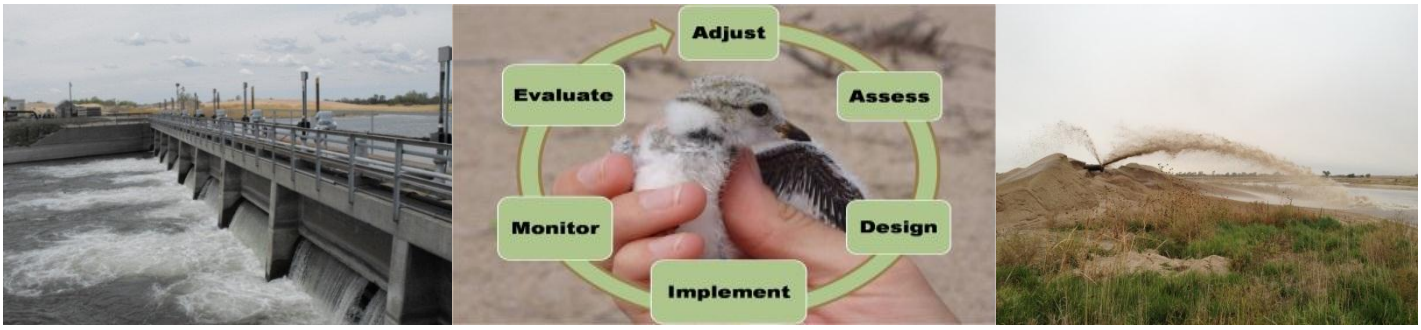
ADAPTIVE MANAGEMENT ON THE PLATTE RIVER



10/31/2012

Platte River Recovery Implementation Program
Adaptive Management Plan (AMP)
2012 "State of the Platte" Report – Executive Summary

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PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
2012 "State of the Platte"

The Platte River Recovery Implementation Program's ("Program" or "PRRIP") Executive Director's Office (EDO) developed this document for the Governance Committee (GC). It is intended to serve as a synthesis of existing Program monitoring data, Program research, analysis of Program data, and associated retrospective analyses to provide important information to the GC regarding key scientific and technical uncertainties. These uncertainties form the core structure of the Program's Adaptive Management Plan (AMP) and are directly related to decisions regarding implementation of management actions, assessment of target species' response to those management actions, how best the Program can spend its resources (money, land, water, etc.), and ultimately the success or failure of the Program.

This report is a series of assessments organized around eleven "Big Questions" categorized as questions of implementation, effectiveness, or larger-scale issues (as detailed on Pages 7-8). Through 2011, the take-away message for each Big Question is:

Implementation – Program Management Actions and Habitat

1) Program monitoring and retrospective analyses indicate that short-duration high flows (SDHF) will likely not build sandbars to a height that is suitable tern and plover nesting habitat with or without sediment balance.
2) Whooping crane roosting habitat suitability increased somewhat from 2009 to 2011, but changes cannot be used to evaluate SDHF because of the confounding effects of a massive phragmites control effort undertaken by the PVWMA. Generally, the emergence and persistence of scour-resistant invasive species like phragmites will necessitate some level of ongoing mechanical intervention in order to maintain the improvements in suitability.
3) Modeling, monitoring, and research indicate that sediment augmentation is necessary to halt continuing channel degradation that negatively impacts target species habitat suitability. However, augmentation alone may not significantly improve habitat suitability.
4) Modeling, monitoring, and analysis indicate that mechanical channel alterations are likely necessary for the creation and maintenance of suitable habitat. However, flow consolidation, which may be necessary to maintain suitable habitat using flow, cannot be implemented in at least half the associated habitat reach.

Effectiveness – Habitat and Target Species Response

5) Program monitoring data suggest whooping crane use of the Associated Habitats may be increasing. However, detailed habitat availability assessments are underway but are not yet completed so at this time we are unable to fully assess this Big Question.
6) Program monitoring and data analysis indicate that as habitat increases, tern and plover use and productivity increase. However, this conclusion is preliminary due to marginal changes in habitat availability and high variability in the data from 2007-2011.
7) Tern and plover use and productivity have increased at sandpit sites and use has decreased at in-channel sites since 2007. Detailed habitat selection analyses have not yet been completed so at this time we are unable to fully address this Big Question.
8) Forage fish monitoring data, the Program's tern/plover foraging habits study, and Program data analysis reveal that forage abundance (fish and invertebrates) is high at nearly all flow levels on the river during the summer as well as on sandpits. Though there is not a strong link between this

available data and tern/plover productivity, the TAC believes this link does not warrant further investigation as a priority issue.

9) Application of the Program's stage change study tool indicates that central Platte River flow management actions are likely to avoid adverse impacts to pallid sturgeon in the lower Platte River.

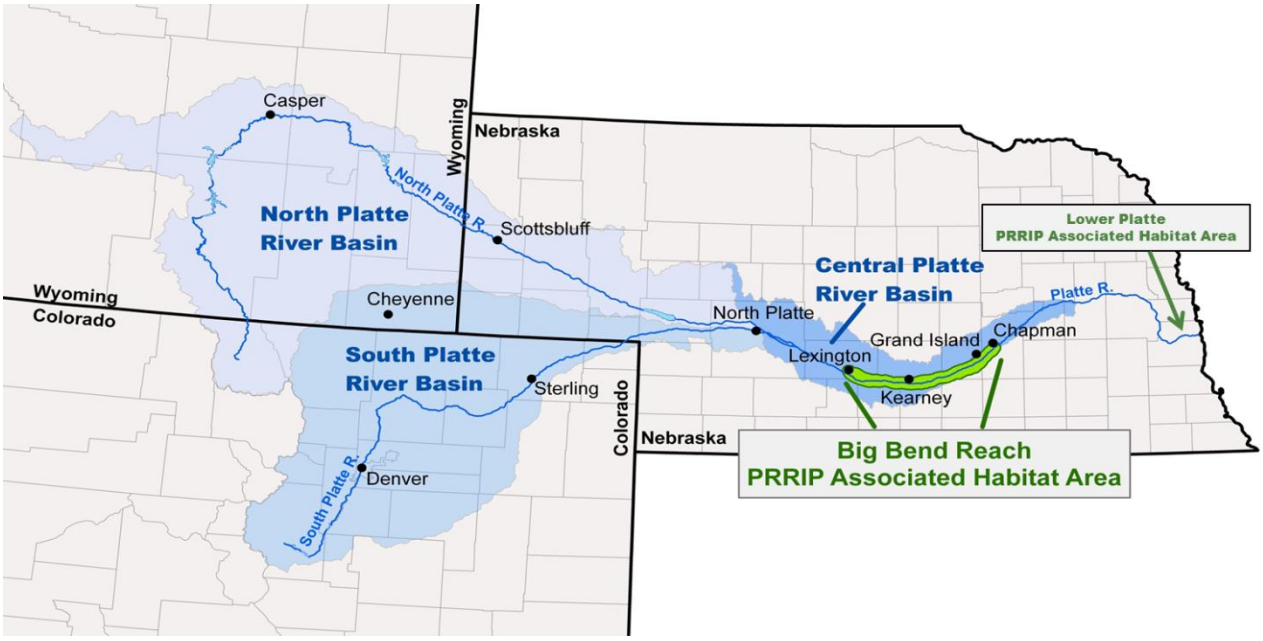
Larger Scale Issues – Application of Learning

10) Program implementation is considered a contribution to the recovery of the target species. A clearer picture of the magnitude of that contribution to the overall health of the three target bird species' populations will emerge closer to the end of the First Increment.

11) A list of existing and/or new unanswered questions will be maintained throughout the First Increment to set the stage for evaluation during the Second Increment.

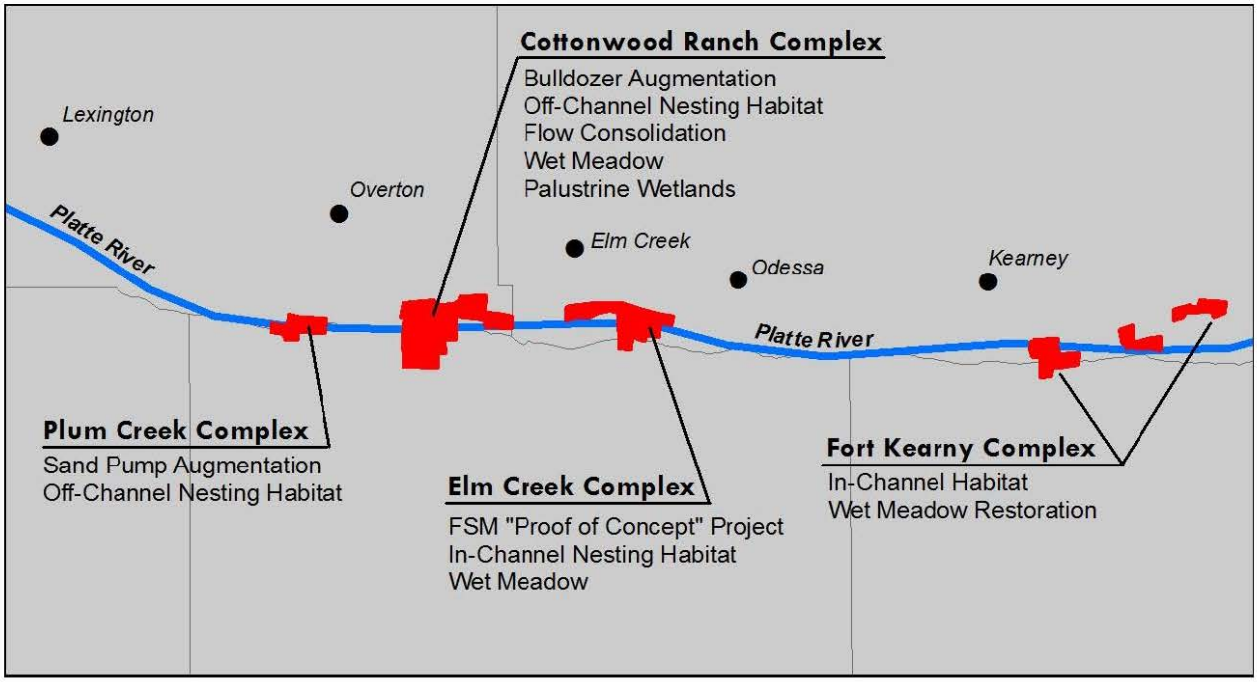
Of the eleven Big Questions, one answer is conclusive (#8), five are trending positive (#3, #4, #6, #9, and #10), one is trending negative (#1), and four remain unknown (#2, #5, #7, and #11). Based on the Big Question categories, good progress is being made in terms of Program implementation with three trending answers and only one unknown answer. More uncertainty exists within the effectiveness category because effectiveness cannot be completely judged until later in the First Increment largely due to species' response time to management actions. The larger scale questions generally cannot be adequately addressed until Program effectiveness has been determined although trending answers should emerge as implementation continues. Assessment of the Big Questions in 2012 reveals the Program is on track towards meeting the AMP management objectives.

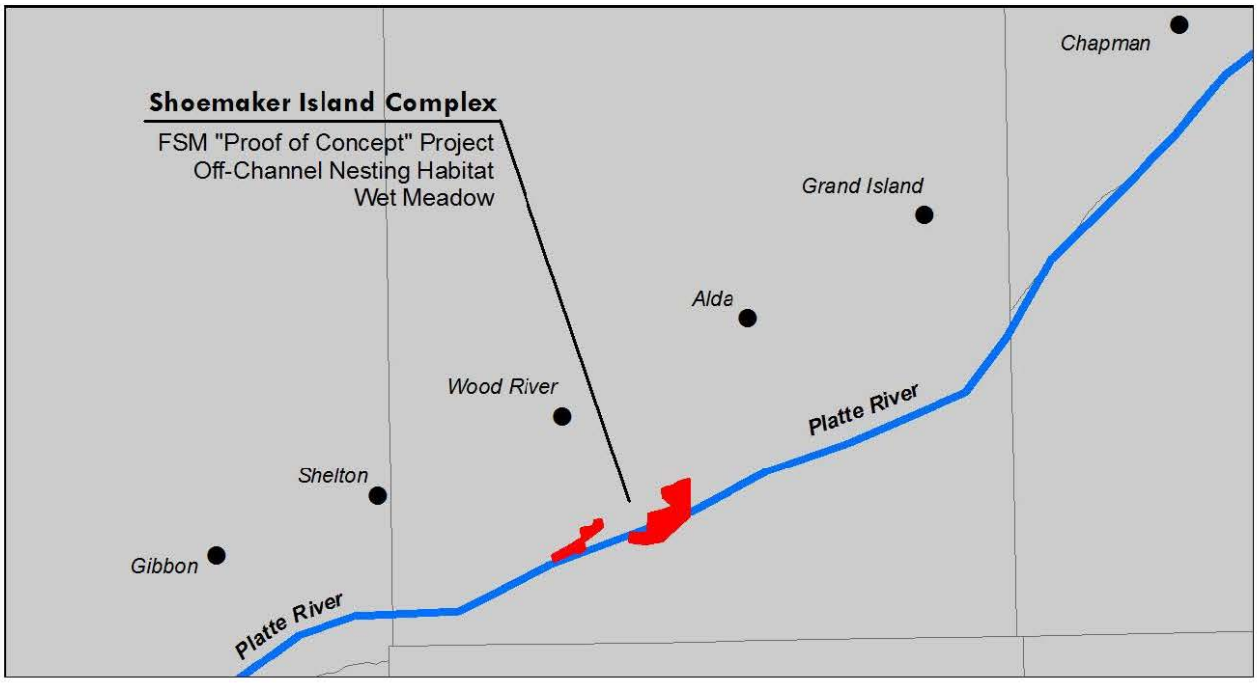
The Program's Independent Scientific Advisory Committee (ISAC) reviewed the Big Questions and the related 2012 assessments and generally agreed with the Big Questions themselves as well as the associated assessments (see **Appendix A**). Similarly, in October 2012 the Program's Technical Advisory Committee (TAC) approved a motion supporting both the Big Questions and the 2012 assessments.



Map depicting the Program area, including the Associated Habitat Reaches on the central and lower Platte River.

The two maps below detail the Program's Associated Habitat Area in the central Platte river, highlighting Program habitat complexes in the western half of the 90-mile reach (top map) and the eastern half (bottom map). Program implementation, data collection, and analysis described in the 2012 assessments of the Big Questions largely center on management actions taken at Program habitat complexes.





PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
2012 "State of the Platte" Report

What is the Executive Summary?

This document presents a highly-condensed version of a large amount of data. The purpose is to provide an assessment of where the Program stands now in addressing major uncertainties, henceforth in this document referred to as "Big Questions". The Executive Summary has been discussed with and reviewed by the Program's Adaptive Management Working Group (AMWG), Technical Advisory Committee (TAC), and Independent Scientific Advisory Committee (ISAC) several times during the course of 2012.

For each of the 11 Big Questions, an assessment is provided in this document with the following content:

- **Big Question** – color-coded to match its location in the Big Question table (see below)
- **Hypothesis Statement** – Directly below the Big Question, a re-statement of the hypothesis being addressed.
- **Analysis Conducted to Date –** A brief summary of Program monitoring, research, or other activities that generated data for assessing the Big Question/hypothesis.
- **What Does the Science Say?** – This section is an attempt to compress a large volume of scientific information into an understandable format and includes conclusions about whether the question has been answered or if more information is needed. This question includes a single statement in a color-coded text box that summarizes the take-away message.
- **Governance Committee Decision-making Q&A** – A set of questions that the GC may have about the conclusions being drawn and what those conclusions might mean for decision-making.

A quick-reference guide is provided on pages 9-10 to serve as a snapshot of the assessment for each Big Question based on data collected through 2011. This document will be updated and presented to the GC annually to chart progress and potentially identify new priorities for learning through implementation of the AMP according to GC needs for decision-making. Note that this document contains a large number of endnotes as a way to identify key documents or data sets that are important to read and understand when reviewing this Executive Summary. In general, those endnotes include hyperlinks to information available in the Public Library section of the Program's web site.

Each year, a "sister" document to this Executive Summary will be developed for the AMP Reporting Session that will include substantially more detailed information but organized using the same framework. The audience for this technical version of the Executive Summary will be the TAC and ISAC with the purpose being to explore questions of a deeper technical nature that influence the ability of the EDO to assess the Big Questions and draw conclusions from year to year.

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PRRIP Big Questions = What we don't know but want to learn	Broad Hypotheses[1]	Priority Hypotheses[2]
Implementation – Program Management Actions and Habitat		
1. Will implementation of SDHF[3] produce suitable[4] tern and plover riverine nesting habitat on an annual or near-annual basis?	*PP-1a: Flows of 5,000 to 8,000 cfs magnitude in the habitat reach for a duration of three days at Overton on an annual or near-annual basis will build sandbars to an elevation suitable for least tern and piping plover habitat.*	Flow #1
2. Will implementation of SDHF produce and/or maintain suitable whooping crane riverine roosting habitat on an annual or near-annual basis?	*PP-1b: Flows of 5,000 to 8,000 cfs magnitude in the habitat reach for a duration of three days at Overton on an annual or near-annual basis will increase the average width of the vegetation-free channel.*	Flow #3, Flow #5
3. Is sediment augmentation necessary for the creation and/or maintenance of suitable riverine tern, plover, and whooping crane habitat?	*PP-2: Between Lexington and Chapman, eliminating the sediment imbalance of approximately 400,000 tons annually in eroding reaches will reduce net erosion of the river bed, increase the sustainability of a braided river, contribute to channel widening, shift the river over time to a relatively stable condition, and reduce the potential for degradation in the north channel of Jeffrey Island resulting from headcuts.*	Sediment #1
4. Are mechanical channel alterations (channel widening and flow consolidation) necessary for the creation and/or maintenance of suitable riverine tern, plover, and whooping crane habitat?	*PP-3: Designed mechanical alterations of the channel at select locations can accelerate changes towards braided channel conditions and desired river habitat.*	Mechanical #2

[1] From the Final Program Document, Adaptive Management Plan (AMP), Broad Hypotheses, Pages 14-17.
[2] From the Final Program Document, Adaptive Management Plan (AMP), Table 2, Pages 70-78. See **Appendix B** for the specific language of each Priority Hypothesis listed as well as the associated X-Y graph.
[3] Short-Duration High Flows (SDHF) = 5,000-8,000 cfs at Overton for 3 days. This is the only flow-related management action specified in the AMP.
[4] The term "**suitable**" is defined by the Program either as a function of habitat suitability criteria developed by the Technical Advisory Committee (see **Appendix C**) or Department of Interior (DOI) target habitat criteria in Land Plan Table 1 (see **Appendix D**).

PRRIP Big Questions = What we don't know but want to learn	Broad Hypotheses	Priority Hypotheses
Effectiveness – Habitat and Target Species Response		
5. Do whooping cranes select suitable riverine roosting habitat in proportions equal to its availability?	*WC-1: Whooping cranes that use the central Platte River study area during migration seasons prefer habitat complexes (Land Plan Table 1) and use will increase proportionately to an increase in habitat complexes. WC-4: In the central Platte River study area, whooping cranes prefer conditions created by species target flows and annual pulse flows.*	WC1, WC3
6. Does availability of suitable nesting habitat limit tern and plover use and reproductive success on the central Platte River?	*TP-1: In the central Platte River study area, terns and plovers prefer/do not prefer riverine habitats as described in Land Plan Table 1 and use will/will not increase proportionately to an increase in habitat complexes.*	T1, P1
7. Are both suitable in-channel and off-channel nesting habitats required to maintain central Platte River tern and plover populations?	*TP-2: The maintenance of tern and plover populations in the central Platte requires/does not require that sandpits and river continue to function together to provide nesting and foraging habitat. TP-3: Ephemeral nesting areas in the river are/are not needed for long-term nesting success of tern and plover.*	TP1
8. Does forage availability limit tern and plover productivity on the central Platte River?	*TP-4: Existing river flows do/do not provide a sufficient forage base throughout the central Platte River study reach for populations of terns and plovers during the nesting season.*	T2, P2
9. Do Program flow management actions in the central Platte River avoid adverse impacts to pallid sturgeon in the lower Platte River?	*PS-2: Water related activities above the Loup River do/do not impact pallid sturgeon habitat.*	PS2
Larger Scale Issues – Application of Learning		
10. How do Program management actions in the central Platte River contribute to least tern, piping plover, and whooping crane recovery?	*S-3: Program management actions will/will not have a detectable effect on target species use of the associated habitats.*	S1b
11. What uncertainties exist at the end of the First Increment, and how might the Program address those uncertainties?	N/A	N/A

1 The Program's "Big Questions", associated Broad Hypotheses from the AMP, and associated Priority Hypotheses from the AMP.

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"Quick Reference" Guide

To assist the GC with quickly evaluating the 2012 Big Question assessments, the icons below are used to visually summarize the basic conclusion for each question. Thumbs up or down indicate a trend in the affirmative or negative and may point to the need to re-evaluate management actions based on collected data and analysis. The unknown "character" is used when there is not enough evidence to indicate a trend in either direction and more time is needed to collect appropriate data and conduct analyses. These icons are intended to provide the GC with a quick and visual means to see where the Program stands each year in moving towards definitive answers for the Program's most significant scientific questions as they relate to management decision-making.

	• Question/hypothesis **answered conclusively** in the **affirmative** • Consider adjustments in actions or influence on decision-making
	• Affirmative answer or trend, but question/hypothesis **NOT answered conclusively**
	• Evidence thus far is inconclusive; no affirmative or negative answer/trend to question/hypothesis
	• Negative answer or trend, but question/hypothesis **NOT answered conclusively**
	• Question/hypothesis **answered conclusively** in the **negative** • Consider adjustments in actions or influence on decision-making

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The following table includes each of the eleven Big Questions and the associated visual icon for the major conclusion in 2012:

PRRIP Big Questions = What we don't know but want to learn	2012 Assessment
Implementation – Program Management Actions and Habitat	
1. Will implementation of SDHF produce suitable tern and plover riverine nesting habitat on an annual or near-annual basis?	
2. Will implementation of SDHF produce and/or maintain suitable whooping crane riverine roosting habitat on an annual or near-annual basis?	
3. Is sediment augmentation necessary for the creation and/or maintenance of suitable riverine tern, plover, and whooping crane habitat?	
4. Are mechanical channel alterations (channel widening and flow consolidation) necessary for the creation and/or maintenance of suitable riverine tern, plover, and whooping crane habitat?	
Effectiveness – Habitat and Target Species Response	
5. Do whooping cranes select suitable riverine roosting habitat in proportions equal to its availability?	
6. Does availability of suitable nesting habitat limit tern and plover use and reproductive success on the central Platte River?	
7. Are both suitable in-channel and off-channel nesting habitats required to maintain central Platte River tern and plover populations?	
8. Does forage availability limit tern and plover productivity on the central Platte River?	
9. Do Program flow management actions in the central Platte River avoid adverse impacts to pallid sturgeon in the lower Platte River?	
Larger Scale Issues – Application of Learning	
10. How do Program management actions in the central Platte River contribute to least tern, piping plover, and whooping crane recovery?	
11. What uncertainties exist at the end of the First Increment, and how might the Program address those uncertainties?	

"Quick Reference" table for 2012 assessments of the Big Questions. See the individual question assessments on the following pages for a more detailed explanation of the conclusions for each Big Question.

The remainder of this document includes a short but more detailed assessment of each Big Question for 2012 based largely on Program actions and data from 2007-2011. The color-coding for the Big Question categories of implementation, effectiveness, and larger-scale issues is carried over into the assessments to assist with identifying to what category of Big Question each assessment pertains.

1. Will implementation of SDHF produce suitable tern and plover riverine nesting habitat on an annual or near-annual basis?

Based upon the SedVeg model and associated assumptions in the FSM management strategy, it is hypothesized that under a balanced sediment budget, a SDHF of 5,000 to 8,000 cfs magnitude for three days (50,000 to 75,000 acre-feet) will build sandbars to an elevation that is suitable for tern and plover nesting.[1]

Analysis Conducted to Date:

The Program developed system and project-scale hydraulic and sediment transport models and collected detailed system and project-scale topographic data following two natural flow events that exceeded SDHF magnitude and duration. The EDO and contractors used these data to analyze sandbar height in relation to peak flow stage and minimum habitat suitability criteria in the portions of the reach that are in sediment deficit (upstream of Gibbon) and sediment balance (downstream of Gibbon).[2]

Thus far, analyses focused on relationships related to SDHF because that flow management action is prioritized in the AMP. Additional monitoring and analysis may be utilized to evaluate alternative flow management actions (i.e. USFWS target flows – pulse flows and species flows) if the GC elects to implement such alternatives.

What Does the Science Say?

Program monitoring and retrospective analyses indicate that SDHF will likely not build sandbars to a height that is suitable tern and plover nesting with or without sediment balance.

The Program's minimum suitable sandbar height criterion for tern and plover nesting is 1.5 feet above a stage of 1,200 cfs.[3] This corresponds to nests having approximately a 45 to 50% probability of being flooded during the nesting season (May-July).[4] During a peak flow event, sandbars grow to some equilibrium height below the flow stage. The maximum stage of an event in combination with equilibrium sandbar height relative to stage, dictate whether or not sandbar heights exceed 1.5 feet above 1,200 cfs. Program modeling, research, and monitoring indicate:

1. Hydraulic modeling and monitoring indicate that stage increase during peak flow events of SDHF magnitude (5,000-8,000 cfs) would be sufficient to produce sandbars meeting the height criterion <u>if</u> sandbars build to the water surface at a discharge of 5,000 cfs or within approximately 0.7' of the water surface at a discharge of 8,000 cfs.[5] (The Final Environmental Impact Statement (FEIS) analysis assumed bars build to the water surface.[6])

2. In 2010, the annual high flow event exceeded SDHF magnitude by 10% (8,800 cfs) and volume by 818% (613 KAF). In 2011, the annual high flow event exceeded SDHF magnitude by 28% (10,200 cfs) and volume by 4,448% (3.34 MAF).[7]

3. Sandbars that formed in the Elm Creek reach during the 2010 and 2011 peak flow events had maximum heights of approximately 1.0' to 1.6' below peak flow stage and did not produce appreciable area meeting the minimum height criterion despite the fact that SDHF magnitude and duration was exceeded in both events. At a SDHF discharge of 8,000 cfs, equilibrium bar heights of 1.0' below peak stage would produce maximum sandbar heights that are 0.3' below the minimum height criterion.[8]

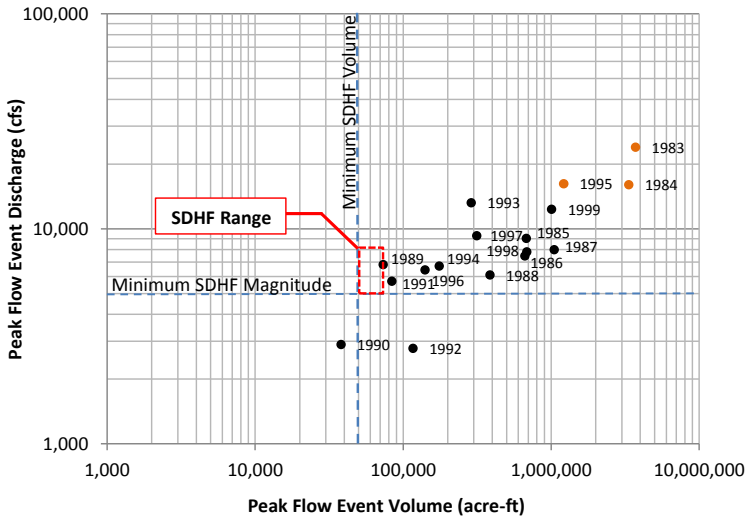
4. Sandbar heights do not appear to differ significantly in the sediment deficient reach upstream of Gibbon versus the reach in sediment balance downstream of Gibbon, indicating that sediment balance alone does not significantly influence sandbar height.[9]

5. The area of in-channel sandbar habitat meeting minimum suitable habitat criteria has declined from approximately 21 acres in 2008 to five acres in 2011 as constructed nesting islands have been eroded by peak flow events.[10]

The finding that SDHF-magnitude and duration flows do not produce suitable nesting habitat is qualitatively supported by a retrospective analysis of annual peak flow events and tern and plover nesting records. During the period of 1942-2011, annual peak flow event magnitude and volume exceeded SDHF minimums in 41 out of 70 years. In addition, there were seven periods when minimums were exceeded in 2 out of 3 years, including recent periods from 1984-1991 and 1993-1999 (see sidebar figure). *If the FSM management strategy is capable of creating and/or maintaining suitable tern and plover nesting habitat on an annual or near annual basis in areas of sediment balance, regular nesting on natural sandbars should have occurred downstream of Gibbon (area of sediment balance) from 1984-1999.*

Tern and plover nesting records for the period 1984-1999 include 63 nest observations on natural sandbars in the years following consecutive extremely high flow events of 23,900 cfs in 1983 and 16,000 cfs in 1984.[11] All 63 nests were found at five sites. Four of the five sites and all but two of the nests were upstream of Gibbon at locations where infrastructure (J-2 return, bridges, and the Kearney Canal diversion) produced localized areas of deposition. The only nest observed on a natural sandbar in the latter half of the 1984-1999 period was downstream of the J-2 Return in 1996 following a high flow event of 16,200 cfs the previous year. During the entire period of 1984-1999, 233 nests were observed on man-made/managed islands, 871 nests were observed on managed sandpits, and 144 nests were observed on unmanaged sandpits.

The low number of nest observations on natural sandbars in comparison to other habitat types and lack of nesting downstream of Gibbon are strong indicators that natural variation in peak flows, sediment, and channel characteristics during this period did not produce suitable nesting habitat



Annual peak flow events exceeded SDHF minimum discharge and maximum volume in all but two years from 1983 through 1999. During this period, 63 nests were observed on natural sandbars in the years following consecutive extremely high flow events in 1983 and 1984 and a single nest was observed following the high flow event in 1995 (see red points on figure). All but two of the nests were located in the degrading reach upstream of Gibbon at locations where bridges or other infrastructure produced localized depositional zones. If, as hypothesized, SDHF-magnitude flows create and/or maintain suitable nesting habitat in areas of sediment balance, nesting should have occurred on an annual or near/annual basis in the reach downstream of Gibbon during this 16 year period. The lack of nesting downstream of Gibbon is a strong indicator that implementation of the FSM management strategy may not produce suitable tern and plover nesting habitat on an annual or near annual basis.

except in areas with unique hydraulics following very high peak flow events. If the Program is to expect a different result in the future, one or a combination of these factors (flow, sediment, or channel form) must be manipulated outside of the ranges typically experienced during this period.

Governance Committee Decision-making Q&A:

Do these results mean the Program shouldn't attempt to make SDHF releases?

There are other hypothesized benefits of SDHF releases including maintaining wide, unvegetated channels for whooping cranes. The inability of SDHF to produce sandbars defined as nesting habitat by the Program should not necessarily be a reason to abandon the action as what constitutes suitable nesting habitat could be revised. However, results to date necessitate the GC be aware that current flow management priorities (SDHF) are not likely to produce all the hypothesized results and discussion of alternative flow management actions may be warranted.

Do these results mean the Program shouldn't augment sediment?

No. The effects of sediment deficit on braided stream morphology are well documented.[12] Without augmentation, narrowing and incision in the reach upstream of Gibbon will continue. The results only indicate that the sediment deficit is not the reason sandbar heights are not suitable for tern and plover nesting.

What management actions could conceivably produce islands that meet suitable nesting habitat criteria?

Some potential alternative management actions are presented below. They may not be feasible or acceptable, or they may come with potentially negative impacts but are provided as examples of what it would mean to "go beyond" naturally occurring conditions.

- *Increasing frequency of large peak flow events* - Given nesting was observed following very large peak flow events, increasing the frequency of flows exceeding 16,000 cfs in magnitude could increase the frequency of suitable habitat creation.
- *Mechanically over-widen a segment of channel to induce sediment deposition* – This action would induce deposition and potentially encourage development of higher bars.
- *Oversupply the entire reach with medium sand (D_{50} 0.4mm)* – This would produce sediment conditions similar to the lower Platte River. The potential success of this alternative, however, is questionable given the 2011 sandbar height analyses by the USGS in the lower Platte that indicated sandbar heights relative to flow event peak stage were similar to the central Platte.[13]
- *Mechanical approach* – Vegetated sandbars aggrade to heights that are suitable for nesting due to stabilization and sediment trapping by vegetation during natural or augmented annual high flow events. A portion of the sandbars at Program habitat complexes could be selectively allowed to vegetate with non-woody and non-invasive vegetation. Once a sandbar aggrades to a suitable height, it could be mechanically cleared and maintained as nesting habitat until it is eroded by subsequent flow events.

NOTE: *A plover nest was initiated on a riverine sandbar in 2012 in an area that was mechanically cleared of vegetation in 2010 and reworked by the extended high flow event of 2011. The TAC requested that the occurrence of riverine nesting in 2012 be noted in this summary. The fate and implications of this nest will be discussed in the 2012 summary.*

2. Will implementation of SDHF produce and/or maintain suitable whooping crane riverine roosting habitat on an annual or near annual basis?

A principal metric of whooping crane roosting habitat suitability is unobstructed channel width. Consequently, roosting habitat suitability can be defined as a function of either: 1) the range of unobstructed channel widths at whooping crane use sites, or 2) the range of unobstructed channel widths thought to be necessary to increase whooping crane use. Based upon the SedVeg model and associated assumptions in the FSM management strategy, it is hypothesized that flows of 5,000 to 8,000 cfs magnitude for three days on an annual or near annual basis (SDHF) will increase the average width of the vegetation-free (surrogate for unobstructed) channel [to a suitable width].[14] By extension, SDHF is also hypothesized to be necessary and sufficient to maintain suitable unobstructed widths on an annual or near annual basis.[15]

Analysis Conducted to Date:

The Program has performed a preliminary analysis of unobstructed channel widths at whooping crane riverine roost locations. The Program has also developed system and project-scale hydraulic and sediment transport models and collected detailed system and project-scale topographic and vegetation data following two natural flow events that exceeded SDHF magnitude and duration. The Program also commissioned vegetation scour directed research and is using these data to analyze the relationship between unvegetated and unobstructed channel width and peak flow event magnitude and duration.

What Does the Science Say?

Whooping crane roosting habitat suitability increased somewhat from 2009 to 2011 but the change cannot be used to evaluate SDHF because of the confounding effects of a massive phragmites control effort undertaken by the PVWMA. Generally, the emergence and persistence of scour-resistant invasive species like phragmites will necessitate some level of ongoing mechanical intervention in order to maintain the improvements in suitability.

The Program's minimum suitable unobstructed channel width criterion for whooping crane roosting is 280 feet, which includes 90% of the whooping crane roost locations during the period of 2001 through spring 2011.[16] The minimum unobstructed width hypothesized by the DOI to be necessary to increase whooping crane use is 750 feet and the targeted width is 1,150 feet.[17,18] Program research, modeling, and monitoring provide the following indications about the ability of SDHF to create and/or maintain unobstructed channel widths meeting the minimum suitability criterion and/or hypothesized use targets:

1. In 2010, the annual high flow event exceeded SDHF magnitude by 10% (8,800 cfs) and volume by 818% (613 KAF). In 2011, the annual high flow event exceeded SDHF magnitude by 28% (10,200 cfs) and volume by 4,448% (3.34 MAF).[19]

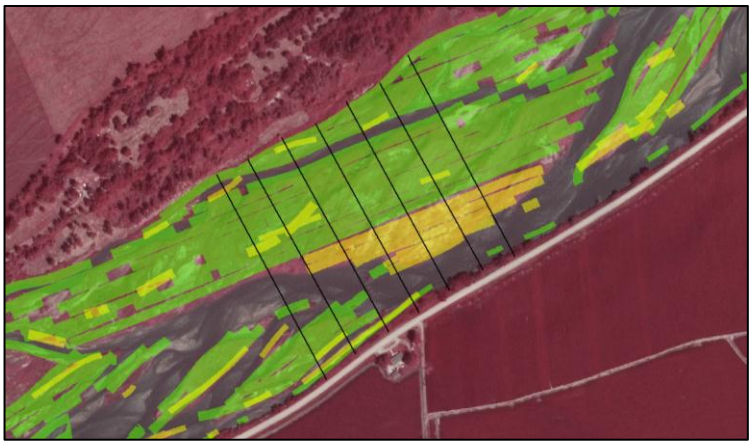
2. A preliminary analysis of system-scale vegetation monitoring data indicates that the average total unvegetated channel width at system-scale monitoring locations increased from 417 feet in 2009 to 721 feet in 2011 (73% increase).[20] During the same period, unobstructed channel width increased from 260 feet to 440 feet (69% increase). In 2011, 80% of monitoring locations exceeded the minimum unobstructed width suitability criterion of 280 feet, 10% exceeded the minimum targeted width of 750 feet, and the Table 1 width of 1,150 feet was not exceeded at any location.[21]

3. In 2008, the Platte Valley Weed Management Association (PVWMA) undertook a massive invasive species control project focused on eliminating phragmites infestations on the Platte River through

aerial application of the non-selective herbicides that kill all vegetation. In the fall of 2008, herbicide was applied to 1,531 acres of channel between Overton and Elm Creek. In the fall of 2009, 3,945 acres were treated between Elm Creek and Chapman. In the fall of 2010, a total of 2,071 acres were treated throughout the Associated Habitat reach extending from Lexington downstream to Chapman.[22] The total sprayed area of 7,547 acres is equivalent to a river treatment corridor approximately 690 feet wide from Lexington to Chapman. The sheer magnitude of the PVWMA control effort will confound the Program's ability to evaluate the relationship between high flow events and increases in unvegetated channel width in 2010 and 2011 (see sidebar figure).

4. Vegetation scour research conducted for the Program indicates that stands of scour-resistant vegetation, including phragmites (> 1 year-old), reed canarygrass (> 1 year-old), and cottonwood trees whose taproots have rooted below the shallow zone of local scour (> 1 year-old), likely cannot be removed through drag and local scour alone, even at the 100-year recurrence interval discharge. Example lateral erosion calculations in the vegetation scour research report indicate that lateral erosion in areas with established phragmites is unlikely but lateral scour of bank and bar edges could be an important mechanism for undercutting, scour and removal of other vegetation and should be studied further.[23]

The combination of natural flow events that significantly exceeded SDHF and the massive PVWMA phragmites control project make it impossible to use 2009-2011 monitoring data to evaluate the ability of SDHF to create and/or maintain suitable whooping crane roosting habitat. However, the rapid colonization of an extremely scour and inundation resistant invasive species like phragmites is a "surprise" that was not envisioned at the time the FSM management strategy was developed. In the absence of a breakthrough in biological control, it appears that some level of ongoing mechanical intervention will be necessary to prevent phragmites from recolonizing the channel.



Summer 2009 aerial photograph of Program Anchor Point 19 showing survey transects (black lines) and area treated with the herbicide Imaziypr in the fall of 2009 (green overlay) and 2010 (yellow overlay) as part of a massive phragmites control project. Imaziypr is a non-selective herbicide that kills all vegetation in the treatment area. The sheer magnitude of the spraying effort makes it impossible to separate increases in unvegetated channel width due to high flow events from increases due to herbicide application.

Given the difficulty in making inferences based on 2009-2011 monitoring data, a retrospective analysis of unvegetated and unobstructed channel widths in 1998 is useful. Imagery flown in 1998 captures channel conditions at the end of a 16 year period when SDHF minimums were exceeded in all but two years, providing an indication of unvegetated channel widths that could be created and/or maintained by SDHF in the absence of an in invasive species like phragmites and reed canarygrass.[24] In 1998, total unvegetated channel width exceeded the minimum target of 750 feet at 40% of monitoring locations but unobstructed width likely only exceeded 750 feet at one location due to the presence of permanently vegetated islands at most

Anchor Point locations (see sidebar figure in Big Question 4 summary).[25] The fact that total unvegetated width exceeded 750 feet at 40% of Anchor Point locations is a positive indicator for ability to maintain suitable unvegetated widths with flow *in the absence of phragmites* or other scour-resistant invasive species. However, all but one of those Anchor Points fell short of the minimum unobstructed width target, indicating that almost all of the unvegetated width must be consolidated into a single confined channel to achieve the target.[26]

Governance Committee Decision-making Q&A:

Do these results mean the Program shouldn't attempt to make SDHF releases?

No. SDHF and possibly other flow management actions such as the pulse flow components of target flows should still be implemented to further refine the relationships between flow, channel width, and vegetation scour.

3. Is sediment augmentation necessary for the creation and/or maintenance of suitable riverine tern, plover and whooping crane habitat?

Based on the SedVeg model and associated assumptions in the FSM management strategy, it is hypothesized that eliminating the existing sediment deficit through sediment augmentation is necessary in addition to SDHF to reduce channel narrowing and incision and contribute to the creation of suitable riverine tern, plover and whooping crane habitat.[27]

Analysis Conducted to Date:

The Program developed system and project-scale hydraulic and sediment transport models, collected annual system-scale topographic, sediment, and vegetation data in 2009-2011, commissioned a sediment augmentation feasibility study, and developed an implementation design for a two year pilot-scale sediment augmentation project.

What Does the Science Say?

Modeling, monitoring, and research indicate that sediment augmentation is necessary to halt continuing channel degradation that negatively impacts target species habitat suitability. However, augmentation alone may not significantly improve habitat suitability.

During Program development, the DOI estimated the average annual sediment deficit in the associated habitats to be 185,000 tons under existing flow conditions and 225,000 tons once First Increment water objectives are achieved.[28] At that time, stakeholders voiced concerns about uncertainties associated with: 1) the magnitude and extent of the deficit and resulting channel degradation and, 2) the relative importance of vegetation versus sediment supply in restoration and maintenance of channel width.[29] Program modeling, monitoring, and data analysis provide the following insights about the importance of achieving sediment balance in creation and/or maintenance of suitable riverine habitat for Program target species:

1. Updated sediment transport modeling indicates that the average annual sediment deficit in the associated habitat reach is on the order of 152,000 tons with the largest deficits occurring in the reach extending from the J-2 Return downstream to Elm Creek.[30]

2. System-scale topographic monitoring shows results consistent with sediment transport modeling, which predicts that sediment balance is achieved between Kearney and Minden.[31]

3. The upper end of the Associated Habitat reach is degrading in the absence of sediment augmentation. The effects of degradation in the reach from the J-2 Return to the Overton Bridge include up to ten feet of channel incision and significant channel narrowing.[32] This incision and narrowing is migrating slowly downstream and, over time, may impact the four Program habitat complexes that are located in the degradational reach.[33] Elimination of the sediment deficit through sediment augmentation is necessary to halt incision and narrowing that may negatively affect habitat suitability at these locations.

4. Although necessary to halt incision and narrowing, sediment augmentation likely will not result in significant channel widening or shift anastomosed reaches to a braided morphology without mechanical clearing and widening of the channel.[34]

A pilot-scale sediment augmentation management experiment to test augmentation material gradations and methods will begin in September 2012. The pilot-scale experiment is expected to help reduce uncertainties about: 1) the most effective material gradation to offset the deficit; 2) the most cost-efficient method to introduce augmentation material into the channel; and 3) verify that augmentation will not decrease channel capacity. Until full-scale sediment augmentation occurs, it will be difficult to evaluate whether or not the entire deficit can be eliminated through augmentation. It will also be difficult to determine if augmentation only slows/halts channel narrowing and incision or also contributes to channel widening, which is necessary to create and/or maintain suitable habitat for the target bird species.

Governance Committee Decision-making Q&A:

Is sediment augmentation intended to reverse historic channel incision and narrowing in the reaches that have degraded significantly?

No. The objective of sediment augmentation is to offset the deficit and eliminate further degradation. Any attempt to "fill the hole" and raise the channel bed elevation would likely require augmentation of material volumes far in excess of the sediment transport capacity of the river. The benefits or potential impacts of oversupplying the channel with sediment have not been discussed or evaluated at this time.

4. Are mechanical channel alterations (channel widening and flow consolidation) necessary for the creation and/or maintenance of suitable riverine tern, plover and whooping crane habitat?

Based on the SedVeg model and associated assumptions in the FSM management strategy, it is hypothesized that designed mechanical channel alterations like mechanical clearing and leveling of islands, channel widening, vegetation clearing from banks, and consolidation of 85-90% of river flow into one channel are needed to accelerate the creation and or maintenance of suitable riverine habitat.[35]

Analysis Conducted to Date:

The Program developed system and project-scale hydraulic and sediment transport models, collected annual system-scale topographic, sediment, and vegetation data in 2009-2011, and commissioned a flow consolidation pre-feasibility study to investigate the potential to implement a flow consolidation management experiment at the Cottonwood Ranch Complex.

What Does the Science Say?

Modeling, monitoring, and analysis indicate that mechanical channel alterations are likely necessary for the creation and maintenance of suitable habitat. However, flow consolidation, which may be necessary to maintain suitable habitat using flow, cannot be implemented in at least half the associated habitat reach.

The central Platte River provides an almost textbook example of the vegetation ratchet effect. During drought periods, vegetation encroaches into the active channel and becomes well established. Subsequent high flow events lack the stream power necessary to remove several-year-old woody vegetation so much of the area that was colonized is permanently stabilized and becomes riparian forest – thus, the one-way ratcheting down of width experienced from the early 1940s through the early 2000s.[36] This effect was the impetus for inclusion of a mechanical component in the FSM management strategy. Mechanical clearing and leveling of islands, channel widening, and flow consolidation are intended to "prepare" a suitable channel that can then be maintained by flow. Program modeling, monitoring, and data analysis provide the following insights about the role of mechanical channel alterations in creating and/or maintaining suitable species habitat.

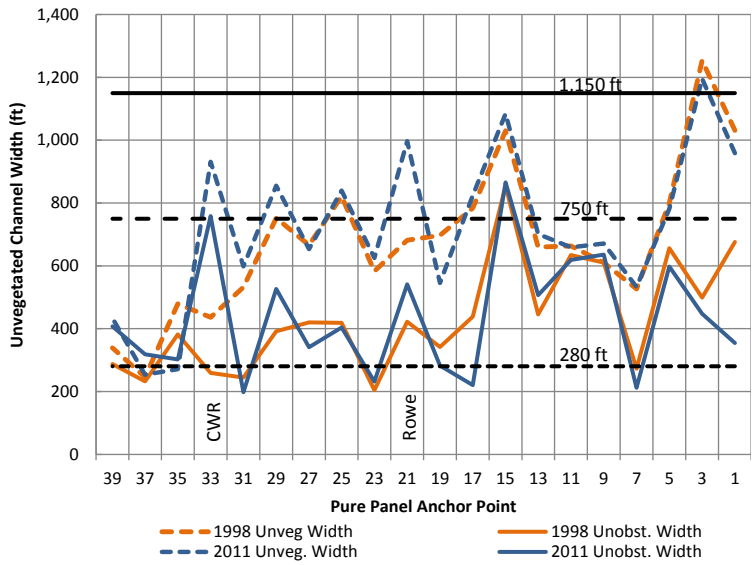
Mechanical Clearing, Leveling and Channel Widening

As discussed in the Big Question 2 summary, the combination of natural high flow events and massive phragmites control effort resulted in substantial increases in total unvegetated and unobstructed channel widths from 2009 to 2011. On a system scale, these increases have generally returned unvegetated channel widths and configurations to 1998 conditions (see sidebar figure).[37] Two notable exceptions are the Anchor Points located on the Cottonwood Ranch Complex and on Audubon's Rowe Sanctuary where the channel has been intensively managed through island clearing and channel widening (in the case of Cottonwood Ranch).[38] In these areas, both the unvegetated and unobstructed channel widths are significantly greater than they were in 1998. This is a positive indicator for the ability of the Program and/or other organizations to be able to successfully alter the channel mechanically for the purpose of improving habitat suitability.

The overall similarity of channel widths and configurations in 1998 and 2011 on a system scale provides an indication that flows in combination with herbicide application eliminated vegetation that encroached into the active channel during the drought of the 2000s but generally did not widen or reconfigure the overall channel sufficiently to improve on habitat suitability prior to the drought. This supports the

contention that mechanical channel consolidation and/or clearing and leveling of permanently vegetated islands is necessary to "prepare" a suitable channel that can then potentially be maintained through SDHF releases.

The channel widening at the Cottonwood Ranch Complex can be attributed to mechanical widening projects implemented by the Nebraska Public Power District (NPPD) and the Program starting in the early 2000s. In addition to channel widening, the Program has conducted mechanical clearing and maintenance activities at every Program habitat complex. As a result of this experience, the Program has developed a good understanding of costs (in terms of both money and time) associated with mechanical channel alterations. This will be useful as the Program begins to evaluate the costs of the FSM and MCM management strategies in relation to their performance.



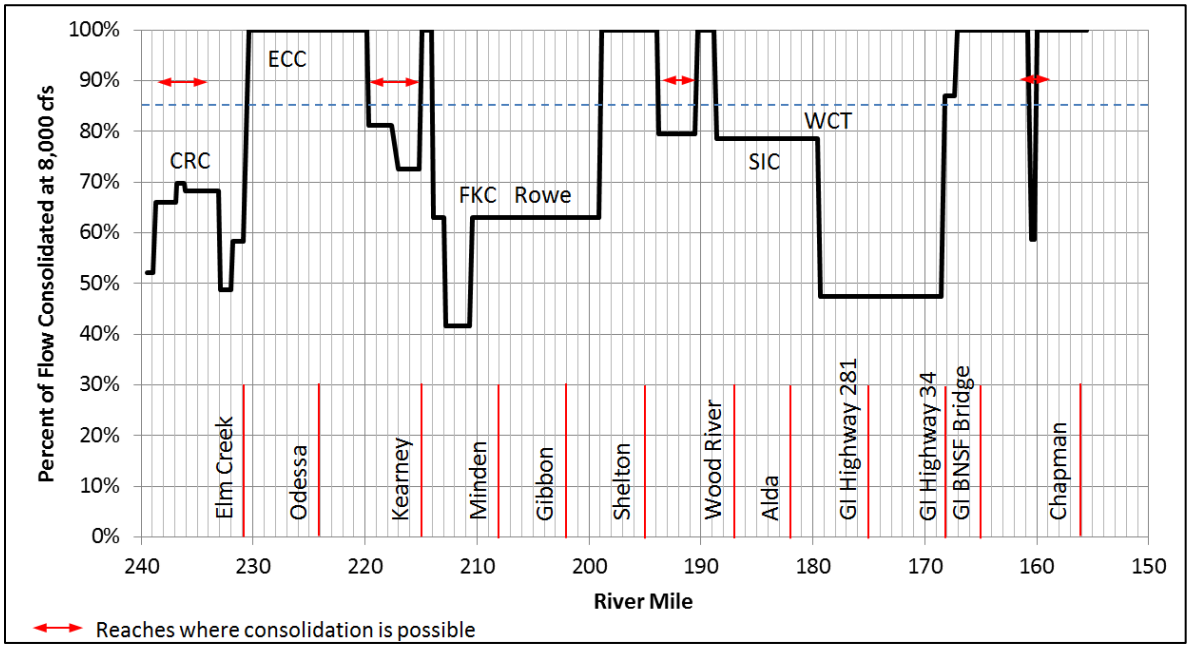
Following the 2011 high flow event, channel widths and configurations in the associated habitat reach are very similar to 1998 conditions except for at locations like Cottonwood Ranch and Rowe Sanctuary where intensive mechanical management actions like island clearing and leveling have increased channel width. This supports the hypothesis that mechanical channel manipulation is necessary to "prepare" a suitable channel that could then potentially be maintained through SDHF releases.

Mechanical Flow Consolidation

The concept of flow consolidation was developed from analysis of unvegetated channel widths in 1998 imagery.[39] At that time, the total unvegetated channel width across much of the associated habitat reach was sufficient to achieve the minimum unobstructed width target of 750 feet but the significant number of flow splits meant that the total width was spread across multiple channels. This resulted in unobstructed width significantly below the target except for reaches where infrastructure or valley confinement consolidated almost all of the flow into a relatively narrow corridor. This observation gave rise to the hypothesis that consolidating 85-90% of flow into a single channel will (at a minimum) accelerate the transition of the river to suitable habitat, and potentially may be necessary to maintain suitable habitat using flow.

Flow consolidation is only a viable management action in reaches where downstream landowners will not be either deprived of flow or subjected to increased flooding risk. There are relatively few reaches in the associated habitats that meet these requirements. The figure on Page 17 presents the existing degree of consolidation in the Associated Habitat reach based on the Program modeling and indicates reaches where consolidation may be feasible. Overall, approximately 33 miles (33%) of the associated habitat reach is consolidated and 17 miles (19%) could potentially be consolidated. *From a FSM performance perspective this means that at best, the transition toward suitable habitat in at least half of the associated habitat reach will be very gradual and at worst, some degree of ongoing mechanical intervention will be necessary in 50% of the Associated Habitat reach in order to maintain suitable habitat.* The Cottonwood

Ranch Complex is one of the reaches where flow consolidation is potentially feasible and the Program is currently working on the implementation design for a flow consolidation management experiment to evaluate the incremental channel maintenance benefit of consolidation.[40]



This figure presents the percent of flow consolidated in the main channel at 8,000 cfs from Overton downstream to Chapman. Approximately 33% of the associated habitat reach is consolidated and another 19% of the reach could potentially be consolidated (see red arrows). If flow consolidation is necessary to maintain suitable habitat using flow, at least half of the associated habitat reach would require some degree of ongoing mechanical intervention.[41]

Governance Committee Decision-making Q&A:

Is flow consolidation a feasible management action?

At best, it can only be an opportunistic action. Flow is generally consolidated at the Elm Creek Complex and the Shoemaker Island Complex, making them prime locations for evaluating the FSM management strategy. Flow can be consolidated at the Cottonwood Ranch Complex and final design and implementation of that action is now underway. This is likely the only flow consolidation management action that will be recommended during the First Increment.

5. Do whooping cranes select suitable riverine roosting habitat in proportions equal to its availability?

It is hypothesized that when whooping crane roosting habitat availability increases, the proportion of the whooping crane population using the central Platte River and the length of those stays will increase (i.e., roosting habitat is limiting).[42]

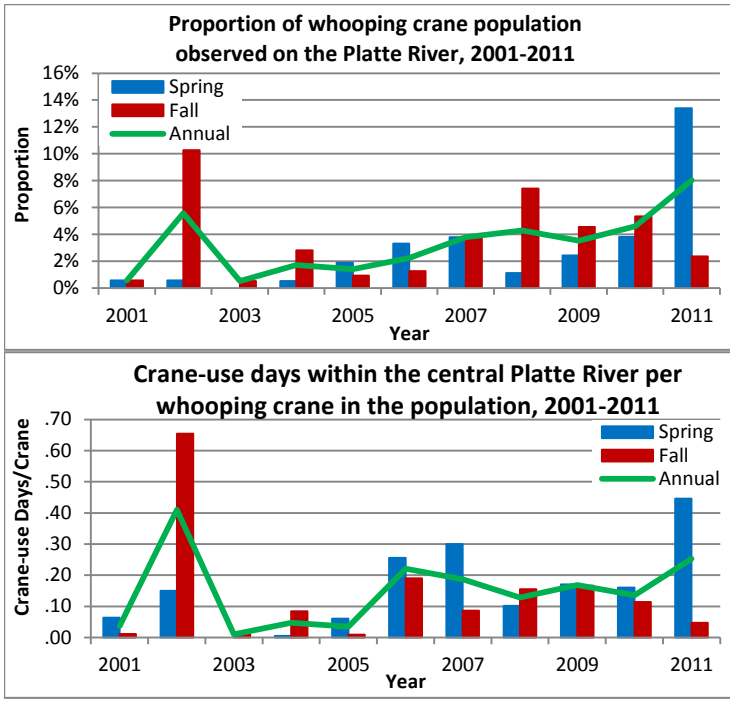
Analysis Conducted to Date:

The Program monitors whooping crane use of the central Platte River during spring and fall migration periods each year and is a core partner in an international whooping crane telemetry tracking project.[43] Program contractors prepare monitoring reports each migration season that, among other things, include raw monitoring numbers, nocturnal roost locations, diurnal use locations, and habitat metrics.[44] Habitat availability during the tern/plover nest initiation period (April-July) and during the spring and fall whooping crane migration periods are calculated each year based on Program-defined suitability criteria using aerial photography, LiDAR imagery, HEC-RAS models, and GIS computing.

What Does the Science Say?

Program monitoring data suggest whooping crane use of the Associated Habitats may be increasing. However, detailed habitat availability assessments are underway but are not yet completed so at this time we are unable to fully assess this Big Question.

Program whooping crane monitoring data collected to date (figures below[45]) indicate that the proportion of the whooping crane population observed using the central Platte River and number of days whooping cranes have used the central Platte River on an annual basis (weighted by population size) appear to be increasing annually[46]; however, use is still being evaluated against habitat availability during each migration season. Detailed whooping crane habitat availability assessments (2001-2012) are now underway and are expected to be completed in early 2013. Once completed, the results of those assessments will be paired with whooping crane use data collected by the Program to more fully evaluate whooping crane use of suitable roosting habitat and to re-examine proposed unobstructed channel width targets for whooping cranes.



Program whooping crane monitoring data from 2001-2011 indicate the proportion of the whooping crane population that utilized the Associated Habitats and crane use days within the Associated Habitats may be increasing. Both figures account for the reported whooping crane population growth, 2001-2011.

Governance Committee Decision-making Q&A:

Will be developed once habitat availability assessments and associated analyses are complete in 2013; this assessment will then be updated for the 2013 Executive Summary.

6. Does availability of suitable nesting habitat limit tern and plover use and reproductive success on the central Platte River?

It is hypothesized that when in-channel (sandbars) and off-channel (sandpits) nesting habitat availability increase, tern and plover use and productivity will increase (i.e., habitat is limiting).[47]

Analysis Conducted to Date:

The Program monitors tern and plover use of the central Platte River from late April through August each year. This includes both river habitat and off-channel habitat monitoring. EDO staff prepares an annual monitoring report that includes raw monitoring numbers and calculations of important bird-related metrics such as breeding pair (use), nest success, and fledge ratios (productivity).[48] Habitat availability during the tern/plover nest initiation period (April-July) is calculated each year based on Program-defined suitability criteria using aerial photography, LiDAR imagery, HEC-RAS models, and GIS computing.

What Does the Science Say?

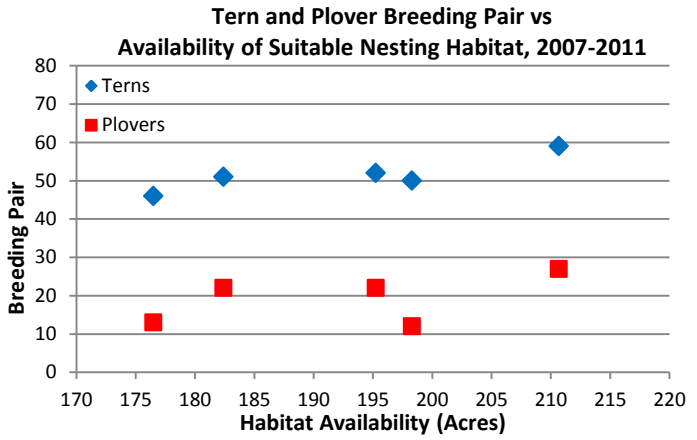
Program monitoring and data analysis indicate that as habitat increases, tern and plover use and productivity increase. However, this conclusion is preliminary due to marginal changes in habitat availability and high variability in the data from 2007-2011.

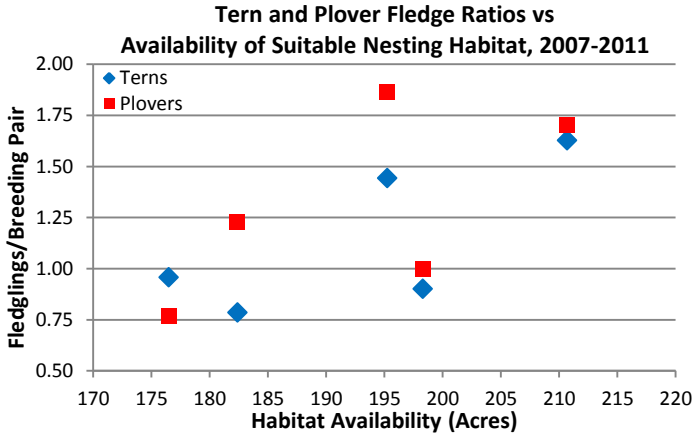
Program management actions since 2007 resulted in a steady increase in off-channel habitat despite vegetation encroachment and annual loss of suitable nesting habitat at privately owned sandpit sites (table below). Prior to the 2012 nesting season, the Program created or enhanced ~75 acres of off-channel nesting habitat which resulted in increased tern and plover nesting at three of these sites. During this same timeframe, availability of in-channel habitat meeting Program suitability criteria decreased steadily due to prolonged natural high-flow events.

Land Ownership	2007 In-Channel Habitat Acres	2011 In-Channel Habitat Acres	% Change		2007 Off-Channel Habitat Acres	2011 Off-Channel Habitat Acres	% Change
Program	6	2	-67%		20	67	235%
Non-Program	20	3	-85%		136	139	2%
TOTAL	**26**	**5**	**-81%**		**156**	**206**	**32%**

Program-defined tern and plover nesting habitat acres in the river as sandbars (in-channel) and at sandpits (off-channel) during 2007 and 2011, and the percent increase or decrease in habitat acres from 2007-2011. Habitat numbers for 2007 are based on preliminary habitat availability assessment results; final results will likely change slightly during 2012. NOTE: "Habitat acres" are different than "Program acres"; all Program acres do not fit Program-defined habitat suitability criteria (for example, only certain acres of a sandpit count as suitable tern and plover nesting habitat based on criteria like slope, distance to trees, etc.).

Program monitoring and data analyses indicate that as availability of Program defined suitable habitat increases, tern and plover use and productivity increase (figure below[49]). Marginal changes in habitat availability and high year-to-year variability in fledge ratios, however, reduces the certainty of whether or not habitat availability currently limits tern and plover productivity on the central Platte River.





These figures show the relationships between availability of Program-defined suitable in- and off-channel nesting habitat and tern and plover use and productivity, 2007–2011. Habitat numbers for 2007 are preliminary estimates and will be updated following completion of the habitat availability assessment in 2012.

Governance Committee Decision-making Q&A:

Should the Program create and maintain additional off-channel nesting habitat?

Yes. The Program and its partners acquired and maintain approximately 125 acres of suitable tern and plover nesting habitat. Program efforts to create and maintain off-channel tern and plover nesting habitat have been successful and resulted in a net increase in off-channel habitat availability and numbers of tern and plover breeding pair and also distributed nesting across a wider stretch of river. Despite these efforts and successes, the amount off-channel habitat available for nesting only increased by approximately 50 acres due habitat loss to vegetation encroachment at privately owned sandpits. The Program is currently constructing an additional 35 acres and monitors approximately 80 acres of privately-owned, off-channel nesting habitat that is not managed to control vegetation. During the next couple years, the privately-owned habitat will likely become developed or vegetated and unsuitable for terns and plovers which will result in only a slight gain in off-channel habitat during the Program's First Increment.

Should the Program create and maintain additional in-channel nesting habitat?

Yes. Since 2007, the Program created approximately 13 acres of suitable in-channel nesting habitat that, along with most in-channel habitat created and maintained by Program partners, was inundated and eroded away by natural high-flow events the past two summers. Through 2011, there was a very limited amount of what the Program-defined suitable in-channel habitat available for nesting. A wider range in habitat availability should be created to confirm the relationships between tern and plover use and habitat availability observed to date. Moving forward, the Program should build in-channel nesting islands to evaluate bird response to habitat availability.

7. Are both suitable in-channel and off-channel nesting habitats required to maintain central Platte River tern and plover populations?

It is hypothesized that ephemeral, in-channel nesting islands (sandbars) are needed for long-term nesting success of terns and plovers on the central Platte and when available, terns and plovers will select sandbars over sandpits for nesting. It is also hypothesized that tern and plover nesting is more successful on in-channel than off-channel habitat which could eliminate the need to maintain off-channel habitat.[50]

Analysis Conducted to Date:

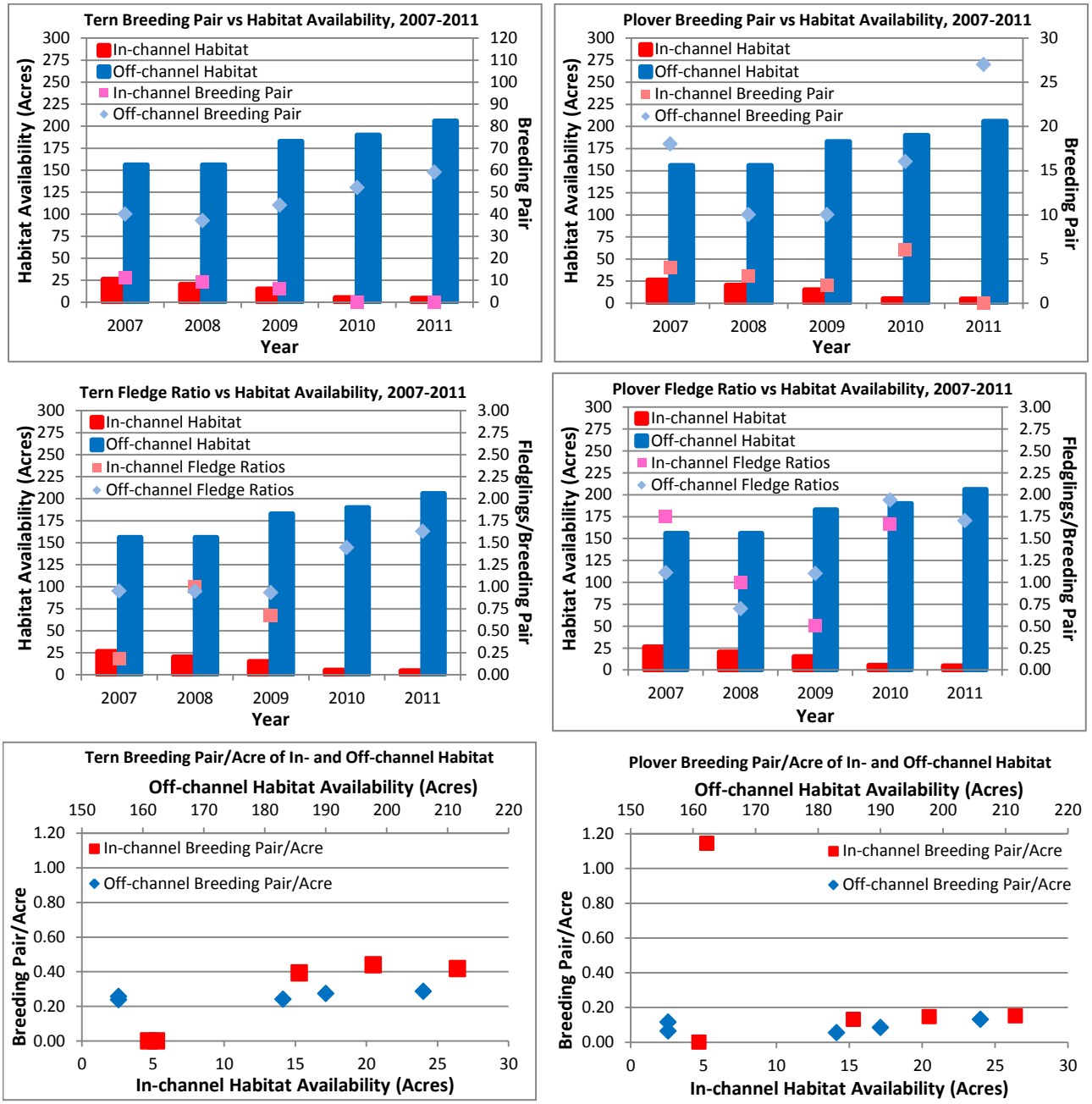
The Program monitors tern and plover use of the central Platte River from late April through August each year. This includes both in-channel and off-channel habitat monitoring. EDO staff prepares an annual monitoring report that includes raw monitoring numbers and calculations of important bird-related metrics such as breeding pairs (use), nest success, and fledge ratios (productivity). Habitat availability during the tern/plover nest initiation period (April-July) is calculated each year based on Program-defined suitability criteria using aerial photography, LiDAR imagery, HEC-RAS models, and GIS computing. EDO staff plan to conduct a rigorous habitat selection analysis that will provide additional insight into answering this Big Question. In addition, the Program conducted a two-year tern and plover foraging habits study[51] (2009-2010) and currently is banding tern and plover adults and chicks to quantify dispersal rates, habitat colonization, and productivity on in-channel and off-channel habitat.

What Does the Science Say?

Tern and plover use and productivity have increased at sandpit sites and use has decreased at in-channel sites since 2007. Detailed habitat selection analyses have not yet been completed so at this time we are unable to fully address this Big Question.

Detailed tern and plover habitat availability assessments (2007-2012) are now underway and are expected to be completed for the Program in 2012. Once completed, habitat availability assessment results will be paired with tern and plover use data collected by the Program to evaluate tern and plover selection of Program-defined suitable nesting habitat. Based on Program monitoring data and minimum suitable tern and plover nesting habitat criteria, in-channel habitat and use have declined steadily since 2007 while off-channel habitat availability, use, and productivity[52] have increased (figure below).

Though variable, tern and plover productivity numbers (fledge ratios) have increased since 2007 and are at levels believed to result in population growth (figure below[53]). Much of the productivity observed to date has been at off-channel sites where productivity is hypothesized to be lower than in-channel sites. We observed higher densities of tern and plover breeding pairs on in-channel nesting habitat (figure below); however, we generally observed lower fledge ratios at in-channel sites and observed no tern nests on river islands during 2010 or 2011 and no plover nests on the river during 2011. Availability of Program-defined suitable in-channel nesting habitat, however, has been low during the first five years of the Program. The decline in sandbar habitat and shortage of sandbar nesting leaves open the question of whether both habitat types are necessary to maintain tern and plover populations on the central Platte River. The Program plans to use habitat assessment results and tern and plover use data to conduct detailed habitat selection analyses and currently is conducting research to quantify dispersal rates, habitat colonization, and productivity on in-channel and off-channel habitat. Results of these studies will allow us to establish better relationships between in-channel and off-channel habitat availability and tern and plover use and productivity and answer this Big Question. Final results of these efforts will be available in 2013 and 2014, respectively.



Relationships between availability of Program-defined suitable in- and off-channel nesting habitat (bars) and numbers of tern and plover breeding pair (points; top row), fledge ratios (middle row), and breeding-pair densities (bottom row) observed on in- and off-channel nesting habitat, 2007–2011. Habitat numbers for 2007 are preliminary estimates and will be updated in 2013 following completion of the habitat availability assessment in late 2012.

Governance Committee Decision-making Q&A:

Should the Program maintain existing off-channel nesting habitat?

Yes, the Program and its partners acquired and maintain approximately 125 acres of suitable tern and plover nesting habitat. Program efforts to create and maintain 67 acres of off-channel tern and plover

nesting habitat have been successful and resulted in a net increase in off-channel habitat availability and numbers of tern and plover breeding pairs and also distributed nesting across a wider stretch of river. Despite these efforts and successes, the amount of off-channel habitat available for nesting only increased by approximately 50 acres due to habitat loss to vegetation encroachment at privately owned sandpits. The Program is currently constructing an additional 35 acres and monitors approximately 80 acres of privately-owned, off-channel nesting habitat that is not managed to control vegetation. During the next couple of years, the privately-owned habitat will likely become developed or vegetated and unsuitable for terns and plovers which will result in only a slight increase in off-channel nesting habitat during the Program's First Increment.

Should the Program create and maintain additional in-channel nesting habitat?
Yes. Since 2007, the Program created approximately 13 acres of suitable in-channel nesting habitat that, along with most in-channel habitat created and maintained by Program partners, was inundated and eroded away by natural high-flow events the past two summers. Through 2011, there was a very limited amount of what the Program-defined as suitable in-channel habitat available for nesting. A wider range in habitat availability should be created to rigorously test the relationships between tern and plover use and habitat availability observed to date. Moving forward, the Program should build islands of various sizes and heights and in channels of various widths to evaluate bird response and ensure Program habitat criteria accurately define habitat conditions used by terns and plovers.

NOTE: Further work is required in 2013 at the technical level of the Program to address the true intent of Priority Hypothesis TP1 and how best to analyze Program data to evaluate the relationship between in-channel and off-channel habitat selection and use by terns and plovers.

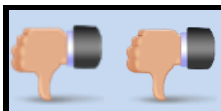
8. Does forage availability limit tern and plover productivity on the central Platte River?

It is hypothesized that availability of fish for terns and invertebrates for plovers limits productivity of both species, especially when flows are below 800 cfs during the nesting season (May through August).[54]

Analysis Conducted to Date:

Nebraska Public Power District (NPPD) and Central Nebraska Public Power and Irrigation District (CNPPID) have monitored forage fish abundance on the central Platte since 1999 to comply with Federal Energy Regulatory Commission (FERC) license requirements.[55] The Program and Program contractors provide staff support for this monitoring effort each summer, but this is not a Program monitoring protocol. The EDO analyzed these data in conjunction with U.S. Geological Survey (USGS) flow data in 2008 and again in 2012 to explore relationships between forage fish availability and river flow.[56] The USGS conducted the Program's tern/plover foraging habits study in 2009-2010 providing additional insight on forage availability and foraging habits for both terns and plovers.[57]

What Does the Science Say?



Forage fish monitoring data, the Program's tern/plover foraging habits study, and Program data analysis reveal that forage abundance (fish and invertebrates) is high at nearly all flow levels on the river during the summer as well as on sandpits. Though there is not a strong link between this available data and tern/plover productivity, the TAC believes this link does not warrant further investigation as a priority issue.

In 2009-2010, invertebrate (plover forage) abundance was higher on sandpit sites than river sites; however, only one river site was sampled. The research also found fish (tern forage) abundance, diversity, and tern foraging success was higher at riverine than sandpit sites.[58] Terns frequently were observed foraging ≥6 miles from their nesting site which indicates terns forage across a wider range of habitat than originally thought. Again, however, in-channel habitat and nesting was fairly minimal so further studies would be needed to confirm these findings.

Despite several years of data collection and the availability of a rather large set of data, we were unable to establish a relationship between discharge and forage fish abundance. Similar to Chadwick and Associates (1992), a vast majority (>80%) of fish captured in open channel areas where least terns forage were deemed suitable forage for least terns.[59] Average forage fish density across all samples, sites and years was 2,438 fish/acre which is similar to what was reported in the Program's Foraging Habits Study.[60] The Foraging Habits Study found abundance, diversity, and tern foraging success was higher at riverine than sandpit sites which would indicate the river likely is an important forage source for least terns. The study also revealed that forage fish abundance at least tern foraging sites and random locations were similar which would indicate forage abundance was high throughout the river channel. We used interior least tern and piping plover habitat classification results for 2009 (low to normal flow year) and 2011 (high flow year) to calculate total wetted channel area within the Program Associated Habitat Area and extrapolated average forage fish densities across the wetted channel areas. We estimated there were 14.8 million potential forage fish available within the active channel area during 2009 and 27.7 million during 2011.[61] The Foraging Habits Study also revealed least terns frequently traveled distances of 6 miles to forage which would make a wide range of habitats and water conditions and hundreds of thousands of forage fish available to least terns while foraging.

Our findings do not easily translate into data useful for assessing priority hypotheses such as T2a and ultimately the relationship between forage fish abundance and least tern productivity. However, with observed least tern productivity numbers[62] and forage fish abundance numbers, there currently is no evidence that abundance of forage fish within the central Platte River limits least tern productivity so long as there is at least some flow in the channel. During years when 0 cfs flows are recorded at gaging stations downstream of NPPD's Kearney Canal Diversion, forage fish populations above the diversion and in other river segments with a consistent supply of water from canal return flows appear to allow the central Platte forage fish populations to rebound quickly once flows return to the river.

The Program collected invertebrate samples at five in-channel and five off-channel sites during the summer of 2012 and preliminary indications are that small and large invertebrates are more abundant on sandbars than sandpit sites; however, final results of this effort will be reported in the Programs 2012 tern and plover monitoring and research report. Contrary to our findings, the Program's Foraging Habits Study found invertebrate (plover forage) abundance was higher on sandpit sites than river sites; however, only one river site was sampled and sampling did not occur within wetted sandbar areas where one would expect to observe plovers foraging. Based on observed plover productivity numbers[63] and a limited amount of invertebrate data, there currently is no evidence that invertebrate abundance within the central Platte River habitats limits plover productivity.

Governance Committee Decision-making Q&A:

Should the Program implement a system-wide forage fish monitoring protocol?

No. While we feel it could be beneficial to continue to monitor forage fish abundance and diversity in the central Platte River as has been done in the past, at this time there is no evidence to warrant implementing a system-wide monitoring protocol. In order to test our assumptions and fully evaluate least tern response to forage fish abundance throughout the Program Associated Habitat Area, additional protocols and a systematic approach, such as sampling at Program anchor points, would be needed. Sampling efforts would also need to be expanded to include the wide range of discharges observed during the May-September time period to provide a larger data set of fish abundance at different river discharges and to capture a broader fish response to discharge related to both fish recruitment and availability as tern forage. Evaluating least tern response to forage fish abundance would also require capturing and weighing least tern chicks on multiple occasions to establish the relationship between growth rates and forage fish abundance. At this time, we do not feel these additional expenses, efforts, and risk of injury to least tern chicks are warranted as it appears forage fish abundance is adequately high to support the central Platte population of least terns.

Should the Program implement a system-scale invertebrate monitoring protocol?

No. While invertebrate data collected to date is limited, at this time there is no evidence to warrant implementing a system-scale invertebrate monitoring protocol on the central Platte River. To test the assumption that invertebrate abundance limits piping plover productivity and fully evaluate plover response to invertebrate densities throughout the Program Associated Habitat Area, a systematic approach and additional protocols would be needed. Evaluating plover response to invertebrate abundance would require sampling at all potential nesting and foraging sites as well as capturing and weighing plover chicks on multiple occasions to establish the relationship between growth rates and invertebrate abundance. At this time, we do not feel these additional expenses, efforts, and risk of injury to plover chicks are warranted given we have observed relatively high productivity that would indicate the forage base at current nesting sites is adequate to support the central Platte population of plovers. Similar to forage fish monitoring, however, we encourage opportunistic sampling to establish baseline invertebrate abundance data at in-channel and off-channel nesting habitats.

9. Do Program flow management actions in the central Platte River avoid adverse impacts to pallid sturgeon in the lower Platte River?

It is hypothesized that Program water management actions, such as diverting excess to target flows for retimed release, will result in a measurable change in stage in the lower Platte River and thus affect pallid sturgeon habitat suitability.[64]

Analysis Conducted to Date:

The Program initiated the Lower Platte River Stage Change Study (IMRP pallid sturgeon activity #3) in 2008 to develop a tool to evaluate the potential effects of Program water management activities (storage projects, re-timing, water conservation, depletions covered by state and federal depletions plans) on stage and how stage changes might affect the physical characteristics of the lower Platte River. Field sampling, 1-D and 2-D modeling, and analysis were completed in 2009. The study was finalized in 2010, peer reviewed in 2011, and the Governance Committee accepted the peer review and the stage change study as complete in June 2012.[65] The Program also completed a pallid sturgeon literature review in 2008.[66]

What Does the Science Say?

Application of the Program's stage change study tool indicates that central Platte River flow management actions are likely to avoid adverse impacts to pallid sturgeon in the lower Platte River.

The stage change study scale was the lower Platte River from the Elkhorn River confluence to the Missouri River confluence, as defined in the Program document. Intensive fieldwork and modeling were conducted on a smaller study reach from the Highway 50 Bridge to the reclaimed Pedestrian Bridge near Louisville, Nebraska. Data collection and modeling began in September 2008 and concluded in October 2009. Performance measures evaluated during the study are provided in the table below.

Performance Measure	Range of Conditions Evaluated
Water depth and velocity	between 3,700 – 40,000 cfs
% of Program water	reaching Louisville
Changes in habitat classifications (slackwater, flat, riffle, run, isolated pool, plunge)	between 3,700 – 40,000 cfs
Number of days	below 4,000 cfs @ Louisville (Dry Conditions Analysis)
Range of flows	below 4,000 cfs @ Louisville (Dry Conditions Analysis)
Number of consecutive days	below 4,000 cfs @ Louisville (Dry Conditions Analysis)

Given the influence of the Loup and Elkhorn Rivers on lower Platte flows, water management activities in the lower Platte, flow attenuation, and their size and timing, the prediction was Program water management activities would not have a statistically significant impact on lower Platte flows or on the type or availability of pallid sturgeon habitat (as defined only by the study's habitat classifications).[67] Stage change study analysis of historic reach gains and losses showed that not all flow reaching Grand Island is translated downstream to Louisville and that predicted changes in discharge due to Program water management activities is likely within the range of gage uncertainty. 2-D modeling conducted during the study accurately predicted changes in the six habitat classifications over the range of modeled discharges.

At the request of Program participants, the study authors conducted a Dry Conditions Analysis as a kind of "worst case scenario" to determine how the stage change study tool might be used to evaluate Program

water management activities at a time of excess flow in the central Platte but low flow in the lower Platte.[68] The period of record was analyzed for one period in the spring and one in the fall when flows were above target at Grand Island, the Program could divert some portion of that excess, and flows were simultaneously in the 4,000-6,000 cfs range at Louisville. Assuming habitat connectivity is important for pallid sturgeon and that connectivity declines below 4,000 cfs, this analysis showed that short-term connectivity could be problematic, but only for a range of 2-14 days depending on flow conditions.[69]

The general conclusion of the stage change study is that Program water management will not result in measurable changes on flow in the lower Platte River and thus little change to the amount of habitat available to pallid sturgeon.[70] However, given that short-term connectivity could be problematic under certain, but infrequent hydrological conditions, and assuming the biological significance of habitat connectivity for pallid sturgeon[71] above 4,000 cfs, the study tool could be used by the Program to implement proactive measures (e.g. altering excess-to-target-flow diversion timing or duration) to prevent potential negative impacts on habitat connectivity. Use of the tool for this purpose would be greatly enhanced if additional data were collected and analyzed regarding what defines pallid sturgeon habitat in the lower Platte and how that habitat is being utilized.

Governance Committee Decision-making Q&A:

Does completion of the stage change study mean the Program is "done" with pallid sturgeon?

No. The stage change study is only a technical tool that can now be used by the Program to evaluate the potential impacts of Program water management actions on stage in the lower Platte. Further Program actions for the pallid sturgeon (for example, pallid sturgeon habitat use/selection research[72]) are squarely a policy decision that is at the sole discretion of the Governance Committee. The U.S. Fish and Wildlife Service maintains the GC needs to address, at the policy level, perceived disagreement between the AMP management objective of "avoid adverse impacts from Program actions on pallid sturgeon populations" and the stated Program goal of "testing the assumption that managing flow in the central Platte River also improves the pallid sturgeon's lower Platte River habitat."[73]

Should the stage change study be utilized to evaluate Program water management actions?

Yes. For example, the stage change study can be used to evaluate different operational scenarios for the J-2 re-regulating reservoir now in the planning stages.

10. How do Program management actions in the central Platte River contribute to least tern, piping plover, and whooping crane recovery?

It is hypothesized that restoring land into five habitat complexes of roughly 2,000 acres each and applying Program management actions that influence those complexes will result in positive effects on the target bird species that will help lead to recovery.[74]

Analysis Conducted to Date:

Since 2007, the Program implemented its Land Plan, Water Plan, and Adaptive Management Plan components. The Program is the Reasonable and Prudent Alternative for the U.S. Fish and Wildlife Service's Final Biological Opinion on the Platte River and is being implemented to secure "defined benefits for the target species and their associated habitat to assist in their conservation and recovery".[75] Thus, implementation of Program management actions itself is considered a contribution toward recovery of the target species. Highlights of successful implementation thus far include:

- Acquisition of over 9,000 of the Program's First Increment Land Objective of 10,000 acres.
- Habitat restoration including channel widening, in- and off-channel tern/plover nesting habitat construction and management, vegetation management, and other related activities at five Program habitat complexes.
- Implementation of FSM "Proof of Concept" activities at the Elm Creek and Shoemaker Island Complexes.
- Sediment augmentation pilot-scale management actions at the Plum Creek and Cottonwood Ranch Complexes.
- Flow consolidation management action at the Cottonwood Ranch Complex.

Additionally, the Program is engaging with entities working with the three target bird species in other river systems and locations to develop a strategy for assessing the significance of Program management actions and the resulting bird response on the overall populations of all three species. Activities include:

- Serving as a "Core Partner" in the Whooping Crane Tracking Partnership, a migratory range-wide telemetry study of whooping cranes.
- Serving as a member of the Working Group for development of an Interior Least Tern Metapopulation Model.
- Participating in range-wide meetings on the status of the piping plover.
- Urging development of life-history based Conceptual Ecological Models (CEM) for all three bird species, and contributing to the development of those CEMs.

What Does the Science Say?

Program implementation is considered a contribution to the recovery of the target species. A clearer picture of the magnitude of that contribution to the overall health of the populations of the three target bird species will emerge closer to the end of the First Increment.

Data collection related to the larger-scale items above is only in the early stages, and any analysis of data such as that collected through the whooping crane telemetry project will produce speculative conclusions. Analyzing data relative to this Big Question will only prove fruitful toward the end of the First Increment, so

Program involvement in data collection and developing CEMs for the target bird species will continue until enough data is collected and analysis procedures are specified in a way that will shed more objective light on this question and the associated hypothesis.

Governance Committee Decision-Making Q&A:

What constitutes recovery of the interior least tern, piping plover, and whooping crane?

Addressing this question by developing objective, quantifiable performance measures will continue to be a priority during the First Increment.

What contribution does the central Platte make to overall recovery of the three target bird species?

As above, developing objective, quantifiable performance measures to address this question remains a First Increment priority. However, as per the Final Program Document, implementation of the Program is itself considered a contribution toward recovery of the target species.

11. What uncertainties exist at the end of the First Increment, and how might the Program address those uncertainties?

A list of existing and/or new unanswered questions will be maintained throughout the First Increment to set the stage for evaluation during the Second Increment.

The intent of this Big Question is to serve as "parking lot" for major scientific and technical uncertainties that remain unanswered toward the end of the First Increment. These "unanswered questions" may be Big Questions that still remain unanswered, or secondary uncertainties that were not sequenced as priorities during the First Increment, or they may be new questions revealed during the course of implementation of the AMP during the First Increment. A sample list of existing Priority Hypotheses not intended, at this point, to be addressed during the First Increment is presented in the table below as a placeholder for potential Second Increment uncertainties to be logged as they are identified. This list will continue to change and grow during the course of the First Increment.

Broad Hypotheses & Other Potential Second Increment "Big Questions"	Priority Hypotheses
Implementation – Program Management Actions and Habitat	
PP-4: Higher water surface elevations resulting from raised river bed elevations can generate measurable increases in the elevation, extent, frequency, and/or duration of growing-season high water tables in wet meadows within 3,000 feet of the river.	WM-2, 3, 4, 8a
Effectiveness – Habitat and Target Species Response	
WC-2: Whooping cranes prefer palustrine wetlands to river channel, based on known migratory stopover habitats. Whooping crane use of the central Platte River study area during migration seasons will increase proportionately to an increase in palustrine wetlands.	WC3
PS-3: Non-Program actions (e.g. harvest, stocking, Missouri River conditions) determine the occurrence of pallid sturgeon in the lower Platte River.	PS-11
Larger Scale Issues – Application of Learning	
What uncertainties exist at the end of the Second Increment, and how might the Program address those uncertainties?	N/A

Potential Second Increment "Big Questions", including existing Broad Hypotheses and Priority Hypotheses from the AMP that could serve as the foundation for additional Big Questions in the Second Increment.

Governance Committee Decision-Making Q&A:

In terms of Program science, what don't we know that the GC wants to investigate to inform decision-making?

This question is directed back at the GC to ensure there is open communication between the GC and the technical representatives of the Program. The purpose of this Big Question is to keep a running list of scientific and technical questions the GC needs to have addressed to inform management decision-making.

APPENDIX A

ISAC COMMENTARY ON THE "BIG QUESTIONS" AND 2012 ASSESSMENTS

October 17, 2012

ISAC Comments on 2012 State of the Platte Report Executive Summary

The ISAC was asked four questions about the document. The questions are listed in bold, followed by our replies in boxes.

Are the Big Questions reasonable and do they adequately encompass the intention/meaning of the Broad Hypotheses and associated Tier 1 Priority Hypotheses as noted in the Big Question table?

Generally yes. The Big Questions (BQs) are reasonable and that they are a very good strategy for collapsing complex hypotheses, issues and a large amount of data into a manageable and effective synthesis. The ISAC has some suggested tweaks to BQ 3, and BQ 7, which are provided in our detailed comments to the EDO. There are challenges in answering these questions due to confounding factors, variability, etc. and those challenges should be made clear. It is important to give the GC (and others) some guidance on what it will take to answer those questions that are still uncertain, and whether that's achievable within the First Increment. Possible replies:

a) **Feasible to answer in First Increment**:
b) **Unlikely; requires significant changes in river conditions to be answerable during First Increment** (e.g., more river nesting sites to answer BQ7). Indicate what *can* be answered at the end of First Increment.
c) **Not feasible to answer in First Increment** given year to year variability in river conditions, the time lags involved in establishing habitat, the variability in bird response to habitat, and the need for multiple years of observations to draw reliable conclusions. Indicate what *can* be answered at the end of First Increment.
d) **Question can probably never be answered as stated and needs to be rephrased.** Due to unanticipated complexities in the system, unexpected and unavoidable confounding by other factors (e.g., effects of spraying on channel width under Q2), or lack of suitable data for a retrospective analysis, we simply will never be able to answer this question as stated, and should either rephrase it or abandon it.
e) **Question has been answered.**

Are the assessments consistent with what you have learned during your involvement with the Program (AMP Reporting Sessions, other ISAC meetings, reviewing documents, etc.) and logical based on your understanding of Program data?

Generally yes. The ISAC was impressed at the synthesis that has been done, and the hierarchical approach to the organization of the report, with details in endnotes. It's a big step forward. There are some tweaks required to either: 1) clarify the relevance of certain assessments to the questions (gets too weedy at times for a GC audience and much could be moved to endnotes); 2) specify the relative amount of weight that should be applied to different lines of evidence; and/or 3) remove a few lines of evidence that are weak or not relevant.

For 10 of the 11 big questions, the ISAC felt that the conclusions (i.e., thumbs up or down, uncertain) were reasonable. The one exception was Q6 ("Does availability of suitable nesting habitat limit tern and plover use and reproductive success on the central Platte River?"). For this question, the ISAC believes that the Program needs more time and more data points. The existing positive slopes to the relationships are driven by just 2 data points, and have weak fits statistically. The statistics should be calculated and stated. It's premature to give one thumb up. Still a "?".

Are the assessments technically adequate?

This summary condenses an incredible amount of information into a straight-forward, well-focused, easy to understand format. Program participants should feel very proud for what they've accomplished. The assessments are thorough and technically adequate for the most part, though there are some suggested changes in wording, presentation and form of conclusions. It is very important to be clear on what one can legitimately conclude or cannot conclude from the available data.

A key issue under Big Question 5 is to re-evaluate the target unconfined channel width for whooping cranes, using roosting site data from both the Platte River and all other rivers where such data exist. There is clearly a large difference between the channel widths that whooping cranes use in the Platte and the channel widths that they are believed to require. The ISAC has indicated in earlier reviews that the Program needs to re-evaluate habitat criteria, and this habitat criterion seems like an excellent focus for such a re-evaluation.

Big Question 1 (the SDHF evaluation) uses a "peak flow and whole cross-section" perspective. Anecdotal information suggests a finer scale of evaluation (e.g., form of the rising limb of the hydrograph and within cross section spatial complexity) could also be important components to this question.

Is the presentation of each assessment clear and understandable?

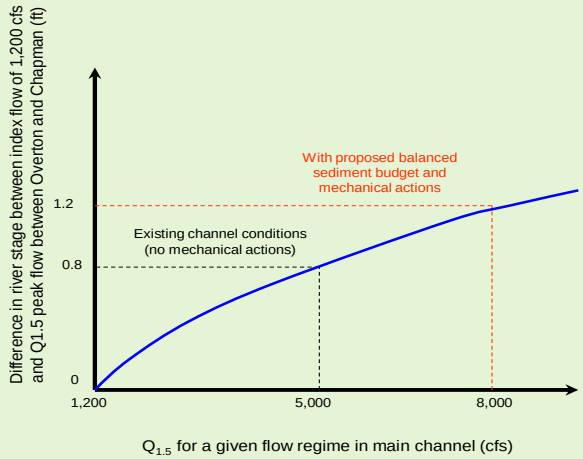
The audience is the GC. The ISAC really liked the boxes "What does the Science Say?" and the closing sections with questions for the GC. It's important to write this document so that all GC members (not just TAC and ISAC members) can follow the logic of the results and explain it to someone else (i.e., the constituency of each GC member). The ISAC has various suggestions on this issue:

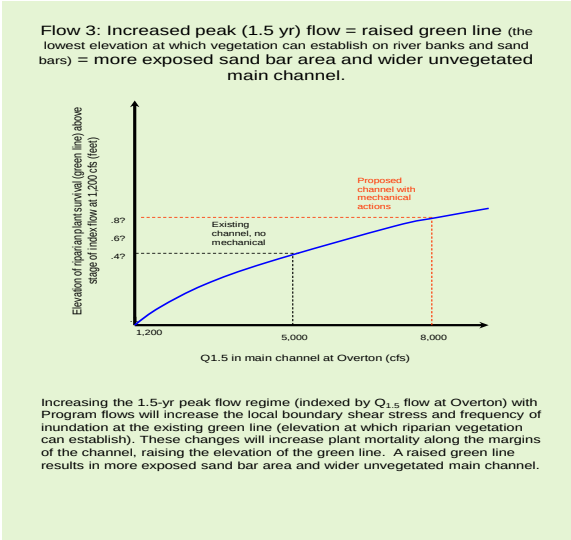
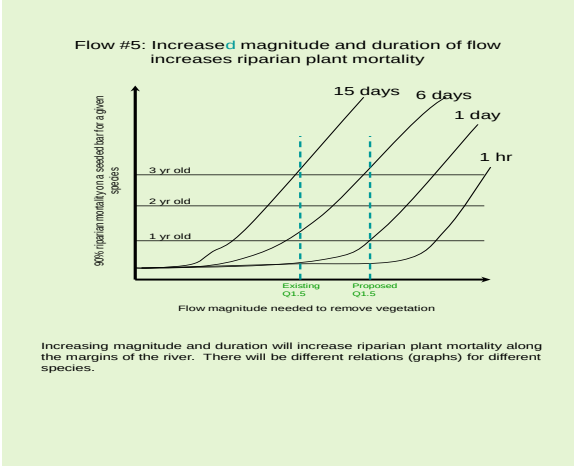
- include a 2-3 page strategic level summary up front for those executives who won't read 30 pages and are mainly concerned about overall program direction and decisions
- move a lot of the technical material into endnotes;
- add maps that show Program actions and habitat complexes
- improve the writing: shorter sentences, less jargon, clear topic and closing sentences to each paragraph
- keep text directly focused on the big question (why it matters, main achievements & what we've learned, next steps, ability to answer in First Increment, GC decisions)
- work towards developing a document (perhaps next year) that would be appropriate for not only the GC, but also the general public, visitors from the Department of Interior, etc. The current document is still largely for those inside the Program who are intimately familiar with all of its details.

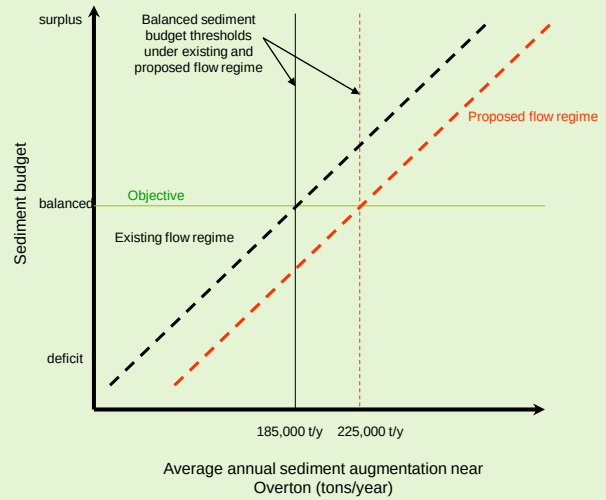
ISAC Members:
David Marmorek (chair), Philip Dixon, David Galat, Robert Jacobsen, Kent Loftin, John Nestler

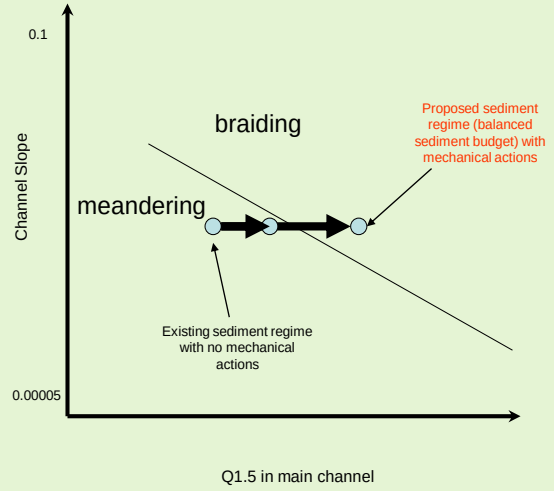
APPENDIX B

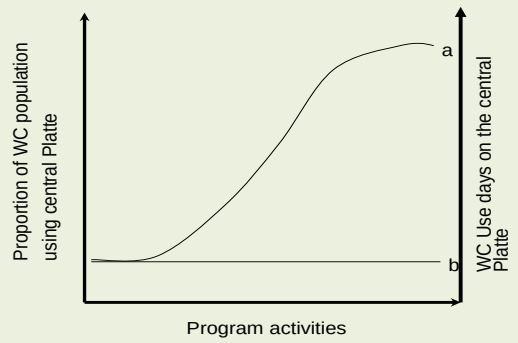
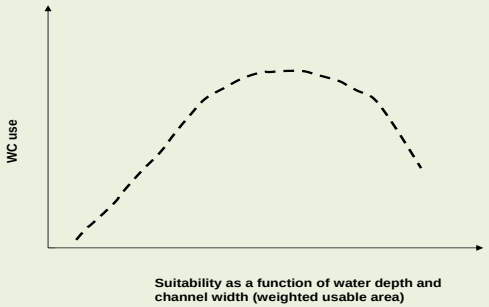
TIER 1 PRIORITY HYPOTHESES & ASSOCIATED X-Y GRAPHS

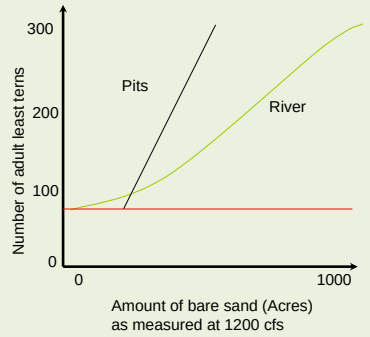
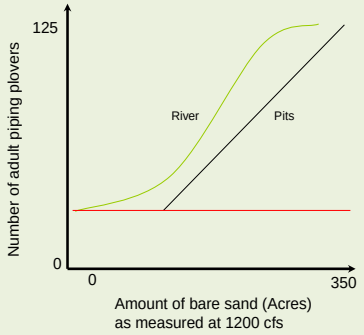
PRRIP "Big Questions"	Priority Hypotheses	Alternative Hypotheses	X-Y Graphs
<u>Implementation</u> – Program Management Actions and Habitat			
1. Will implementation of SDHF produce suitable tern and plover riverine nesting habitat on an annual or near-annual basis?	**Flow #1:** ↑ the variation between river stage at peak (indexed by Q1.5 flow @ Overton) and average flows (1,200 cfs index flow), by ↑ the stage of the peak (1.5-yr) flow through Program flows, will ↑ the height of sandbars between Overton and Chapman by 30% to 50% from existing conditions.	Flow magnitudes and channel compilations are insufficient to generate bars high enough to provide habitat for ILT and PP. Bars may become quickly vegetated, making them poor habitat for target species. Bars can be created or maintained by mechanical or other means.	Flow 1: Increasing river stage variation will increase sand bar height  Increasing the variation between river stage at peak flow (indexed by $Q_{1.5}$ flow at Overton) and average flows (1,200 cfs index flow), by increasing the stage of the peak (1.5-yr) flow through Program flows, will increase the height of sand bars between Overton and Chapman by 30% to 50% from existing conditions, assuming balanced sediment budget.

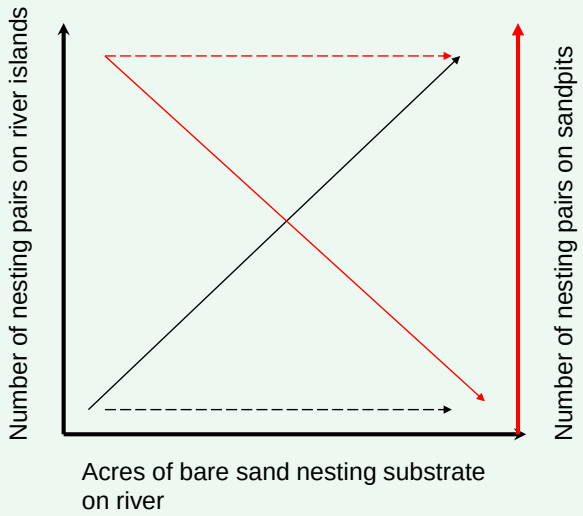
PRRIP "Big Questions"	Priority Hypotheses	Alternative Hypotheses	X-Y Graphs
<u>Implementation</u> – Program Management Actions and Habitat			
2. Will implementation of SDHF produce and/or maintain suitable whooping crane riverine roosting habitat on an annual or near-annual basis?	**<u>Flow #3</u>**: ↑ 1.5-yr Q with Program flows will ↑ local boundary shear stress and frequency of inundation @ existing green line (elevation at which riparian vegetation can establish). These changes will ↑ riparian plan mortality along margins of channel, raising elevation of green line. Raised green line = more exposed sandbar area and wider unvegetated main channel.	Insufficient Program flows to adequately increase shear stress on banks. Plant mortality can be achieved by other means.	
	<u>Flow #5:</u> ↑ magnitude and duration of a 1.5-yr flow will ↑ riparian plan mortality along the margins of the river. There will be different relations (graphs) for different species.	Insufficient Program flows to adequately increase shear stress on banks. Plant mortality can be achieved by other means.	

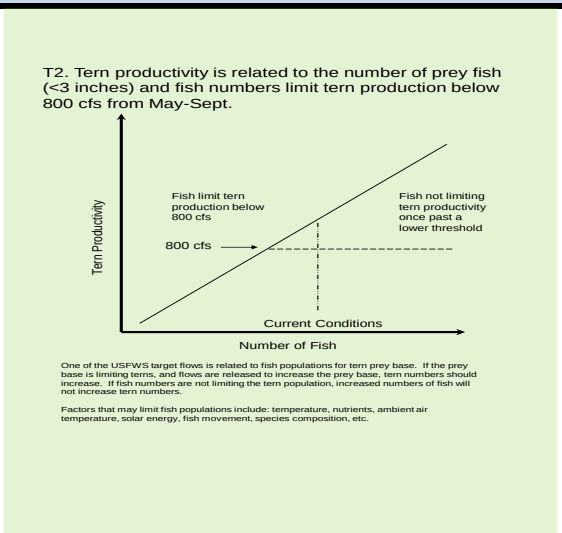
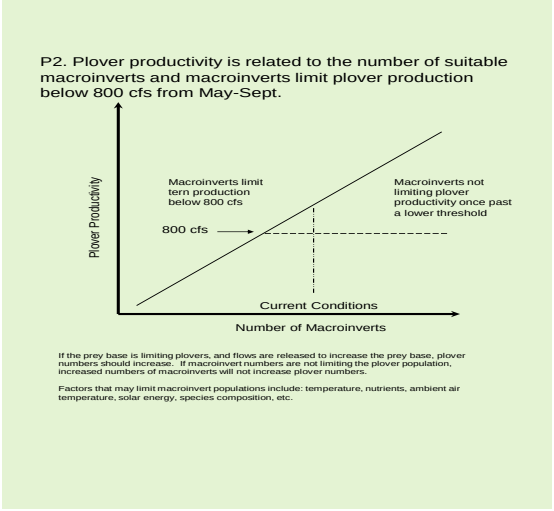
PRRIP "Big Questions"	Priority Hypotheses	Alternative Hypotheses	X-Y Graphs
<u>Implementation</u> – Program Management Actions and Habitat			
3. Is sediment augmentation necessary for the creation and/or maintenance of suitable riverine tern, plover, and whooping crane habitat?	**<u>Sediment #1</u>**: Average sediment augmentation near Overton of 185,000 tons/yr. under existing flow regime and 225,000 tons/yr. under GC proposed flow regime achieves a sediment balance to Kearney.	Augmentation greater than or less than 225,000 tons/year is needed to balance the sediment budget and increase exposed bar area. There is no sediment imbalance. Exposed bar area or occurrence of braiding will not be affected by increased sediment. Sediment balance is insignificant except in local instances. Satisfactory bar areas can be created and maintained through strictly mechanical actions.	Sediment 1: Sediment augmentation balances the sediment budget.  Sediment augmentation near Overton to 185,000 tons/yr under existing flow regime and 225,000 tons/year under the Governance Committee proposed flow regime achieves a sediment balance to Kearney.

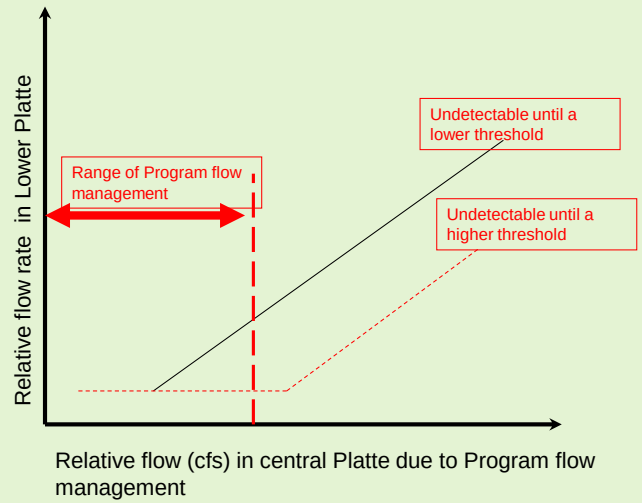
PRRIP "Big Questions"	Priority Hypotheses	Alternative Hypotheses	X-Y Graphs
<u>Implementation</u> – Program Management Actions and Habitat			
4. Are mechanical channel alterations (channel widening and flow consolidation) necessary for the creation and/or maintenance of suitable riverine tern, plover, and whooping crane habitat?	**<u>Mechanical #2</u>**: Increasing the Q1.5 in the main channel by consolidating 85% of the flow, and aided by Program flow and a sediment balance, flows will exceed stream power thresholds that will convert main channel from meander morphology in anastomosed reaches, to braided morphology with an average braiding index > 3.	Higher stream power (higher 1.5 yr. Q and/or more consolidation of side channels) needed to convert channel to braided morphology. Lower stream power will convert channel to braided morphology.	Mechanical (channel manipulation) 2: Stream power determines braided channel morphology (this focuses on channel consolidation rather than increased releases)  Increasing the Q1.5 in the main channel by consolidating 85% of the flow, and aided by Program flow and a sediment balance, flows will exceed stream power thresholds that will convert the main channel from a meander morphology in anastomosed reaches to a braided morphology with an average braiding index greater than 3.

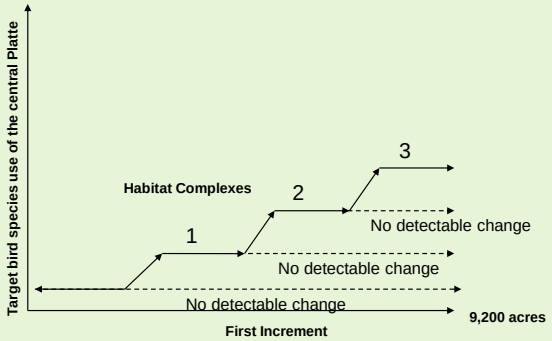
PRRIP "Big Questions"	Priority Hypotheses	Alternative Hypotheses	X-Y Graphs
<u>Effectiveness</u> – Habitat and Target Species Response			
5. Do whooping cranes select suitable riverine roosting habitat in proportions equal to its availability?	**<u>WC1</u>**: Whooping crane use will increase as function of Program land and water management activities.	Whooping crane use will not increase as function of Program land and water management activities.	WC 1. Whooping Crane use will increase as function of Program land and management activities.  a. The amount of whooping crane use days will increase as Program activities increase. b. Whooping crane use days will not increase with Program activities. Analysis and consideration will be needed to investigate Program activities and non Program activities (e.g., Trust land management). Analysis could also be done on a bridge segment basis as well as a system basis.
	<u>WC3</u>: Whooping crane use is related to habitat suitability. The prediction of habitat suitability for whooping crane in channel habitat as a function of water depth (preferred depth?) and channel width (define as wetted width, open width, other?).	Whooping crane use is not related to habitat suitability. The prediction of habitat suitability for whooping crane in-channel habitat is not a function of water depth (preferred depth?) and channel width (define as wetted width, open width, other?).	WC 3. Whooping crane use is related to habitat suitability  The prediction of habitat suitability for whooping crane in channel habitat as a function of water depth and unobstructed channel width. FWS Instream flow recommendation for fall and spring whooping crane migration season is 2,400 cfs. Farmer et al. estimates that peak suitability is achieved at 1700 cfs.

PRRIP "Big Questions"	Priority Hypotheses	Alternative Hypotheses	X-Y Graphs
<u>Effectiveness</u> – Habitat and Target Species Response			
6. Does availability of suitable nesting habitat limit tern and plover use and reproductive success on the central Platte River?	**<u>T1</u>**: Additional bare sand habitat will ↑ number of adult least terns. **<u>P1</u>:** Additional bare sand habitat will ↑ number of adult piping plovers.	Bare sand is not currently limiting number of adults.	T1: Additional bare sand habitat will increase the number of adult least terns.  Green line is island densities from central Platte constructed islands using only years when birds were present on islands densities would be approximately half this if we use all years islands were present. Black line using estimated acres and 96 bird average on 81 acres of sandpits last 4 years Red line is bare sand not currently limiting so additional acres has no effect. P1. Additional bare sand habitat will increase the number of adult piping plover.  Green line is island densities from central Platte constructed islands using only years when birds were present on islands densities are approximately half this is we use all years islands were present. Black line using estimated acres and 30 bird average on 81 acres sandpits last 4 years Red line bare sand not limiting so additional acres no effect

PRRIP "Big Questions"	Priority Hypotheses	Alternative Hypotheses	X-Y Graphs
<u>Effectiveness</u> – Habitat and Target Species Response			
7. Are both suitable in-channel and off-channel nesting habitats required to maintain central Platte River tern and plover populations?	**<u>TP1</u>:** Interaction of river and sandpit habitat.	ILT and PP show no preference for the river over sandpits.	TP 1. There is an Interaction of river and sandpit habitat.  As river habitat increases, additional birds will 1) move into the region, and birds will continue to use the sandpits at current number or 2) move from sandpits to the river. The relationship between use and location (river, sandpit) may indicate a relative preference for nesting location.

PRRIP "Big Questions"	Priority Hypotheses	Alternative Hypotheses	X-Y Graphs
Effectiveness – Habitat and Target Species Response			
8. Does forage availability limit tern and plover productivity on the central Platte River?	**T2**: Tern productivity is related to the number of prey fish (<3 inches) and fish numbers limit tern production below 800 cfs from May-Sept.	Prey fish do not limit tern production at 799 cfs or tern production is limited by summer flows of < 50 cfs.	
	P2: Plover productivity is related to the number of suitable macroinverts and macroinverts limit plover production below 800 cfs from May-Sept.	Macroinverts do not limit plover production at 799 cfs or plover production is limited by summer flows of < 50 cfs.	

PRRIP "Big Questions"	Priority Hypotheses	Alternative Hypotheses	X-Y Graphs
<u>Effectiveness</u> – Habitat and Target Species Response			
9. Do Program flow management actions in the central Platte River avoid adverse impacts to pallid sturgeon in the lower Platte River?	**<u>PS2</u>**: Program water management will result in measurable changes on flow in the lower Platte River.	Program water management will result in statistically insignificant changes on flow in the lower Platte River.	PS 2: Program water management will result in measurable changes on flow in the lower Platte River.  Program flow management results in measurable change in the lower Platte flows. The probability of detecting flow changes in the lower Platte as a result of Program water management activities (e.g., new depletions plans, summer flow augmentation) is improbable. Program pulse flow management will have the greatest chance of resulting in measurable changes in the lower Platte.

PRRIP "Big Questions"	Priority Hypotheses	Alternative Hypotheses	X-Y Graphs
<u>Larger Scale Issues</u> – Application of Learning			
10. Do Program management actions in the central Platte River contribute to least tern, piping plover, and whooping crane recovery?	**<u>S1b</u>**: Program land management actions (i.e. restoration into habitat complexes) will have a detectable effect on target bird species' use of the associated habitats.	Cannot detect a significant effect on indicators.	S1b Program land management actions (i.e., restoration into habitat complexes) will have a detectable effect on target birds species use of the associated habitats  Achieving habitat features on Program lands with characteristic approximating the guidelines in Table of the Land Plan (Habitat Complexes) and the Mgt. Joint Study will be an efficient and biologically effective long-term land conservation and management strategy on the Platte River for the target bird species. Overall habitat complex approach <u>Distribution</u> – 3 complexes distributed throughout study reach <u>Location</u> – 6,400 ac above Minden; 2,800 ac below Minden <u>Channel</u> – 2 miles long; 1,150 ft channels (overall 30% increase in channels >750 ft); maintained by clear/level/pulse approach <u>Wet Meadows</u> – 640 ac per complex (10% increase in central Platte region) <u>Buffers</u> – Up to 0.5 miles wide but may be variable <u>Restoration</u> – At least 50% of land would undergo restoration
11. What uncertainties exist at the end of the Second Increment, and how might the Program address those uncertainties?	N/A	N/A	N/A

APPENDIX C

PRRIP HABITAT SUITABILITY CRITERIA

WHOOPING CRANES
&
INTERIOR LEAST TERNS/PIPING PLOVERS

DISCLAIMER: Preliminary Habitat Suitability Criteria were based on an evaluation of Cooperative Agreement and Program whooping crane data collected between 2001 and spring 2011 and generally were set to incorporate 90% of whooping crane observations. These criteria are subject to revision based on Program evaluation of future monitoring and research data.

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
Whooping Crane Habitat Suitability Criteria Descriptions

Terminology for Quantifying Whooping Crane Habitat Availability

- Obstruction – Object ≥1.5 meters above ground level at a reference point or the waterline for wetted areas.
- Unobstructed Channel – Along a line perpendicular to the channel that extends from obstruction to obstruction and passes through a reference point, the unobstructed channel is the area that lies between the vegetation lines of the island or bank that contain the obstructions that lie on the line and on each side of the reference point.
- Disturbance Feature – Road, town, residence, out-building, etc. that may influence whooping crane use of an area. Bridges are an in-channel disturbance feature only.
- Benchmark Flows – To be determined by the Program's Technical Advisory Committee. Year-1 Assessment will be conducted @ 1,700cfs, 2,400cfs, and observed flows.

Whooping Crane In-channel Minimum Habitat Suitability Criteria (Appendix 1)

1. Channel Depth	**≤8 inches**
2. Suitable Channel Area	**≥40% of the channel ≤8 inches or bare sand**
3. Distance to Disturbance Feature	**≥160 feet and ≥1,320 feet (¼ mile) from a bridge**
4. Distance to Obstruction	**≥75 feet**
5. Unobstructed Channel Width	**≥280 feet**
6. Wetted Channel Width	**≥250 feet**
7. Unobstructed View Width	**≥330 feet**

Channel Depth

- *Definition* – Depth of channel from the surface of the water to the bed of the channel at benchmark and observed flows.
- *Criterion* – Channel areas ≤8 inches deep at benchmark and observed flows are habitat if the areas meet all additional in-channel minimum habitat criteria.

Suitable Channel Area

- *Definition* – Proportion of the channel ≤8 inches deep or bare sand.
- *Criterion* – Areas where ≥40% of the channel is ≤8 inches deep or bare sand at benchmark and observed flows are habitat if the areas meet all additional in-channel minimum habitat criteria.

Distance to Disturbance

- *Definition* – Distance from a point in any direction to the nearest disturbance feature.
- *Criterion* – Areas within individual channels that are ≥160 feet from all disturbance features and ≥1,320 feet (¼ mile) from a bridge are habitat if the areas meet all additional in-channel minimum habitat criteria.

Distance to Obstruction

- *Definition* – Distance from a point in any direction to the nearest obstruction (Figure 1).

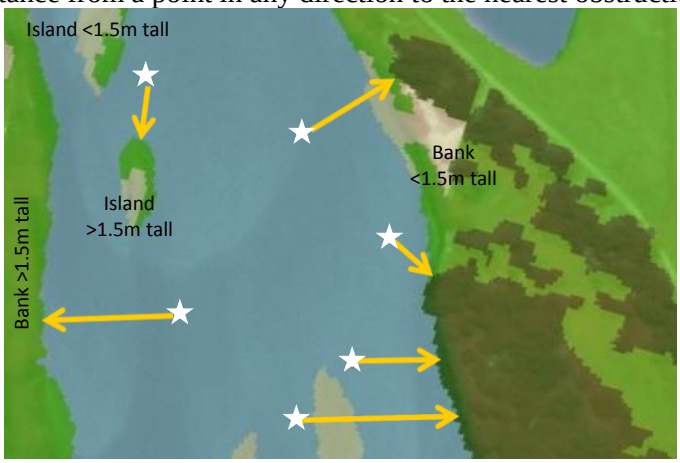


Figure 1. Distance to Obstruction

- *Criterion* – Areas within individual channels that are ≥75 feet from an obstruction are habitat if the areas meet all additional in-channel minimum habitat criteria.

Unobstructed Channel Width

- *Definition* – Measured width of the unobstructed channel at benchmark or observed flows (Figure 2). Unobstructed channel width measurements start and end at the vegetated portion of islands or banks containing the obstruction in either direction from the reference point (i.e., unobstructed channel width does not extend beyond vegetated bank lines). Unobstructed channel width includes bare sand areas and vegetated sandbars that do not contain an obstruction that lies on a line running perpendicular to the channel.

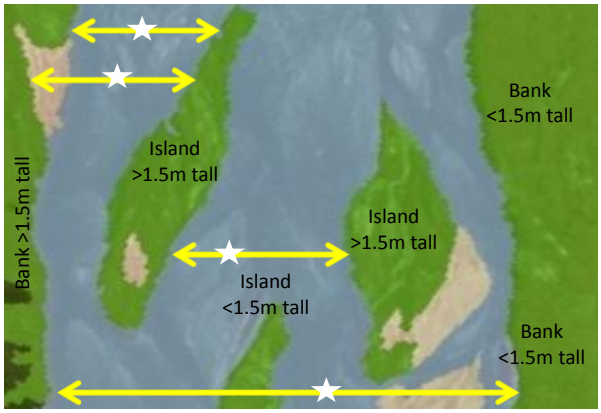


Figure 2. Unobstructed Channel Width

- *Criterion* – Areas with unobstructed channel widths ≥280 feet at benchmark or observed flows are habitat if the areas meet all additional in-channel minimum habitat criteria.

Wetted Channel Width

- *Definition* – Distance within the unobstructed channel that is covered by water at benchmark or observed flows (Figure 3). Wetted channel width measurements exclude bare sand and vegetated sandbar areas within the unobstructed channel.

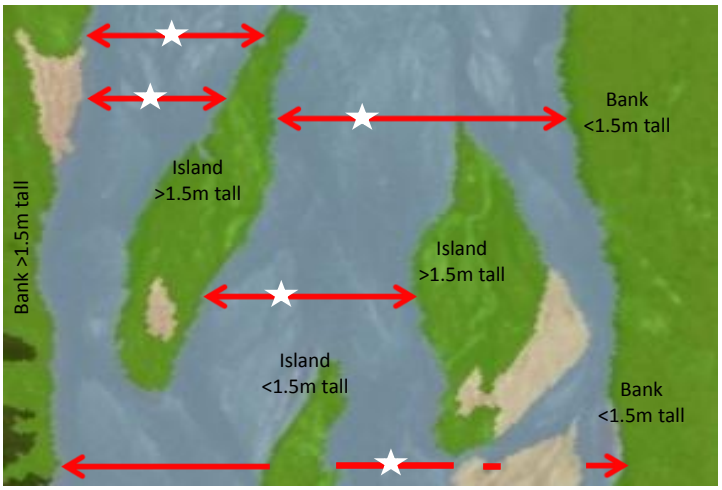


Figure 3. Wetted Channel Width

- *Criterion* – Areas with wetted channel widths ≥250 feet at benchmark or observed flows are habitat if the areas meet all additional in-channel minimum habitat criteria.

Unobstructed View Width

- *Definition* – Along a line perpendicular to the channel that extends from obstruction to obstruction and passes through a reference point, the unobstructed view width is the distance between the obstructions (Figure 4). Unobstructed view width includes all island/bare sand, vegetated sandbars, and banks between the first obstruction on either side of the reference point.

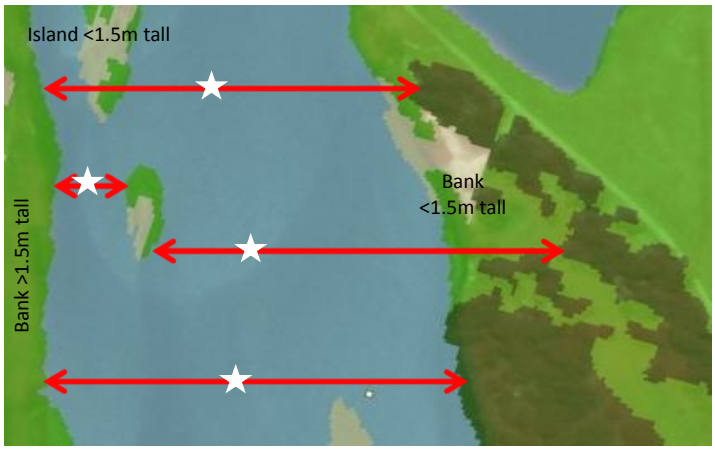


Figure 4. Unobstructed View Width

- *Criterion* – Areas with unobstructed view widths ≥330 feet at benchmark or observed flows are habitat if the areas meet all additional in-channel minimum habitat criteria.

Whooping Crane Off-channel Minimum Habitat Suitability Criteria (Appendix 2)

1. **Area** **≤3.5 miles of main channel or ≤2 miles of side channel**
2. **Landcover Type and Structure**
   - **i. Corn, soybean, alfalfa, wheat, grassland, wet meadow, and palustrine wetland**
     1. Suitable grassland acres determined by visiting a sample of sites
     2. Suitable cropland acres determined by reports of percent of crop fields harvested prior to the migration season
   - **ii. Wet Meadow Criteria**
     1. Wet Meadow Working Group (WMWG) identified potential wet meadow areas
     2. Habitat availability assessment contractor classify all grassland types as grassland
        - i. Identified grasslands that conform to the Program's Wet Meadow Habitat Guidelines (Appendix 3) and meet all Program WC Minimum Habitat Criteria will be classified as whooping crane wet meadow habitat by the habitat availability assessment contractor; however, the WMWG will make the final determination of whooping crane wet meadow areas on a site-by-site basis.
   - **iii. Palustrine Wetland Criteria (Roost Habitat)**
     1. ≥5 acres of water area ≤18 inches deep
     2. ≥25% of the water area ≤12 inches deep
     3. at least 1 water area that is 500 feet × 500 feet
3. **Distance to Obstruction** **≥75 feet**
4. **Unobstructed View Width** **≥330 feet**
5. **Distance to Disturbance Feature** **≥285 feet**

Area

- *Definition* – Program Associated Habitat Area
- *Criterion* – Areas ≤3.5 miles of the main channel or ≤2 miles of side channel or the Platte River are habitat if the areas meet all additional minimum habitat criteria.

Landcover Type and Structure

- *Definition* – Landcover types suitable for whooping crane use
- *Criterion* – Areas of corn, soybean, alfalfa, wheat, grassland, wet meadow, and palustrine wetland are habitat if the areas meet all additional off-channel minimum habitat criteria.
  - *Cropland* – Suitable acres of cropland will be determined by reducing the total acres by the proportion of each crop type reported to have been harvested prior to 1 November each year.
  - *Grasslands* – Suitable acres of grassland will be determined by visiting a sample of grassland sites and reducing the total acres by the proportion of the sample that were of unsuitable structure for whooping crane use.
  - *Wet Meadow* – Wet Meadow areas will be delineated by the Program's Wet Meadow Working Group. Once an area is classified wet meadow habitat, it will remain wet meadow until management activities change the landcover type.
  - *Palustrine Wetland* – ≥5 acres of water area ≤18 inches deep with ≥25% of the water area ≤12 inches deep and at least 1 water area that is 500 feet × 500 feet.

Distance to Obstruction

- *Definition* – Distance from a point in any direction to the nearest obstruction (Figure 5).

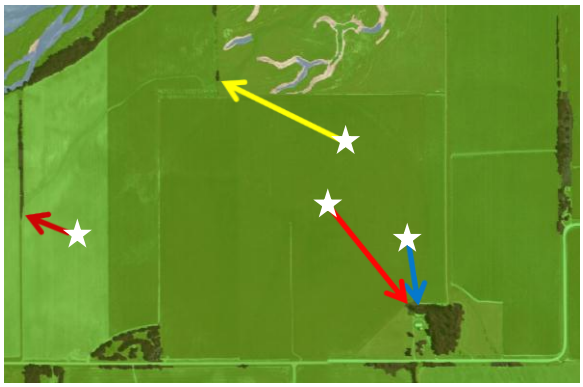


Figure 5. Distance to Obstruction

- *Criterion* – Areas that are ≥75 feet from an obstruction are habitat if the areas meet all additional off-channel minimum habitat criteria.

Unobstructed View Width

- *Definition* – Along a line passing through a reference point in any direction, unobstructed view width is the distance between obstructions (Figure 6). Unobstructed view width includes the area between the first obstruction on each side of the reference point.

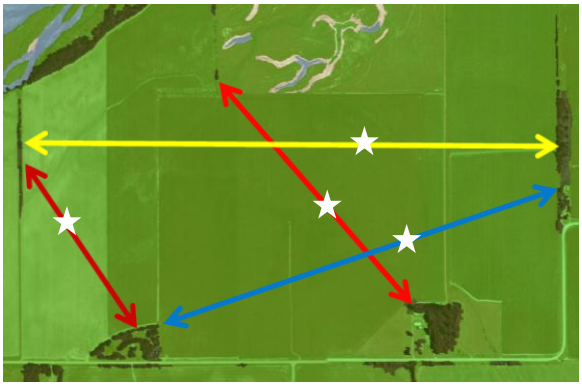


Figure 6. Unobstructed View Width

- *Criterion* – Areas with unobstructed view widths ≥330 feet are habitat if the areas meet all additional off-channel minimum habitat criteria.

Distance to Disturbance Feature

- *Definition* – Distance from a point in any direction to the nearest human disturbance feature (Figure 7).

Figure 7. Distance to Disturbance Feature

Criterion – Areas that are ≥285 feet from a disturbance feature are habitat if the areas meet all additional off-channel minimum habitat criteria.

Appendix 1. Percentiles for in-channel habitat metrics collected at whooping crane roost locations on the central Platte River, 2001 – Spring 2011.

Metric	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
Channel Depth (in)	0.5	1.1	1.7	2.2	3.3	3.9	4.3	4.7	5.2	6.1	6.9	6.9	7.1	7.8	8.6	10.1	10.6	12.1	17.0	21.3
Suitable Channel Area	19%	38%	45%	50%	54%	59%	64%	67%	68%	73%	79%	81%	86%	90%	94%	96%	97%	99%	100%	100%
Distance to Obstruction (ft)	46	72	98	118	135	135	138	161	190	197	233	249	292	302	328	394	479	584	630	787
Unobstructed Channel Width (ft)	212	281	350	390	440	467	521	550	591	620	632	683	714	751	751	813	846	891	950	1207
Wetted Channel Width (ft)	208	256	290	328	341	370	402	417	473	493	516	553	571	614	646	652	689	781	868	1310
Unobstructed View Width (ft)	253	331	381	472	530	622	666	722	750	766	810	840	878	920	1031	1092	1175	1175	1237	1537
Flow (cfs)	94	154	175	220	256	342	427	487	582	698	830	965	1074	1161	1183	1480	1720	2568	3670	4240
Sandbar Roost Height (in)	0.1	0.1	0.2	0.3	0.4	0.6	0.8	0.8	1.0	1.0	2.0	2.1	2.4	3.4	3.6	4.2	5.2	6.8	8.2	10.2
Average Distance to Obstruction (ft)	173	215	258	272	290	300	335	376	433	448	490	497	530	554	621	650	791	809	1166	1351
Channel Openness (acres)	3	4	5	7	8	10	13	14	16	17	20	22	27	31	35	37	47	58	126	241
Transect Channel Depth (in)	4.3	4.5	5.1	5.7	5.7	6.0	6.6	7.0	7.4	8.2	8.4	8.7	9.6	10.1	10.6	11.5	12.6	14.8	17.2	25.5

Appendix 2. Percentiles for off-channel habitat metrics collected at whooping crane use locations along the central Platte River, 2001 – spring 2011.

Metric	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
Distance to Obstruction (ft)	33	49	82	164	164	197	210	246	322	328	328	328	361	492	656	820	984	1312	1640	4921
Distance to Disturbance (ft)	105	164	328	328	361	492	656	820	935	984	984	1312	1312	1640	1640	2297	2625	2625	3937	5905
Habitat Type	Channel		Sandbar		Corn		Soybean		Alfalfa		Wheat		Grassland		Wet Meadow			Palustrine Wetland		

Appendix 3. Initial guidelines for classifying Program Wet Meadow Habitat (Revised by the WMWG 2-15-12)

Wet Meadow Habitat	Characteristics	When to measure
Location	Within 3.5 miles of main channel or 2 miles of a side channel of the Platte River	During land review process
'Gold Standard' acreage	≥40 acres not less than 0.25-mile from potential disturbance or appropriately screened from roads, railroads, occupied dwellings, bridges, etc.	During land review process
Distance from disturbance	Wet meadow habitat areas for whooping cranes will be ≥285 feet from a potential disturbance feature and will conform to the Gold Standard acreage requirements; sites evaluated by WMWG on a case-by-case basis	During land review process
Vegetation composition	Manage for native prairie grasses and herbaceous vegetation; mosaic of wetland (hydrophytic) and upland (non-hydrophytic) plants	Survey after acquisition, after application of management, and annually thereafter
Hydrology	Continuously saturated soils during the WC migration season 2 out of 3 years if possible	Survey after application of management and annually thereafter
Water management	Between February and April, mean monthly groundwater levels are at or above the ground surface in swales 25% to 75% of the time	Survey after application of management and annually thereafter
Topography and soils	Level or low undulating surface with swales and depressions; wetland soils with low salinity in swales and non-wetland soils in uplands	Survey after acquisition and after application of management
Flora and fauna	Supports characteristic aquatic, semi-aquatic, and terrestrial fauna and flora (especially aquatic invertebrates, beetles, insect larvae, and amphibians)	Survey after acquisition, after application of management, and annually thereafter
Whooping crane habitat requirements	Size – 640 contiguous acres or more when possible Unobstructed view area – As far as possible (330 feet = minimum habitat criteria) Low vegetative structure area – As much as possible Water area – As much as possible while maintaining wet meadow flora and fauna	During land review process then evaluate annually

DISCLAIMER: These are draft habitat suitability criteria and are subject to revision based on Program evaluation of monitoring and research data.

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM
Tern and Plover Habitat Suitability Criteria Descriptions

Terminology for Quantifying Tern and Plover Habitat Availability

- Bare Sand – River island or sandpit site with <20% vegetative cover. Bare sand areas can be composed of dry sand or gravel substrate and nest furniture may be present.
- Predator Perch – Tree, power line, power pole, etc. ≥10 feet tall that could be used by an avian predator to view the potential nesting area.

Tern and Plover In-channel Minimum Habitat Suitability Criteria

8. **Suitable Nesting Area – ≥1/4-acre sandbar ≥18 inches above river stage @ 1,200cfs.**
9. **Channel width – ≥400 feet**
10. **Water Barrier – ≥50 feet**
11. **Distance to Predator Perch – ≥200 feet**

Suitable Nesting Area

- *Definition* – ≥0.25-contiguous acres of bare sand 18 inches above river stage @ 1,200cfs with ≥1.5 acres of exposed bare sand within a ¼-mile reach of channel.

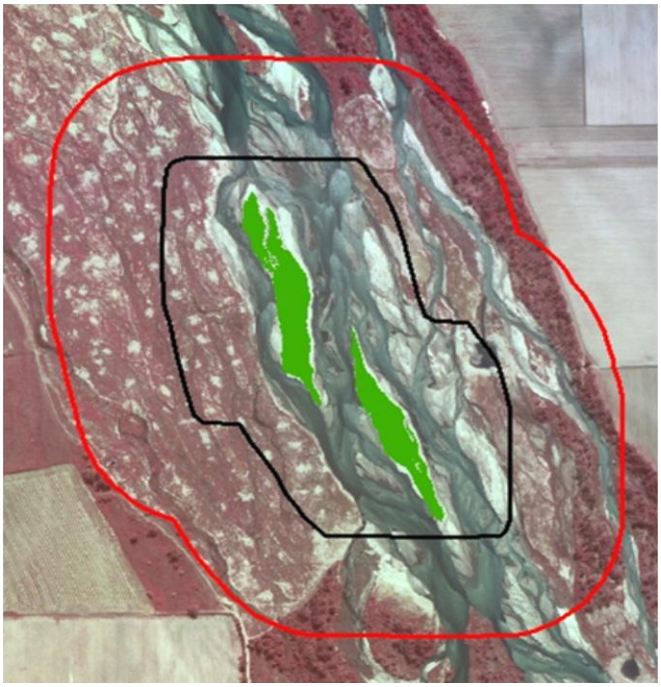


Figure 1. Suitable nesting area (green) with ≥1.5 acres of exposed bare sand within a ¼ mile stretch of channel.

- *Criterion* – all sandbar areas ≥1/4-acre in size and ≥18 inches above river stage @ 1,200cfs are suitable nesting habitat if there is ≥1.5 acres of exposed bare sand within a ¼-mile reach of channel and the areas meet all additional in-channel minimum habitat criteria.

Channel Width

- *Definition* – Along a line perpendicular to the channel extending through the center of a potential nesting island, channel width is the entire open-channel area, including sand, which lies between the vegetation lines of the island or bank on each side of the sandbar.

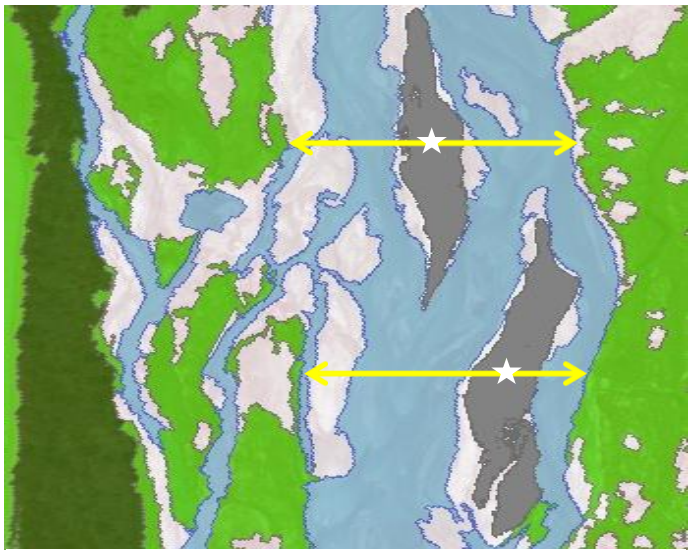


Figure 2. Channel width measured perpendicular to flow from the center of potentially suitable nesting areas.

- *Criterion* – Sandbar areas in channels ≥400 feet wide at 1,200cfs and observed flows are suitable nesting habitat if the areas meet all additional in-channel minimum habitat criteria. Bare-sand areas within channels <400 feet wide contribute to the 1.5 acres of bare sand within a ¼-mile reach of river, but are not suitable nesting habitat.

Distance to Predator Perch

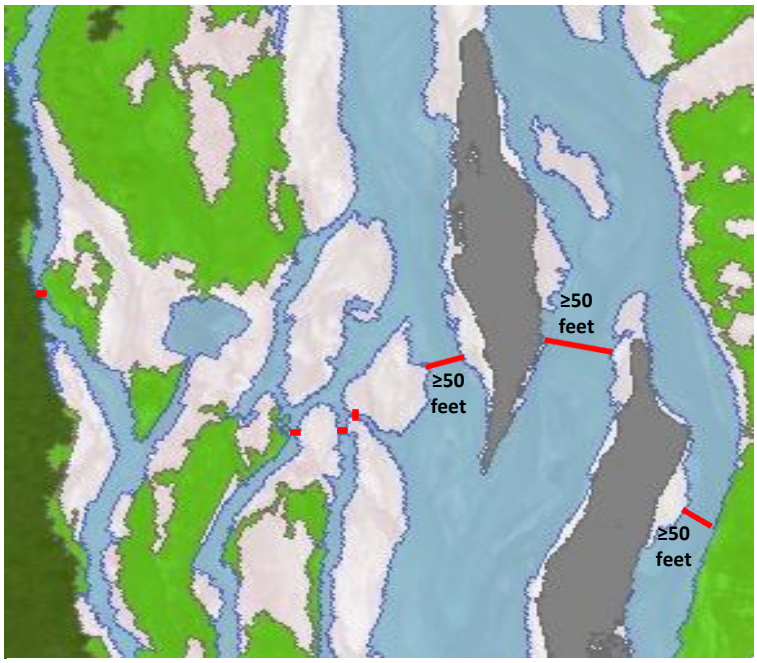
- *Definition* – Distance from the edge of potentially suitable nesting habitat in any direction to the nearest potential predator perch.

Figure 3. 200-foot buffer around predator perches (red area).

Criterion – Sandbar areas ≥200 feet from a predator perch are suitable nesting habitat if the areas meet all additional in-channel minimum habitat criteria. Bare-sand areas <200 feet from a predator perch contribute to the 1.5 acres of bare sand within a ¼-mile reach of river, but are not suitable nesting habitat.

Water Barrier

- *Definition* – Width of individual threads of channel, measured perpendicular to flow, that lie between the bank and potential nesting habitat (Figure 4).



- *Criterion* – Sandbar areas with a ≥50-foot contiguous water barrier between each shoreline and edge of bare sand are suitable nesting habitat if the areas meet all additional in-channel minimum habitat criteria. Bare-sand areas with a water barrier <50 feet contribute to the 1.5 acres of bare sand within a ¼-mile reach of river, but are not suitable nesting habitat.

Tern and Plover Off-channel Minimum Habitat Suitability Criteria

3. **Area – ≤3.5 miles of main channel or ≤2 miles of side channel**
4. **Minimum Habitat Size – ≥1.5 acres of suitable nesting habitat per site; contributing habitat must be ≥0.25 acres in size.**
5. **Distance to Predator Perch – ≥200 feet**
6. **Off-channel sites delineated annually; must contain sand with adjacent water areas**
7. **Suitable Nesting Area – Delineated by monitoring crew annually**

Area

- *Definition* – Program Associated Habitat Area
- *Criterion* – Areas ≤3.5 miles of the main channel or ≤2 miles of side channel of the Platte River are habitat if the areas meet all additional minimum habitat criteria.

Minimum Habitat Size

- *Definition* – Total of ≥1.5 acres of conforming habitat per site
- *Criterion* – ≥¼-acre patches of dry bare sand and/or gravel are suitable nesting habitat if there is ≥1.5 acres of suitable nesting habitat total within a site and the areas meet all additional off-channel minimum habitat criteria.

Distance to Predator Perch

- *Definition* – Distance from potentially suitable nesting habitat in any direction to the nearest potential predator perch.
- *Criterion* – Bare-sand areas ≥200 feet from a predator perch are suitable nesting habitat if the areas meet all additional off-channel minimum habitat criteria.

Water-Sand Criteria

- *Definition* – Off-channel sites will be delineated on an annual basis.
- *Criterion* – Sites with sand and adjacent water areas are suitable nesting habitat if the site meets all additional off-channel minimum habitat criteria.

Suitable Nesting Area

- *Definition* – Delineation of areas within each site that, according to the monitoring crew, are suitable habitat for nesting.
- *Criterion* – Monitoring personnel will hand delineate suitable nesting areas within sites that are monitored to exclude sand and gravel piles and active mining areas that are not conducive to tern and plover nesting. The habitat availability assessment contractor will identify suitable habitat through application of the various filters, document spatial extent and availability of habitat identified via image interpretation, and apply the hand-delineated polygon layer as a final filter to remove unsuitable nesting areas within each site.

APPENDIX D

DEPARTMENT OF INTERIOR TARGET HABITAT CRITERIA LAND PLAN TABLE 1

Table 1. Target Habitat Complex Guidelines[8]

1. Riverine Habitat	Characteristics
Location	Between Lexington and Chapman, NE
Channel area	Approximately 2 miles long, 1,150 feet wide and includes both sides of the river. "Channel area" represents the portion of the river that conducts flow and is bounded either by stable banks or permanent islands that obstruct view. At low flows, the channel area includes interconnected small channels and exposed sand or gravel bars and non-permanent islands.
Water depth	A range of depths with approximately 40 percent of the channel area less than 0.7-foot deep during whooping crane migration periods.
Wetted width	90 - 100 percent of channel area inundated during migration periods.
Water velocity	Velocity is variable with depth. During whooping crane migration and least tern and piping plover nesting seasons, velocity should be less than 4 mph in shallow areas.
Sandbars and Channel Morphology	Non-permanent sandbars and low, non-permanent islands throughout the channel area, high enough to provide dry sand during the tern/plover nesting season and free of vegetation that inhibits nesting or creates visual obstructions to whooping cranes. Diverse channel morphology providing a variety of submerged sand bars and other macrohabitats, including backwater areas and side channels inundated by discharge.
Proximity to wet meadow forage habitat	Within 2 miles, but contiguous is preferred.
Distance from disturbance	For whooping cranes: In general, not less than 0.5-mile distant or appropriately screened from potential disturbances. Potential disturbances may include roads, railroads, occupied dwellings, bridges or other activities that would disturb whooping cranes from using a site. For least tern/piping plover: Potential disturbances should be evaluated case-by-case. In general, not less than 0.25 mile distant, or appropriately protected from human disturbances.
Unobstructed View	Good visibility upstream, downstream, and across the channel.
Flight Hazards	Overhead lines should be avoided, if possible. Overhead lines within 0.5 mile of complex boundaries should be evaluated during the screening process to determine whether marking would be appropriate.
Security	Sufficient control to avoid human disturbance to target species.

[9]The Parties have agreed to use these habitat complex characteristics as an initial acquisition, restoration and maintenance target. The states and July 1997 Cooperative Agreement Land Committee continue to disagree that these characteristics represent the "best" habitat or necessary habitat for the target species, or that the Program will be able to sustain the characteristics solely with flow management. The states and July 1997 Cooperative Agreement Land Advisory Committee believe that an approach based on acquiring and developing habitat with a range of characteristics is justified.

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2. Wet Meadow Habitat	Characteristics
Location	Within 2 miles of the above-described channel area.
Size	Approximately 640 contiguous acres or more.
Distance from Disturbance	In general, not less than 0.5-mile distant or appropriately screened from potential disturbance. Potential disturbances may include roads, railroads, occupied dwellings, bridges or other activities that would disturb target species from using a site.
Vegetation Composition	Native prairie grasses and herbaceous vegetation, lacking or mostly lacking sizable trees and shrubs, occurring in a mosaic of wetland (hydrophytic) and upland (non-hydrophytic) plants.
Hydrology	Swales subirrigated by ground water seasonally near the soil surface and by precipitation and surface water, with the root zone of the soil continuously saturated for at least 5 - 12.5% of the growing season. Except immediately following precipitation events, higher areas may remain dry throughout the year.
Topography and Soils	The topography is generally level or low undulating surface, dissected by swales and depressions. Mosaic of wetland soils with low salinity in swales and non-wetland soils occurring in uplands.
Food Sources	Capable of supporting aquatic, semi-aquatic, and terrestrial fauna and flora characteristic of wet meadows; especially aquatic invertebrates, beetles, insect larvae, and amphibians.
3. Buffer	**Characteristics**
	That portion of a complex used to isolate channel areas and wet meadows from potential disturbances. In general, it is up to 0.5 miles wide, but is variable depending on topography, screening, and other factors. Buffer areas may include an extended wet meadow or channel area, upland grassland, pasture, hay land, cropland, palustrine wetland, woodland, managed sandpits, or a combination of these and other compatible land features.

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[1] This is a restatement of the first bullet under broad hypothesis PP-1. See p. 16 of the Adaptive Management Plan.
[2] The USBR estimated that sediment balance is achieved at approximately Gibbon based on repeat channel surveys (Trends of Aggradation and Degradation along the Central Platte River: 1985-2005, pp. 54-56). Program sediment transport modeling predicts that sediment balance is achieved at approximately Minden (1-D Hydraulic and Sediment Transport Model Final Hydraulic Modeling Technical Memorandum, p. 144).
[3] See PRRIP draft least tern and piping plover minimum habitat criteria document. The criteria are currently based on a combination of professional judgment and historic use data. The Program is intending to perform a habitat selection analysis in 2012 using 2007 through 2011 monitoring data.
[4] This approximation is based on 1-D model stage-discharge relationships and 1947-2008 seasonal peak flow exceedance for the months of May - July. (Inundation risk memorandum in development).
[5] The conclusion that stage change is generally sufficient is supported by stage-discharge relationships from Program hydraulic modeling. The specific heights (e.g. 0.7') are based on two-dimensional hydraulic modeling performed for the Elm Creek Complex FSM "Proof of Concept" management experiment (Implementation Design for Elm Creek Flow-Sediment-Mechanical (FSM) "Proof of Concept" management Actions Experiment, Preliminary Draft Version 1.0)
[6] See pp. 4-36 and 4-37 of Volume I of the Final Environmental Impact Statement for the Program.
[7] 2010 and 2011 high flow event discharges and volume records from USGS Grand Island gage (USGS 06770500). Analysis assumes a maximum SDHF discharge of 8,000 cfs and volume of 75,000 AF.
[8] 2010 sandbar heights from analysis for Elm Creek Complex FSM "Proof of Concept" management experiment implementation design (see footnote 5). 2011 sandbar heights from management experiment effectiveness monitoring in 2011 (2011 Elm Creek FSM Annual Monitoring Report in development).
[9] Preliminary determination based on visual inspection of fall 2011 LiDAR imagery. Almost all sandbars in the associated habitat are inundated or at the water surface in the imagery. The flow at the time of acquisition was 2,700 cfs throughout the entire reach. A system-scale analysis of sandbar heights is planned following completion of 2009-2011 system scale geomorphology and vegetation data and will build on hydrologic and stage-discharge metrics from system-scale analyses.
[10] This is based on preliminary results of the 2007-2011 tern and plover habitat availability analysis being conducted for the Program by the Rainwater Basin Joint Venture (see preliminary methods and results document). Final analysis results and report will be delivered in the fall of 2012.
[11] Nest observations based on a 2004 compilation of central Platte River tern and plover nest observations by Gary Lingle. This document (PRRIP DEIS Response Final Report) is the only documents known to categorize nest observations according to habitat type.
http://www.platteriverprogram.org/intranet/NonPublic%20Program%20Library/PRRIP%20DEIS%20Response.pdf
[12] See Big Question 3 summary.
[13] Pilot study results presented by Jason Alexander at the 2011 University of Nebraska-Lincoln Water Center Climate, Water and Ecosystems Conference.
[14] This is a restatement of the second bullet under broad hypothesis PP-1. See p. 16 of the Adaptive Management Plan. Paragraph 2 on pg. 22 of the AMP states that the over-arching hypothesis of the FSM management strategy is that it will generate "detectible changes" in channel morphology and species habitat characteristics. In the following sentence, those changes are identified as achieving the habitat conditions described in Table 1 of the Land Plan, which are hypothesized (WC 3b) to be suitable for the target species. As such, it is reasonable to conclude that the second bullet under broad hypothesis PP-1 infers that FSM will increase unvegetated channel widths to a suitable width.
[15] Otherwise, suitable unobstructed channel widths would already be maintained by the existing peak flow regime. The ability of SDHF to maintain suitable unvegetated channel widths is especially critical during drought periods when natural peak flow events may be completely absent for several years.
[16] See PRRIP draft whooping crane minimum habitat criteria document. The criteria are currently based on a combination of professional judgment and a habitat selection analysis of 2001-2006 use data. The Program is currently updating the habitat selection analysis to include 2007-2011 data.

[17] See hypothesis WC 3b X-Y graph in Appendix D of the Adaptive Management Plan. The Department of the Interior hypothesizes that increasing unobstructed channel width to a minimum of 750 feet and a target of 1,150 feet is needed to increase the probability of whooping crane roosting.
[18] INSERT WC ROOST UNOBSTRUCTED WIDTH PERCENTAGES
[19] 2010 and 2011 high flow event discharges and volume records from USGS Grand Island gage (USGS 06770500). Analysis assumes a maximum SDHF discharge of 8,000 cfs and volume of 75,000 AF.
[20] Widths based on a preliminary analysis of 2009-2011 system-scale geomorphology and vegetation monitoring data by EDO. The TAC recommended approval of a system-scale geomorphology and vegetation data analysis protocol in July of 2012. Final analysis of 2009-2012 monitoring data is expected to be completed by the end of the year.
[21] See bullet three on p. 33 of Draft 2012 State of the Platte Report. The calculations in bullet three are unobstructed width calculations, not unvegetated width calculations (they were mislabeled).
[22] See PVWMA 2008-2011 invasive species control summary.
[23] See pp. i-iii of the draft PRRIP Directed Vegetation Research Study conducted for the Program by the USDA-ARS National Sedimentation Laboratory in association with the University of Tennessee. The draft report was subjected to Program peer review in the spring of 2012 and revisions are expected to be complete by October 2012. In August of 2012, the Program re-engaged the research team to conduct a lateral erosion/scour research project.
[24] See sidebar figure in Big Question 2 summary for annual peak flow magnitudes and volumes for the period of 1983-1999.
[25] Analysis performed by EDO for executive summary using Program Pure Panel Anchor Point locations and 1998 CIR imagery. Unobstructed width calculated as maximum unvegetated width of any single channel.
[26] See Fotherby, L.M., Valley confinement as a factor of braided river pattern for the Platte River, Geomorphology (2008), doi:10.1016/j.geomorph.2008.08.001 for a discussion of the role of flow consolidation (valley confinement) in the occurrence of braided planform in 1998.
[27] This is a restatement of broad hypothesis PP-2. See p. 17 of the Adaptive Management Plan.
[28] During Program development, the magnitude of the sediment deficit was estimated using several approaches. See pp. 5-55 – 5-57 of Volume I of the Final Environmental Impact Statement for a discussion of the process used to estimate the annual sediment deficit.
[29] See Platte River Channel Dynamics Investigation (which was developed in response to a draft version of the DOI publication titled The Platte River Channel: History and Restoration) and the DOI response to the investigation.
[30] See p. 17 of the Sediment Augmentation Experiment Alternatives Screening Study.
[31] See p. 144 of 1-D Hydraulic and Sediment Transport Model Final Hydraulic Modeling Technical Memorandum.
[32] See p. 8 of Appendix A of the Program's 2009 Geomorphology and Vegetation Monitoring Report for a comparison of the 2009 longitudinal thalweg profiles of the north and south channels at Jeffery Island which demonstrates the degree of channel incision. This reach also exhibits the narrowest channel widths in the associated habitat reach as demonstrated in the Big Question 4 sidebar figure.
[33] See Germanoski, D. and Schumm, S. A., 1993. Changes in Braided River Morphology Resulting from Aggradation and Degradation. J. of Geology, v. 101 for a discussion of the progressive effects of a sediment deficit on the morphology of a braided sand bed river.
[34] See Management of the Platte River for Braided Planform memorandum by Program Special Advisor Dr. Chester Watson for discussion of the role of flow, sediment, and vegetation management in maintenance of a braided planform.
[34] This is a restatement of broad hypothesis PP-3. See p. 17 of the Adaptive Management Plan.
[35] See section 4.1 of Tal, M., Gran, K., Murray, B., Paola, C., and Hicks, M., 2004. Riparian Vegetation as a Primary Control on channel Characteristics in Multi-thread Rivers. Riparian Vegetation and Fluvial Geomorphology Water Science and Application 8. American Geophysical Union for a Platte River-specific discussion of the vegetation ratchet effect.
[36] Analysis performed by EDO for executive summary using Program Pure Panel Anchor Point locations and 1998 CIR imagery. Unobstructed width calculated as maximum unvegetated width of any single channel.

[37] Reference Habitat Management Methods for Least Terns, Piping Plovers, and Whooping Cranes for a discussion of the various mechanical management actions that have been taken by a variety of organizations to create and/or maintain target species habitat in the associated habitat reach.
[38] See Fotherby, L.M., Valley confinement as a factor of braided river pattern for the Platte River, Geomorphology (2008), doi:10.1016/j.geomorph.2008.08.001 for a discussion of the role of flow consolidation (valley confinement) in the occurrence of braided planform in 1998.
[39] See Cottonwood Ranch Flow Consolidation Feasibility Study.
[41] Figure acronyms include: CRC – Cottonwood Ranch Complex, ECC – Elm Creek Complex, FCK – Fort Kearny Complex, Rowe – Audubon Rowe Sanctuary, SIC – Shoemaker Island Complex, and WCT – Whooping Crane Trust.
[42] This is a re-statement of Priority Hypotheses WC1 and WC3 in the Adaptive Management Plan. In general, these hypotheses suggest that whooping cranes will select habitat similar to Land Plan Table 1 characteristics (see **Appendix C**) and/or habitat created by Program management actions.
[43] See the Whooping Crane Tracking Partnership Statement of Work for an explanation of the telemetry project and expected outcomes.
[44] See Final Spring 2012 Whooping Crane Monitoring Report for the latest example of a Program whooping crane migration monitoring report. (REPORT WILL BE FINALIZED AND UPLOADED IN FALL 2012).
[45] Summary numbers from Final PRRIP 2012 State of the Platte Report – Technical Details, Whooping Crane Monitoring Summary (Pages 14-23) as provided for the March 2012 AMP Reporting Session.
[46] Regression analyses and statistical tests were performed and indicate some relationships were significant (α=0.05) and others were not; however, results of these analyses are not included in this report because there are so few data points and significance or lack-there-of could easily change based on 1 additional data point (i.e., 2012 data).
[47] This is a restatement of Priority Hypotheses T1 and P1 in the Adaptive Management Plan which suggest that more "bare sand" (i.e. habitat) will result in greater tern and plover use and higher reproductive success.
[48] See Final 2011 PRRIP Interior Least Tern & Piping Plover Monitoring Report.
[49] Regression analyses indicate tern and plover fledge ratios observed on the central Platte River increase with habitat availability; however the relationships were not significant. (tern fledge ratio=0.0203*Acres of suitable nesting habitat-2.7697; Spearman's Rho=0.50, df=3, p=0.39; plover fledge ratio=0.0224*Acres of suitable nesting habitat-3.0071; Spearman's Rho=0.5, df=3, p=0.39).
[50] This is a re-statement of Priority Hypotheses TP1 in the Adaptive Management Plan. This hypothesis is one of the more complex hypotheses in the AMP and may require refinement during the First Increment.
[51] See the final USGS report Foraging Ecology of Least Terns and Piping Plovers Nesting on Central Platte River Sandpits and Sandbars.
[52] See endnote 46.
[53] See endnote 46.
[54] This is a re-statement of Priority Hypotheses T2 and P2 in the Adaptive Management Plan, which suggest that at low flows a lack of forage fish and invertebrates limit tern and plover productivity on the central Platte.
[55] See 2011 Fish Population Studies Report from NPPD for example of monitoring effort and data.
[56] See the PRRIP 2012 Forage Fish Analysis Report.
[57] See the final USGS report Foraging Ecology of Least Terns and Piping Plovers Nesting on Central Platte River Sandpits and Sandbars.
[58] See the final USGS report Foraging Ecology of Least Terns and Piping Plovers Nesting on Central Platte River Sandpits and Sandbars.
[59] See the PRRIP 2012 Forage Fish Analysis Report.
[60] See the final USGS report Foraging Ecology of Least Terns and Piping Plovers Nesting on Central Platte River Sandpits and Sandbars.
[61] See the PRRIP 2012 Forage Fish Analysis Report.
[62] See Final 2011 PRRIP Interior Least Tern & Piping Plover Monitoring Report.
[63] See Final 2011 PRRIP Interior Least Tern & Piping Plover Monitoring Report.
[64] This is a re-statement of Priority Hypothesis PS2 in the Adaptive Management Plan, which suggests that Program water management actions in the central Platte River will result in measurable changes in lower Platte River flow.

[65] See Final PRRIP Stage Change Study for full report of methodology and results.
[66] See Final PRRIP Pallid Sturgeon Literature Review Report. The associated Access database and compendium of PDF publications are available in the non-public section of the Program library on the PRRIP web site.
[67] Table 10, Page 21 of the Final Stage Change Study presents a description of the six habitat classifications used to evaluate the potential impacts of Program management actions in the central Platte on flow in the lower Platte.
[68] The Dry Conditions Analysis was presented in the Final Stage Change Study as Appendix G, "Alternative Analysis of Program Activities" (see Page 167 of the PDF version of Final Stage Change Study).
[69] Table 2, Appendix G (Page 170 of PDF version of Final Stage Change Study).
[70] See "Interpretation and Analysis" section of the Final Stage Change Study, Page 22.
[71] The "Alternative Analysis of Program Activities" evaluated a hydrologic scenario against all six habitat classifications (i.e. longitudinal habitat in the channel and lateral habitat connections between the channel and floodplain) during both the spring (spawning period) and the fall (overwintering and upcoming spawning movements).
[72] Pallid sturgeon item V.K.3.2, Integrated Monitoring and Research Plan (IMRP), Adaptive Management Plan (Page 45).
[73] See Page 1 of the Adaptive Management Plan for the three overall management objectives of the Program, and Page 3 of the Final Program Document for the Program's three sub-goals that comprise the Program's long-term goal to improve and maintain the associated habitats.
[74] This is a re-statement of Priority Hypothesis S1b in the Adaptive Management Plan. In the context of this Big Question, this hypothesis will be used to evaluate tern, plover, and whooping crane use of Program habitat complexes (or habitat identified as "suitable" by the Program) during the course of the First Increment and evaluate that use in terms of its contribution to the broader health of the overall populations of all three target bird species.
[75] See Page 1 of the Final Program Document, Program Purposes.