXHIBIT C

Stage Change Study Peer Review Scope of Work

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
Scope of Work
Lower Platte River Stage Change Study Peer Review

Purpose of Peer Review

The Lower Platte River Stage Change Study was completed in early 2010 by a contractor team led by HDR pursuant to the Platte River Recovery Implementation Program ("Program" or "PRRIP") RFP (Request for Proposals) dated 12/10/2007 (Attachment 1). The purpose of this peer review is to provide independent review of the stage change study to determine if it satisfies the objective(s) of the RFP and withstands scientific and technical scrutiny.

The purpose of the stage change study is to serve as a tool to assist the Governance Committee (GC) in determining the effect of "Program related flow effects", if any, over time on lower Platte River stage and associated parameters thought to be of significance to pallid sturgeon. The stage change study was not intended to define lower Platte River pallid sturgeon "habitat", evaluate the quantity or quality of pallid sturgeon habitat in the lower Platte River, or document or evaluate use of habitat by pallid sturgeon in the lower Platte River.

For the purposes of the stage change study, the spatial scale of the lower Platte is the "associated habitat" for pallid sturgeon. As defined by the Program, the associated habitat is the reach of the lower Platte River from its confluence with the Elkhorn River downstream to its confluence with the Missouri River (mouth of the Platte River).

Scope of Work

Each Peer Review Panel member will be tasked with reviewing the Stage Change Study from their particular area of expertise following the PRRIP Peer Review Guidelines for Reports & Studies (Attachment 2). Peer reviewers will be asked to submit all comments, questions, and other communication in writing to ensure an appropriate record is built, and all communication with peer reviewers will be conducted via e-mail. Peer Review Panel members will be provided with the following information:

- Lower Platte River Stage Change Study Peer Review Scope of Work (PRRIP)
- Final Lower Platte River Stage Change Study, including all appendices and figures (HDR)
- Final Stage Change Study Protocol Development Report (HDR)
- Final PRRIP Stage Change Study RFP (PRRIP)
- PRRIP Peer Review Guidelines for Reports & Studies (PRRIP)
- Additional information as requested by Peer Review Panel members – if a document(s) is requested by one member, it will be transmitted to all members simultaneously

Specific Questions

Review of the Stage Change Study should address the following specific questions:

1) Does the Stage Change Study adequately address the **overall objective** of the RFP, which is *"…to develop information needed to evaluate the effects of Program water management activities, including new activities covered by state or federal depletion plans, on water stage and how those stage changes affect physical parameters in the reach of the lower Platte River from the Elkhorn River confluence to the Missouri River confluence"*?

2) Are the physical parameters and measured data considered in the study (flow quantity, depth, velocity, temperature, turbidity, sediment, and sandbars and bedforms at selected sites throughout the study reach) adequate and scientifically defensible for the purposes of the study?

3) Are the habitat classifications considered in the study (slackwater, flat, riffle, run, isolated pool, and plunge) adequate and scientifically defensible for the purposes of the study?

4) Is the Stage Change Study sufficient to determine if First Increment Program water activities can be detected (statistically significant beyond the error of the gauging equipment) from base flow conditions?

5) If "yes" to Question #4 above, is the Stage Change Study sufficient to detect if First Increment Program water activities have an impact (statistically significant beyond the error of the gauging equipment) on stage, velocity, temperature, turbidity, substrate, or channel morphology?

6) Are the findings of the stage change study and the conclusions reached in the report supported by the data and analysis?

If the answer to any of the questions above is "no", please suggest possible remedies to data collection methodologies, analysis, or other study tasks.

General Comments

Review of the Stage Change Study should also address more general comments and questions as outlined in the PRRIP Peer Review Guidelines for Reports & Studies. Please refer to Attachment 2 for information regarding these guidelines.

Peer Review Panel

The stage change study will be the first Program document peer reviewed in 2011. Potential reviewers will be screened and recommended by PBS&J. The GC will ultimately approve the members of the Peer Review Panel, but certain areas of expertise are considered essential for representation on this panel:

- Pallid sturgeon ecology (prefer experience with fish habitat modeling)
- Riverine physical processes/geomorphology
- River engineering and hydraulic modeling
- Hydrology and hydrologic analysis
- Ecological statistics

Budget Implications

Each Peer Review Panel member receive a stipend of **$5,000** for a total of **$25,000** (5 panel members X $5,000/each). Stipends will be paid from the PRRIP FY 2011 Budget Line Item *PD-3: AMP & IMRP Peer Review*.

ATTACHMENT #1

LOWER PLATTE RIVER STAGE CHANGE STUDY RFP

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
REQUEST FOR PROPOSALS

SUBJECT:	Lower Platte River Stage Change Study
REQUEST DATE:	December 10, 2007
CLOSING DATE:	January 18, 2008
POINT OF CONTACT:	Chad Smith – Executive Director's Office Platte River Recovery Implementation Program 6512 Crooked Creek Drive Lincoln, Nebraska 68516 (402) 261-3185 *smithc@headwaterscorp.com*

RECITALS

The Governance Committee of the Platte River Recovery Implementation Program (Program) submits this Request for Proposals (RFP) to solicit proposals from contractors to develop and implement a protocol for a lower Platte River (Nebraska) stage change study. The protocol will be used to define the final scope and budget for the stage change study, but proposals submitted in response to this RFP need to provide enough detail on the overall project to convey an understanding of the stage change study. The results of the study will serve as a tool for the Governance Committee to assist in determining the effects of flow changes over time on river stage and associated physical parameters thought to be of significance to pallid sturgeon (*Scaphirhynchus albus*).

In responding to this RFP, the Governance Committee requests the following information:

1) **Scope of work** for completing this project. Prospective contractor should address the tasks outlined herein.

2) **Detailed schedule** for completing each task in the preliminary scope. The following are the critical dates for the Governance Committee's preferred schedule for the project:

February 15, 2008	Protocol draft for Governance Committee review
March 31, 2008	Final Protocol/ Notice to Proceed with Protocol Implementation
September 30, 2008	Draft of First Progress Report on field work activities
December 31, 2008	Draft of Second Progress Report on field work activities
July 30, 2009	Complete field portions of study as defined in the Scope of Work
September 30, 2009	Submit draft report and other materials for review
December 31, 2009	Final Report

Prospective contractors should address their capability to comply with the above schedule. If it is deemed that the above critical dates should be revised, prospective contractors should offer alternative schedules describing the logic and reasons for the alternative.

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

4) **Detailed cost not to exceed proposal** to complete the project, separated into protocol development and protocol implementation. The proposal should identify costs and hours allocated for each task in the scope of work and the total cost for the study. Hourly rates and reimbursable expenses for the proposing firm/individual and any sub-contractors must be attached to the detailed price proposal. The contract will be awarded on a Cost Not to Exceed basis. The initial contract will be for protocol development. Governance Committee approval is needed before the contractor is authorized to begin protocol implementation.

5) **List of relevant project experience** within the past five (5) years, including name, location and brief description of the projects; name, address and phone number of the contracting officer for the client; and identification of key participants and their tasks on previous projects who would also be working on this study.

6) **Resumes** of key participants and subcontractors proposed for this study. The resumes should address experience on projects similar to this stage change study. Types of expertise that may be appropriate include familiarity with pallid sturgeon biology and the key physical parameters, river hydraulics and hydrology, the lower Platte River, and river monitoring and research techniques.

7) **Description of Insurance** shall be provided with the proposal. Proof of insurance will be required before a contract is issued. Minimum insurance requirements will include $1,000,000 general liability per occurrence. To the extent authorized by law, the contractor shall indemnify, save, and hold harmless the Nebraska Community Foundation; the states of Colorado, Wyoming, and Nebraska; the Department of the Interior; members of the Governance Committee; and the Program Executive Director's Office, their employees, employers, and agents; against any and all claims, damages, liability, and court awards including costs, expenses, and attorney fees incurred as a result of any act or omission by the contractor or its employees, agents, subcontractors, or assignees pursuant to the terms of this project.

8) **A pre-bid meeting** of interested parties will be held to address questions associated with this Request for Proposals at a time and location that will be set by the Program's Executive Director's Office.

Please submit one electronic copy of your proposal in PDF format by January 18, 2008 to Chad Smith at *smithc@headwaterscorp.com*.

Terms and Conditions: The selected contractor will be retained by:

Nebraska Community Foundation
650 J Street, Suite 305
PO Box 83107
Lincoln, NE 68501

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

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

Point of Contact: Questions regarding this RFP that could impact budget estimates or scope of services should be e-mailed to Chad Smith at *smithc@headwaterscorp.com*. Questions and responses will be provided by e-mail to all bidders.

SCOPE OF WORK FOR CONTRACT SERVICES

INTRODUCTION

The Platte River Recovery Implementation Program (Program) was initiated on January 1, 2007 between Nebraska, Wyoming, and Colorado and the Department of the Interior to address endangered species issues in the central and lower Platte River basin. The species considered in the Program, referred to as "target species", are the whooping crane, piping plover, interior least tern, and pallid sturgeon.

A Governance Committee has been established that reviews, directs, and provides oversight for activities undertaken during the Program. The Governance Committee is comprised of one representative from each of the three states, three water user representatives, two representatives from environmental groups, and two members representing federal agencies. The Governance Committee has named Dr. Jerry Kenny to serve as the Program Executive Director. Chad Smith, representing the Program Executive Director's Office, will be the primary contact for prospective contractors responding to this RFP.

NEEDS AND SCOPE

The overall objective of the study is to develop information needed to evaluate the effects of Program water management activities, including new activities covered by state or federal depletion plans, on water stage and how those stage changes affect physical parameters in the reach of the lower Platte River from the Elkhorn River confluence to the Missouri River confluence. **The physical parameters to be considered include flow quantity, depth, velocity, temperature, turbidity, sediment, and sandbars and bedforms at selected sites throughout the study reach, and over the range of discharges which are important in determining these parameters.**

In accordance with the Program's Adaptive Management Plan (AMP), the study should provide sufficient data to evaluate the effect of changes in river stage over a range of flows on a micro, meso, and macro scale. The following example is provided to help define these terms and provide a framework for the range of flows to be considered and the interval measurements that need to be made:

River Gage:	Louisville, NE (Station ID 06805500)
Range of River Flows:	5,000 cfs to 39,000 cfs (bankfull flows)
Precision Level:	90% confidence
Possible Measurement Interval:	Every 1,000 cfs (roughly 0.1 foot of stage change)

In responding to this RFP, potential contractors should provide information on the needed methods to obtain this data, the appropriate discharge/stage measurement intervals necessary for achieving the desired level of precision, and the efficacy of applying these methods over a larger range of flows. In addition, potential contractors can use guidance provided by the Program's Final Environmental Impact Statement (EIS) and the Final Biological Opinion (BO) to better understand the types of flow changes of concern and the related impact on the identified physical parameters. Copies of the relevant sections of the Final EIS and Final BO can be downloaded from the Program Web site (www.PlatteRiverProgram.org) or obtained from Chad Smith.

Given this framework, the study should provide information sufficient to estimate changes in the physical parameters identified above, across the identified range of flows and the three scales of measurement intervals, that occur during the study period and as can be determined from historic information. The intent should be to draw inferences to the types of process changes that would occur in the system as a result of river stage changes.

a. Information will be sufficient to determine if Program water activities can be statistically identified (significant beyond the error of the gauging equipment) from base flow conditions (AMP Hypothesis X-Y Graph PS-2).

b. Information will be sufficient to detect if Program water activities have a statistically significant impact on stage, velocity, temperature, turbidity, substrate, or channel morphology (AMP Hypothesis X-Y Graphs PS-3, PS-4, PS-6, PS-9).

This includes an emphasis on floodplain connectivity and the inundation of otherwise terrestrial habitat (not out of the high banks), and how both of these factors vary with flow.

Proposals should include the scope, timeline, and budget for developing a detailed protocol for estimating the effects of stage change on the identified physical parameters. The protocol will be reviewed by a selected Program sub-group before being finalized. The final protocol will be in sufficient detail to identify all aspects of data collection, analysis, reporting, and deliverables for the overall project. The final protocol and detailed budget estimate for actual implementation of the protocol will be provided to the appropriate Program sub-group and/or Advisory Committee for review. Approval of the protocol and budget by the Governance Committee is needed prior to the contractor proceeding with protocol implementation.

AVAILABLE INFORMATION

In addition to the Program Document and its AMP (Attachment 3), several additional sources of information are available to assist potential contractors in responding to this RFP. Many of these documents can be accessed either from the Program Web site (www.PlatteRiverProgram.org) or by contacting the originating party or Chad Smith.

1) In the late 1980's, the Nebraska Game and Parks Commission (NGPC) recorded transect information on sections of the lower Platte River for use with Instream Flow Incremental Methodology analysis. While this information may no longer be current, it allows historical comparisons in some stretches of river.

2) Multiple cross-sectional transect data collected by Mussetter, Inc. as part of a NGPC evaluation of the Sarpy County/Clear Creek Levee project.

3) Cumulative Impact Study for the Lower Platte River Corridor Alliance that may have some overlap with this study. The information includes a digitized series of aerial photographs of the lower Platte reach, and a GIS database covering a decadal time-step.

4) Several reports from Drs. Ed Peters and Jim Parham on pallid sturgeon use of the lower Platte River: one submitted to NGPC for a Federal Aid to Sport Fish Restoration Grant; one submitted to the Pallid Sturgeon/Sturgeon Chub Task Force; and one in press as a NGPC Technical Report.

5) Relevant sections of the Program's Final EIS and Final BO.

6) Completed and ongoing, studies conducted by the U.S. Geological Survey and other partners related to pallid sturgeon use of the Missouri River.

7) The National Research Council's report titled "Endangered and Threatened Species of the Platte River".

DELIVERABLES

The first project deliverable will be a draft protocol (see above discussion). The protocol will be reviewed and revised, as needed, before being finalized. Once approved, the protocol will be implemented as agreed upon by the contractor and the Governance Committee. Future deliverables will be clearly identified as one of the items in the protocol. It is anticipated that progress reports will be provided along with a final report. Other deliverables will include any raw data, models, and other documents or materials collected and/or developed as a part of the study. Data will be reported in accordance with guidelines outlined in the Program's AMP and the Program's Database Management System.

ATTACHMENT #2

PRRIP PEER REVIEW GUIDELINES FOR REPORTS & STUDIES

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
Excerpt from PRRIP Peer Review Guidelines – Reports & Studies

Instructions to Peer Reviewers

Thank you for agreeing to review this product. The following is a summary of expectations for peer-review and the topics that we wish each peer reviewer to address.

A. INDEPENDENCE OF A PEER REVIEW

Peer-review must provide an unbiased opinion of the scientific quality of a product (proposal, report, data, map, etc.) by individuals who are independent from the authors and external to them and their institution. A review must be independent of various types of conflicts of interest with the author(s) and with the product under review. The Platte River Recovery Implementation Program (Program) places considerable reliance on the objectivity, integrity, and professionalism of each peer reviewer to provide technical opinion of each product without bias or conflict of interest.

Please review each question about your bias or independence. Your peer-review will be anonymous to the author unless you choose to share it. Your review will be held in the file for the Program as documentation of the peer-review process for this product.

YOUR CONSIDERATIONS SHOULD INCLUDE THE FOLLOWING FACTORS THAT COULD LEAD TO BIAS OR CONFLICT OF INTEREST:

- Financial interest in the product or the author(s);
- Familial relationship with the author(s);
- Bias, for personal reasons, for or against the author(s) or institutions of this product;
- Professional connection (current or former: student or advisor, supervisor or supervised, employer, etc.) to the author(s) or the institution of this product;
- Organizational affiliation (same agency, department, organization, business, etc.);
- Impacts of lobbying or political pressure exerted by persons looking for a particular result or more work in the area of this product;

IF YOU FEEL THAT YOU CANNOT PROVIDE AN UNBIASED REVIEW, PLEASE DO NOT REVIEW THIS PRODUCT AND IMMEDIATELY RETURN THE DOCUMENT TO THE PROGRAM'S EXECUTIVE DIRECTOR.

CONFIDENTIALITY – The enclosed manuscript is a privileged communication. Please do not show it to anyone or discuss it, except to solicit assistance with a technical point. Your review and your recommendation should also be considered confidential.

TIMELINESS – In fairness to the author(s) and to the needs of the Program, please return your review within __ days. If it seems likely that you will be unable to meet this deadline, please return the manuscript immediately or contact the Executive Director.

CONFLICTS OF INTEREST – Please review "Independence of a Peer-Review" above. If you feel you might have any difficulty writing an objective review, please return the paper immediately, un-reviewed. If your previous or present connection with the author(s) or an author's institution might be construed as creating a conflict of interest, but no actual conflict exists, please discuss this issue in the cover letter that accompanies your review.

YOUR REVIEW SHOULD ADDRESS THE FOLLOWING:
What is the major contribution of this document? What are its major strengths and weaknesses, and its suitability for publication and/or use by the Program? Are conclusions based on sound scientific methods and reasoning? Please include both general and specific comments bearing on these questions and emphasize your most significant points.

General Comments:
1. Scientific soundness
2. Organization and clarity
3. Conciseness
4. Degree to which conclusions are supported by the data
5. Cohesiveness of conclusions

Specific Comments:
Please support your general comments with specific evidence and literature. You may write directly on the manuscript, but please summarize your handwritten remarks separately. Comment on any of the following matters that significantly affected your opinion of the manuscript:

1. Presentation: Is a tightly reasoned argument evident throughout? Does the manuscript wander from the central purpose?

2. Methods: Are they appropriate? Current? Described clearly and with sufficient detail so that someone else could repeat the work?

3. Data presentation: When results are stated in the text of the manuscript, can you easily verify them by examining tables and figures? Are any of the results counterintuitive? Are all tables and figures clearly labeled? Well planned? Too complex? Necessary?

4. Statistical design and analyses: Are they appropriate and correct? Can the reader readily discern which measurements or observations are independent of which other measurements or observations? Are replicates correctly identified? Are significance statements justified?

5. Conclusions: Has the author(s) drawn conclusions from insufficient evidence? Are the interpretations of the data logical, reasonable, and based on the application of relevant and generally accepted scientific principles? Has the author(s) overlooked alternative hypotheses?

6. Errors: Point out any errors in technique, fact, calculation, interpretation, or style.

7. Citations: Are all (and only) pertinent references cited? Are they provided for all assertions of fact not supported by the data in the manuscript?

FAIRNESS AND OBJECTIVITY
If the research reported in this paper is flawed, criticize the science, not the scientist. Harsh words in a review will cause the reader to doubt your objectivity; as a result, your criticisms will be rejected, even if they are correct!

Comments should show that:
1) You have read the entire manuscript carefully.
2) Your criticisms are objective and correct, and are not merely differences of opinion, and are intended to assist the author in improving the manuscript.
3) You are qualified to provide an expert opinion about the research reported in this manuscript.

ANONYMITY
You may sign your review if you wish. If you choose to remain anonymous, avoid comments to the authors that may serve as clues to your identity, and do not use paper that bears the watermark of your institution.

RATING:
Please score each aspect of this manuscript using the following rating system: 1=excellent, 2=very good, 3=good, 4=fair, 5=poor.

	Rating
Scientific soundness	___
Degree to which conclusions are supported by the data	___
Organization and clarity	___
Cohesiveness of conclusions	___
Conciseness	___
Importance to objectives of the Program	___
(For use by internal review panel only)	

RECOMMENDATION	**(check one)**
Accept	___
Accept after revision	___
Unacceptable	___