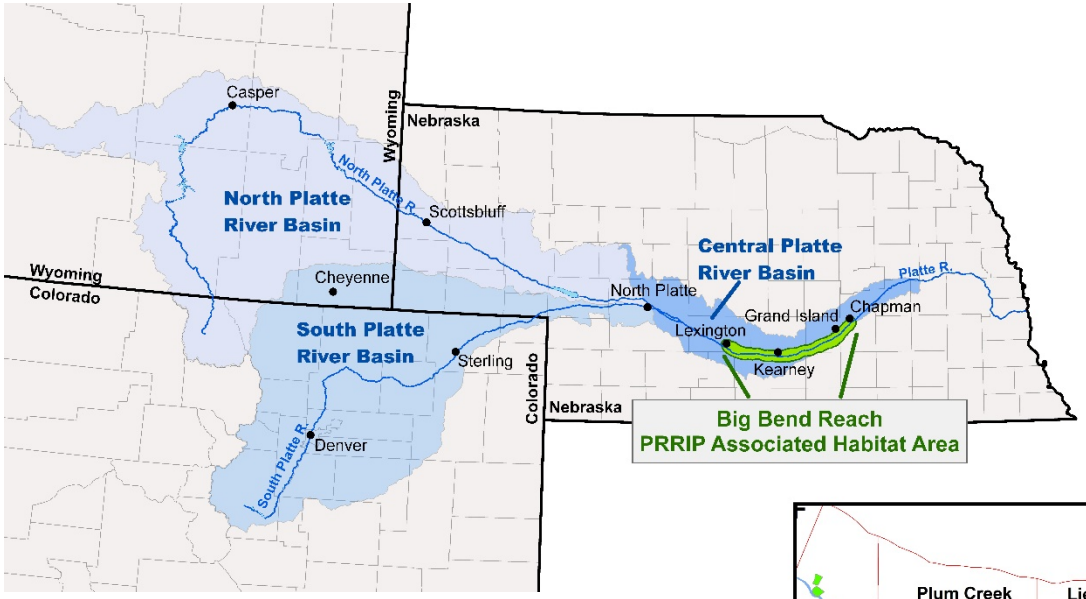
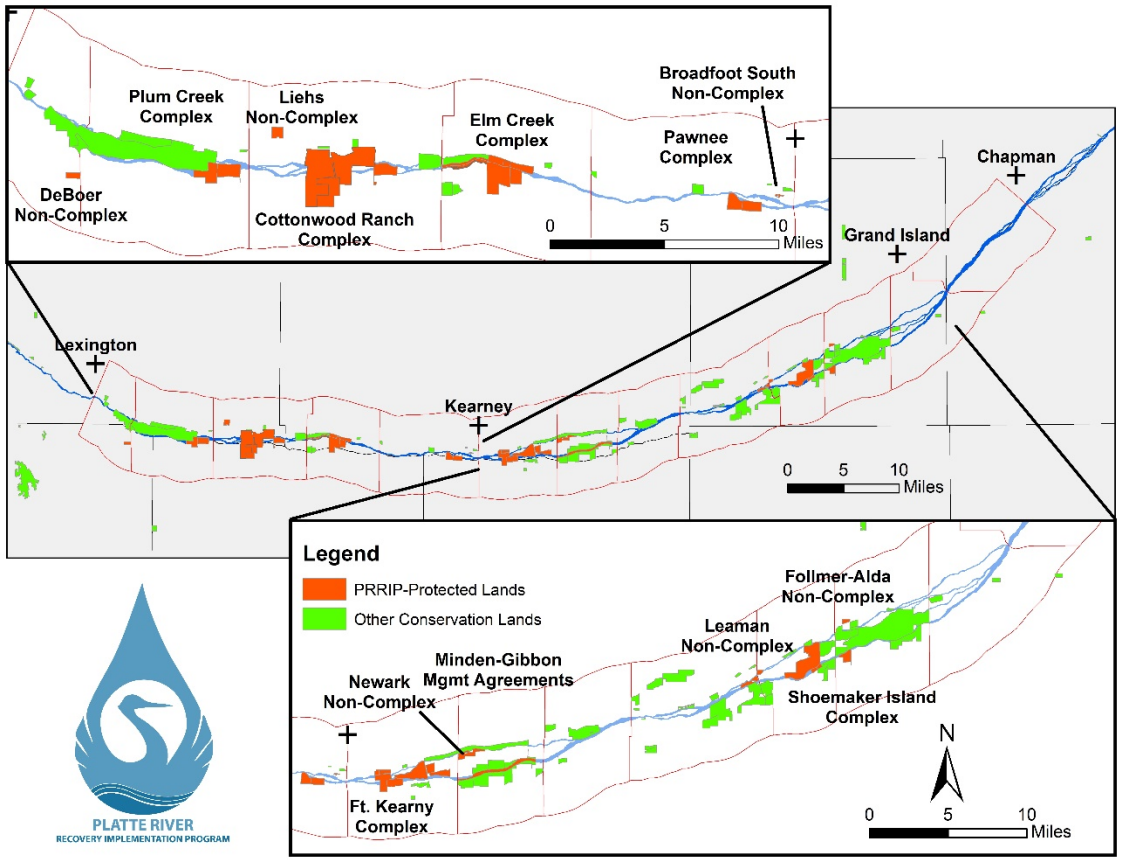
2016
State of the Platte

PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM



Map depicting the Platte River system, including the Program Associated Habitat Reach on the central Platte River.



Program habitat complexes in the Associated Habitat Reach.

2016
State of the Platte

Adaptive Management Plan (AMP)
2016 "Big Question" Assessments*
May 18, 2018

*updated primarily with 2007-2016 data

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PLATTE RIVER
RECOVERY IMPLEMENTATION PROGRAM

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INTRODUCTION

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 Program monitoring data, research, analysis, 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.

A quick reference assessment for each of ten Big Questions is provided in Table 1, followed by an assessment write-up for each Big Question. Each assessment includes information noting any updates or changes from previous State of the Platte reports. This document contains endnotes to identify key documents or data sets that are important to read and understand when reviewing this report. Those endnotes include hyperlinks to information available in the Public Library section of the Program's web site.

KEY OBSERVATIONS AND PROGRESS

The 2016 State of the Platte Report includes assessments incorporating Program data from years 2007-2016. Seven of ten Big Questions are answered conclusively and two are trending in a direction that will affirm or reject important hypotheses. One question (#9) is being addressed by the GC through a facilitated Pallid Sturgeon Process.

WHOOPING CRANE HABITAT AND USE

Implementation of SDHF releases as currently envisioned will not create and/or maintain suitably-wide unobstructed channel widths (UOCW) for whooping cranes. Mechanical methods such as disking and herbicide application at Program habitat complexes will create and maintain suitably-wide UOCWs, though these management actions do not have the system-scale beneficial effects of natural high flow events. Based on the findings of habitat selection analyses and related synthesis, the Program should continue management that provides UOCWs for whooping cranes that are ≥650 ft and unforested corridor widths that are ≥1,100 ft.

FORAGE AND TERN/PLOVER PRODUCTIVITY

Data analyses and syntheses indicate there is no relationship between flow and tern productivity and there is no evidence the forage base along the central Platte River limits tern and plover productivity. These same analyses and syntheses do not support Program summer flow releases to maintain the current 800 cfs target and a revised summer flow target in the range of 200-600 cfs would likely be sufficient to meet the objective of an abundant and diverse forage base for terns.

GLOSSARY OF ACRONYMS

ACRONYM	DEFINITION
AFY	Acre-feet per Year
AHR	Associated Habitat Reach
AMP	Adaptive Management Plan
AMWG	Adaptive Management Working Group
BQ	Big Question
EDO	Executive Director's Office
FSM	Flow-Sediment-Mechanical
GC	Governance Committee
ISAC	Independent Science Advisory Committee
LTPP	Least Tern and Piping Plover
NF	Nearest Forest
PRRIP or Program	Platte River Recovery Implementation Program
SDHF	Short-Duration High Flow
SoPR	State of the Platte Report
TAC	Technical Advisory Committee
USFWS	United States Fish and Wildlife Service
UOCW	Unobstructed Channel Width
WAP	Water Action Plan
WC	Whooping Crane

INDEPENDENT SCIENTIFIC ADVISORY COMMITTEE (ISAC) COMMENTS ON THE 2016 STATE OF THE PLATTE REPORT

This report was discussed with and reviewed by the Program's Independent Scientific Advisory Committee (ISAC) in fall 2017. The ISAC provided the following comments on the 2016 State of the Platte Report:

GENERAL COMMENTS

- **Format.** The format and content of the 2016 State of the Platte Report (SoPR) is excellent. It concisely summarizes information for the GC, while providing the TAC with more details through endnotes. Some improvements could be made to the format which would make the report even better.
    - **ISAC Recommendation: Include the following in the 2016 and future State of the Platte Reports to help the reader and improve clarity: 1) captions summarizing the bottom line messages below each figure; 2) a glossary of Acronyms; 3) a list of all peer reviewed papers and reports published by the Program by year; and 4) an appendix which shows progress on land and water.**
- **Expand the audience.** The 2016 SoPR is appropriate for GC and TAC members who have been attending the Adaptive Management Plan (AMP) reporting session for several years. However, we suggest that the intended audience be viewed as a somewhat larger group than just those who have been active in the PRRIP for many years. New GC or TAC members have told us that they found the State of the Platte Report in need of more explanation and/or references. The Report should be concise, complete and understandable to multiple audiences, but with no particular knowledge of the PRRIP. Correcting this shortcoming should not require a great deal of effort. For the most part, some additional background (a few sentences or short paragraph) and references to the appropriate PRRIP report should be sufficient.
    - **ISAC Recommendation: Ensure that the State of the Platte Report is understandable to multiple audiences (decision makers, the well-informed public, scientists, engineers), but with no particular knowledge of the PRRIP.**
- **TABLE 1. 2016 Big Question Assessments.** We understand that this Table needs to be a succinct one-pager, as it is what everyone will read. However, the *Basis for Assessment* column does not consistently or very well provide *the underlying support or foundation for an idea, argument, or process;* the *justification for or reasoning behind something* (definitions). For 3 BQs it provides the basis (status) for the assessment (BQ#2, 9, 10). In one case the table lists what has occurred since the assessment is reported (BQ#1). In another case it explicitly provides the justification for the assessment (BQ#3). In numerous instances it references the foundational document where the justification can be found, a logical approach given space limitations (BQ's 2, 4-8). Here are two suggestions to consider. The first and simplest suggestion is to just rename the column heading to: *Source for Assessment* as in most instances it gives where someone can go to find the justification for the assessment but is not necessarily the basis for it. This may seem quibbling about definitions (as basis and source are sometimes listed as synonyms). The second and more complex suggestion is to keep the current title (or change to Source) but have either a hyperlink to the referenced document in the box or a footnote to a hyperlinked reference. This will direct the reader to the actual basis for the BQ status.
    - **ISAC Recommendation: Improve the consistency of the contents under the column 'Basis for Assessment' in Table 1.**
- **Format for BQ 2-pagers.** These 2-page summaries provide an excellent synopsis for each BQ. The consistent section headings (e.g., What the Science says in 2016; Management Implications) are very helpful. However, it is not until the text box embedded in the second page figure where the reader learns the priority hypothesis underlying each BQ. In some cases, these hypotheses form the basis for the analyses illustrated in figures, while in other cases the analyses have moved beyond the original hypotheses. There are often habitat suitability criteria in the figure captions, but the context for these criteria only become clear once one encounters the hypotheses. Ideally, the hypotheses and suitability criteria would come sooner in the BQ 2-pager (e.g., on the first page where the BQ is listed), but we recognize that some hypotheses are more relevant than others, and that you don't want to cram too much onto each page.
    - **ISAC Recommendation: Please carefully consider how to more clearly link the hypotheses and suitability criteria to the Big Questions in the report.**
- Good progress has been made on evaluating the hypotheses. Over the next two years, it's worth doing a detailed assessment of these Big Questions and hypotheses (i.e., Assess step of AM cycle), building on what's been learned, in preparation for an extension of the First Increment in 2020. The main output would be a proposed set of revised hypotheses, **without proposing any new actions.** The revised Big Questions and hypotheses should reflect the larger view of how to integrate the use of water, sediment, herbicide and bulldozers to achieve intended objectives. Several hypotheses state "under a balanced sediment budget." While the ISAC agrees that a quasi-sediment balance is a necessary but not sufficient condition for maintaining habitat, it has proven to be very difficult to draw reliable conclusions on whether or not the sediment budget

is balanced in the Central Platte, due to high levels of spatial and temporal variation in sediment transport. These hypotheses should be rethought, and rephrased, bearing in mind recent advances with Green LIDAR. See comments below on BQ3.

- **ISAC Recommendation: Over the next two years, complete a detailed assessment of the Big Questions and hypotheses building on what's been learned, in preparation for an extension of the First Increment in 2020. The main output would be a proposed set of revised hypotheses, without proposing any new actions.**

- The ISAC has provided the EDO with many detailed comments to improve the graphics and/or text in the document; the following bullets focus only on major comments. The PRRIP will be best served by having annual responses to all ISAC recommendations.
  - **ISAC Recommendation: We recommend that the EDO provide responses to all ISAC recommendations, as was done in the final 2014 State of the Platte Report (but has not been done since then).**

COMMENTS ON THE ASSESSMENTS OF BIG QUESTIONS

BQ1: ISAC supports the conclusion of two thumbs down.

- There is no scientific rationale for continuing to test SDHF (defined as 5,000 to 8,000 cfs for three days) in the Central Platte River to benefit terns and plovers.

BQ2: ISAC supports conclusion of two thumbs down.

- There is no scientific rationale for implementing SDHF in the Central Platte River to create or maintain WC riverine roosting habitat.
- Herbicide treatments and disking provide the foundation for reaping the maximum benefit of natural high flow events in creating and maintaining WC riverine roosting habitat. Indeed, much longer duration events are the best predictors of unobstructed channel width, (e.g., 40-day mean peak flow). Sediment augmentation may be valuable for maintaining WC habitat below J2.
- It's worth assessing the vulnerability of the system to decadal-scale and longer-term climate changes (e.g., effects of the choke point in the North Platte), and building in resiliency to wide ranges of climate variation. More herbicide and mechanical work will likely be required during drier periods.

  - **ISAC Recommendation: the Program should consider holding a Structured Decision Making workshop similar to that done for BQ#1, to seek a consensus on how to maintain WC habitat across a wide range of climatic conditions.**

BQ3:

- ISAC agrees that the one thumb up conclusion is justified, that there is degradation below the J2 return, and that you can estimate with confidence that it is worth doing sediment augmentation. The benefit of this action is for whooping cranes, not terns and plovers. However, you don't know *with confidence* that 80,000 tons is the right amount of sediment to be added annually, particularly with the recent discovery of sediment additions from a new channel bringing water and sediment from the north fork of the Platte. It's worth specifying a range of the required amount of sediment. The optimal amount in each year will likely need to be determined iteratively, using Green LIDAR to provide a census of annual channel change, and to separate incision from widening.
- Further downstream, the signal of sediment augmentation will likely get lost in the noise of year to year and spatial variation, even with assessment via Green LIDAR. Sediment augmentation may still be a good thing to do, even if you can only prove its benefit for the upstream area. Will sediment augmentation need to be maintained forever, or is there an alternative solution?
- Effect sizes should be defined for each performance measure used to assess whether or not sediment augmentation has been effective. If Green LIDAR works, then it should be possible to use Geomorphic Change Detection software.
  - **ISAC Recommendation: the PRRIP should consider publishing a paper on the lessons learned from attempting to assess sediment balance in very dynamic sandy rivers like the Platte.**
  - The main message of this paper would be that the spatial and temporal variability of sediment transport is too high to merit using standard approaches of monitoring cross-sections or sediment transport to assess sediment balance. Different methods are required, such as Green LIDAR.
    - The original sampling design for the system scale is described in the Platte AMP (pdf pages 214-222). This design proposed sampling 40 anchor points over the 90-mile system scale (145 km), or one anchor point every 3.6 km. Assuming an average channel width of 300m (J. Farnsworth, pers. comm.), that works out to one anchor point every 12 channel widths. At each anchor point there would be 10 cross-sections, each spaced 50m apart, extending 250m upstream and downstream of the anchor point. The design recommended that 15 pure anchor points be visited every year, with 5 rotating panel anchor points visited every fourth year.
    - As described on page 3 of the 2016 TetraTech report, the amended design included 20 pure panel anchor points and 5

rotating panel points visited every year (i.e., 25 total per year), with only 3 cross-sections at each anchor point, spaced approximately one channel width apart. The overall number and spacing of anchor points didn't change (still 40 anchor points, with 12 channel widths between them), but some anchor points were sampled more frequently than anticipated in the original design.

- By contrast, the spacing of transects in other published studies of reach wide sediment budgets, in rivers less dynamic than the Platte, has been about one channel width (Ned Andrews, pers. comm.). So, from the ISAC's perspective, the spatial density of anchor points is about one twelfth what it should have been to assess sediment budgets on a system wide scale. Similarly, the sampling frequency of bedload and suspended load was too low to estimate sediment budgets through rating curves.
- The PRRIP realized that it wasn't feasible to address the question of sediment balance on a system scale with the required density of transects, and instead tried to focus at an appropriate density at somewhat isolated points (Jason Farnsworth, pers. comm.). According to the EDO, the big unknown is how representative those isolated locations are in relation to reach-level channel characteristics. The EDO intends to assess the representativeness of those locations once they get the fall 2017 LIDAR and can do a full system-wide evaluation. The ISAC supports this analysis.
- The proposed paper could build on a sensitivity analysis of the Shoemaker Island x-section data collected by Graham Matthews and Associates (see ISAC's report from November 2015, pg. 12-13), or (better) sensitivity analyses of recent results from Digital Elevation Models and successive overflights taking Green LIDAR. The objective of this analysis would be to add two types of confidence intervals to the estimates of reach-wide changes in sediment volume derived from the cross-section data (i.e., Figure 3.12b on page 70 in TetraTech's final 2016 report on channel geomorphology and vegetation): one based on a comparison of the fixed and rotating panel data to Green LIDAR, and another based on the Shoemaker Island data
- Preliminary analyses of DEMs by Jason Farnsworth indicate that locating transects every 800' (243m) results in errors of ± 30% in estimating the change in sediment volume. A transect spacing of 3.6 km could easily yield errors of greater than ± 100%.
- The paper could indicate what intensity of sampling would be required to reliably test hypotheses related to sediment balance using cross sectional data (it may be infeasible except at very small scales). Such a paper could save other investigators millions of dollars in not bothering to collect cross-section or bedload/suspended data that will be inconclusive for testing hypotheses on sediment balance in very dynamic rivers like the Platte, and instead moving to Green LIDAR. This analysis could also help to suggest what subset of cross-section data may be worth maintaining to ground truth the Green LIDAR.

BQ4: ISAC supports the conclusion of two thumbs up for whooping cranes, but not for terns and plovers. Some of the phrasing of evidence needs to be improved to clarify that herbicide treatment and disking provide the foundation for reaping the maximum benefit of natural high flow events in creating and maintaining WC riverine roosting habitat as described in the ISAC's responses to BQ2.

BQ5: ISAC agrees with the corrected evaluation of two thumbs down.

BQ6: As the ISAC has mentioned in several previous reports, the Program needs to examine the likelihood of alternative hypotheses to explain the observed increase in tern and plover nesting (e.g., meta-population trends, movement of birds from non-program to program lands, movement of birds from Lake McConaughy). Response to BQ6 is still two thumbs up, but other hypotheses need to be addressed to fortify the conclusions. These hypotheses are not mutually exclusive.

BQ7: The ISAC concurs with the conclusion of two thumbs down.

- River survey and observational data, however, indicate the river is a valuable source of forage for both species as forage availability appears to be lower on off-channel habitats. The 2 thumbs down assessment should not imply that the river channel could dry up without affecting the birds.

BQ8: The ISAC concurs with the conclusion of two thumbs down.

BQ9: BQ9 has been challenging to both the PRRIP and the ISAC. Table 1 below summarizes the conclusions on BQ 9 in past State of the Platte reports, and the ISAC Comments and Recommendations, including our recommendations for the 2016 State of the Platte report (final row of table, highlighted in yellow)

- In the past, the ISAC has advised the GC of the need to clarify the objective of PRRIP work on pallid sturgeon: ensuring that the Program is doing no harm (the focus of BQ9 and the First Increment, and the objective described on pg. 20 of the 2007 AM Plan[1]) vs. devising actions to benefit pallid sturgeon (as described on pg. 8 of the 2007 AM Plan[2], and on page 3 of the 2006 Final Platte River Recovery Implementation Program[3])). This clarification remains a high priority as the PRRIP ponders investing in research and monitoring activities for pallid sturgeon.
- The Structured Decision Making workshop with the GC on September 13-14, 2017, and the subsequent meeting with pallid sturgeon experts from NGPC, USGS and UNL on October 18, 2017 points towards a multi-year collaborative effort to monitor the use of the Platte River by telemetered male and female sturgeon, so as to learn more about the timing, location and success of spawning in the Platte, and other uses of the Platte by adult pallid sturgeon. Acquiring such information will require substantial resources but would hopefully provide a basis for evaluating whether or not PRRIP flow management is likely to have any effects on pallid sturgeon. The proposed research is generally consistent with work recommended in the 2007 AM Plan (section V.K.3, pg. 45), and consistent with the ISAC's comments in 2009 (Table 1).

Table 1: Summary of conclusions on BQ 9 in past State of the Platte Reports (SoPR), and ISAC comments / recommendations.

State of the Platte Report for year shown	**Conclusion on BQ 9 in State of the Platte Report**	**ISAC Comments / Recommendations** [page reference, date of ISAC report]
2009 (no SoPR)	N/A	*ISAC was asked the following question about AMP objectives* [pg. 27, ISAC report dated September 10, 2009]*:* Q27) The Program's long-term goal is to "improve and maintain the associated habitats", which includes "testing the assumption that managing flow in the central Platte River also improves the pallid sturgeon's lower Platte River habitat". The specific management objective in the AMP related to pallid sturgeon is currently a "Do No Harm" objective. From a scientific and AMP implementation standpoint, how should the Program approach prioritizing actions related to pallid sturgeon in the lower Platte River as detailed on Pages 45 and 66 of the AMP? *Robb Jacobson of the ISAC responded as follows:* "Evidence supports the notion that Platte River pallid sturgeon are Missouri River sturgeon. Movement of fish between the Missouri and Platte is a fundamental issue that needs to be addressed through expanded telemetry. If it is demonstrated that Program-managed discharge events persist downstream to affect reaches occupied by sturgeon, the remainder of the actions will depend on establishing the relative numbers of sturgeon using the Platte, and whether the Platte (or Elkhorn) provides critical habitat for its reproduction."
2012	One thumb up	"The current conclusion is one thumb up, which is reasonable… While a one thumb up conclusion is justified, we do not support a conclusion of two-thumbs up at this time. The water part of the peer-reviewed stage change study is robust. However, the connection to sturgeon habitat is less certain because we don't know if the area modeled for sturgeon habitat suitability was sufficient given the true distribution of sturgeon, as discussed above. We recommend that the Program use the stage-change tool to adjust Program water operations to

[1] "Avoid adverse impacts from Program actions on Pallid Sturgeon populations"

[2] "Program water activities would be designed to provide benefits for the target bird species in the central Platte River region with subsequent benefits to the pallid sturgeon in the lower Platte River region (below the confluence with the Elkhorn River)".

[3] "The Program's long-term goal is to improve and maintain the associated habitats. This goal includes: (1) improving and maintaining migrational habitat for whooping cranes, and reproductive habitat for least terns and piping plovers; (2) reducing the likelihood of future listings of other species found in this area; and (3) testing the assumption that managing flow in the central Platte River also improves the pallid sturgeon's lower Platte River habitat."

State of the Platte Report for year shown	Conclusion on BQ 9 in State of the Platte Report	ISAC Comments / **Recommendations** [page reference, date of ISAC report]
		further minimize downstream effects during low-water conditions, and then re-evaluate the evidence for BQ 9." [pg. 10, ISAC report dated October 30, 2013]
2013	One thumb up	"ISAC agrees with this conclusion. No new information was presented to change this assessment" [pg. 10; ISAC report dated Nov. 16, 2014].
2014	Two thumbs up	**"we recommend that the Program repeat its "Alternative Analysis of Program Activities" (Appendix G in HDR et al. 2009) to determine if Program flow management actions also yield minimal predicted effects on water physical and chemical conditions in the Elkhorn to Loup segment of the Lower Platte River"** [pg. 3, ISAC report dated August 21, 2015] "**The ISAC recommends that the Program formulate an operational rule that would be applied to the operation of the J2 reservoir. Provided that such a rule is put in place by the Program to protect the habitat of pallid sturgeon, then the ISAC supports the conclusion of two thumbs up on Big Question #9"** [pg. 3, ISAC report dated August 21, 2015]
2015	Scratchy head, based on new observations of pallid sturgeon, and changes in the meaning of BQ9	"Based on the ISAC report from Aug 2015, it's reasonable to conclude 2 thumbs up for the area below the Elkhorn River. **The ISAC recommended more study above the Elkhorn based upon observations of adult pallid sturgeon above the Elkhorn.** Predicted changes in water surface elevations and velocities above the Elkhorn are likely to be within the error range of model accuracy." [pg. 1, ISAC report dated October 26, 2016]
2016	Scratchy head, based on same rationale as 2015 report	As the ISAC stated in our report from October 26, 2016, it's reasonable to conclude 2 thumbs up for the area below the Elkhorn River. **We continue to recommend more study above the Elkhorn based upon observations of adult pallid sturgeon above the Elkhorn.** **The ISAC recommends that a simple sensitivity analysis be completed to test the hypothesis that changes in flow and channel geometry above the Elkhorn will be within the range of model accuracy.** Since the questions of interest on pallid sturgeon have changed, **the ISAC recommends that the Program formulate a new Big Question and associated hypotheses.**

BQ10:

- The ISAC agrees that the number of tern and plover nests have increased coincident with increases in suitable off-channel habitat. As described above for BQ6, other hypotheses should be investigated.
- The ISAC agrees that herbicide treatment, disking, and high natural flows have been effective in increasing the amount of suitable roosting habitat for whooping cranes.
- It can be misleading to estimate an annual average percent utilization based on either: 1) the FWS approach of computing [sum of WC in both spring and fall] / [prior winter population estimate]; or 2) the EDO approach of computing [WC_{Spring} + WC_{Fall}] / [prior winter population plus following winter population]. Both approaches make unsupported assumptions: e.g., there's no evidence that birds migrating through the Platte in the fall are different individuals from those migrating through the Platte in the spring, as would be assumed by the FWS approach. Hence, we favor the use of separate metrics for fall and spring (PUPIS and PUPIF).
    - **ISAC recommendation: whooping crane use should be calculated in terms of two metrics:**

        - **Percent Using Platte in Spring (PUPIS) = [# WC observed through PRRIP protocols in spring] / [prior winter population in Aransas]**
        - **Percent Using Platte in Fall (PUPIF) = [# WC observed through PRRIP protocols in fall] / [following winter population in Aransas]**
- No single algorithm for computing annual average percent utilization is assumption free or superior to both PUPIS and PUPIF for purposes of reporting Program results. All reported percentages must be accompanied by an explanation of how they were derived.
    - **ISAC recommendation: the PRRIP work with the FWS on the most appropriate metrics for the PRRIP to use in the State of the Platte report, and other studies to be referenced.**
- The ISAC agrees that spring use of the Platte AHR by WC has increased, but that there has been no trend for fall use, based on presentation 11 (slide 42) at the AMP Reporting Session. These graphs should be included in the State of the Platte Report. Alternative explanations for these trends (e.g., changes in available habitat, changes in the availability of alternative stopover habitats in Nebraska) should be investigated.
- Given these concerns the ISAC supports the Program's one thumb's up assessment for 2016
    - **ISAC recommendation: Due to the difficulties of proving causality, the phrasing of BQ10 should be changed**
        - **FROM: Do Program management actions in the central Platte River cumulatively 1) produce detectable changes in the physical environment (i.e. habitat) and 2) result in a detectable increase in tern, plover and whooping crane use of the associated habitats?**
        - **TO: Do Program management actions in the central Platte River cumulatively produce detectable changes in the physical environment (i.e. habitat) that are associated with in a detectable increase in tern, plover and whooping crane use of the associated habitats?**

TABLE 1. 2016 BIG QUESTION ASSESSMENTS

PRRIP Big Question	2016 Assessment	Basis for 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?		Conclusively answered. Peer reviewed and published interior least tern and piping plover habitat synthesis chapters best address this question.[2]
2. Will implementation of SDHF produce and/or maintain suitable whooping crane riverine roosting habitat on an annual or near-annual basis?		Conclusively answered. Peer reviewed whooping crane habitat synthesis chapters[5] and published vegetation scour research[3] best address this question.
3. Is sediment augmentation necessary for the creation and/or maintenance of suitable riverine tern, plover, and whooping crane habitat?		Trending positive and certainty about the sediment deficit in the south channel above the Overton bridge; uncertainty about the role of that deficit in habitat creation and maintenance in the rest of the Associated Habitat Reach (AHR).
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?		Conclusively answered. Peer-reviewed WEST habitat selection analysis, PRRIP WC habitat synthesis chapters,[5] and publications related to the Program's vegetation scour research[3] best address this question. Additional publications expected in early 2018.
Effectiveness – Habitat and Target Species Response		
5. Do whooping cranes select suitable riverine roosting habitat in proportions equal to its availability?		Conclusively answered. Peer-reviewed WEST habitat selection analysis and PRRIP WC habitat synthesis chapters best address this question. Related publications expected in early 2018.
6. Does availability of suitable nesting habitat limit tern and plover use and reproductive success on the central Platte River?		Conclusively answered. Tern and plover breeding pair manuscript published in 2015 best addresses this question.
7. Are both suitable in-channel and off-channel nesting habitats required to maintain central Platte River tern and plover populations?		Conclusively answered. Tern and plover breeding pair manuscript published in 2015 best addresses this question.
8. Does forage availability limit tern and plover productivity on the central Platte River?		Conclusively answered. Productivity in relationship to flow manuscript published in 2017 best addresses this question.
9. Do Program flow management actions in the central Platte River avoid adverse impacts to pallid sturgeon in the lower Platte River?		The GC is currently conducting a facilitated Pallid Sturgeon Process to determine how best to address this question and related issues.
10. Do Program management actions in the central Platte River cumulatively 1) produce detectable changes in the physical environment (i.e. habitat) and 2) result in a detectable increase in tern, plover, and whooping crane use of the Associated Habitats?	**LTPP Off-Channel** Habitat:  Species Response:  **WC On-Channel** Habitat:  Species Response: 	Generally trending positive. The EDO proposed a methodology for addressing this question at the 2017 AMP Reporting Session and will update this assessment and the related write-up based on that discussion.

READING THE BIG QUESTION ASSESSMENTS

To assist the GC with quickly evaluating the 2016 Big Question assessments, the icons in Table 2 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 or 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 resolution of the Program's most significant scientific questions as they relate to management decision-making.

Each Big Question assessment includes an indicator of the "test results" for relevant priority hypothesis. Hypothesis Test Results are indicated as one of the following categories:

Hypothesis answered conclusively – affirmed.

Hypothesis answered conclusively – rejected.

Hypothesis not yet answered – ongoing implementation, analysis, and synthesis.

Not currently being addressed through implementation of the AMP and related data analysis and synthesis.

See **Appendix A** for a more detailed status report for each priority hypothesis in the AMP.

TABLE 2. QUICK REFERENCE LEGEND EXPLAINING ICONS USED TO ASSESS BIG QUESTIONS.

Icon	Trend or Answer Explained by Icon
	• Big Question and underlying hypotheses **answered conclusively** in the **affirmative** • Foundational documents, analysis, and other references on which this assessment is based have undergone peer review through the PRRIP peer review process and/or publication in refereed journals • Governance Committee should consider adjustments to decisions related to PRRIP management actions
	• Affirmative answer or trend, but Big Question and underlying hypotheses **NOT answered conclusively** • Assessment can be based on draft documents and analysis, but peer review and/or publication may be pending • To the extent possible, consider what information is necessary to change this designation
	• Evidence thus far is **inconclusive**; no affirmative or negative answer/trend to Big Question and underlying hypotheses • Assessment can be based on draft documents and analysis, but peer review and/or publication may be pending • To the extent possible, consider what information is necessary to change this designation
	• Negative answer or trend, but Big Question and underlying hypotheses **NOT answered conclusively** • Assessment can be based on draft documents and analysis, but peer review and/or publication may be pending • To the extent possible, consider what information is necessary to change this designation
	• Big Question and underlying hypotheses **answered conclusively** in the **negative** • Foundational documents, analysis, and other references on which this assessment is based have undergone peer review through the PRRIP peer review process and/or publication in refereed journals • Governance Committee should consider adjustments to decisions related to PRRIP management actions

Big Question #1

Will implementation of Short-Duration High Flow releases produce suitable tern and plover riverine nesting habitat on an annual or near-annual basis?

The minimum sandbar height suitability criterion is ≥1.5 ft above 1,200 cfs river stage.

2016 Assessment

- Observational studies of natural high flow events since 2007 have provided sufficient data to test the hypothesis that SDHF releases will create suitably-high sandbars.
- Full SDHF magnitude of 8,000 cfs is not sufficient to create sandbars exceeding the PRRIP's minimum height suitability criterion.
- Sandbars created by SDHF releases will be inundated during the nesting season in most years.
- Peak flow magnitudes of 15,000 cfs will produce sandbars meeting the minimum height criterion. However, suitably-high sandbar area would be well below the Adaptive Management Plan objective of 10 acres per river mile.

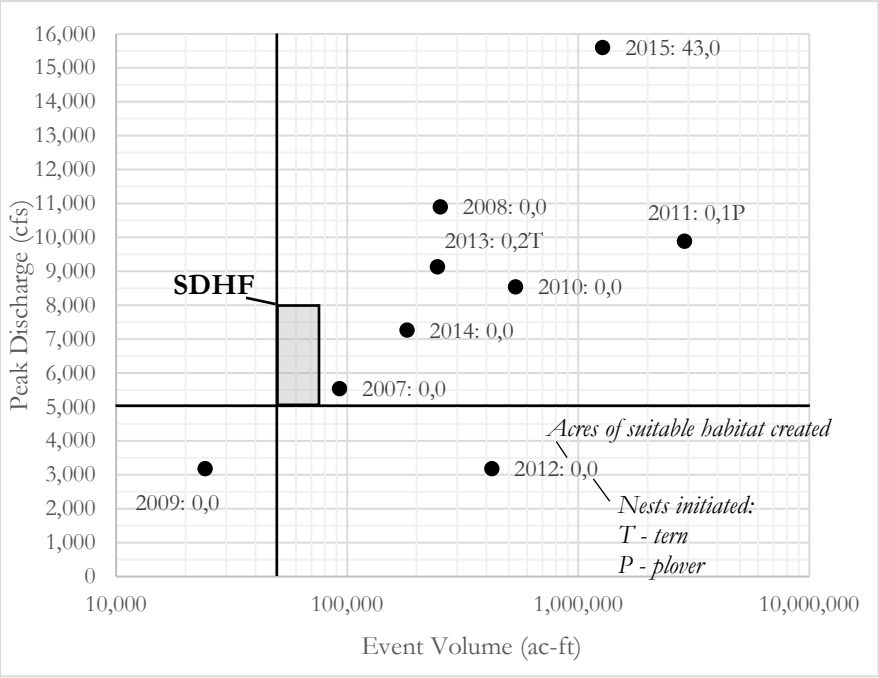


Figure 1. First Increment peak flow event magnitudes and volumes in relation to SDHF. Four events (2010, 2011, 2013, and 2014) exceeded SDHF magnitude and duration and did not produce suitably-high sandbar nesting habitat.

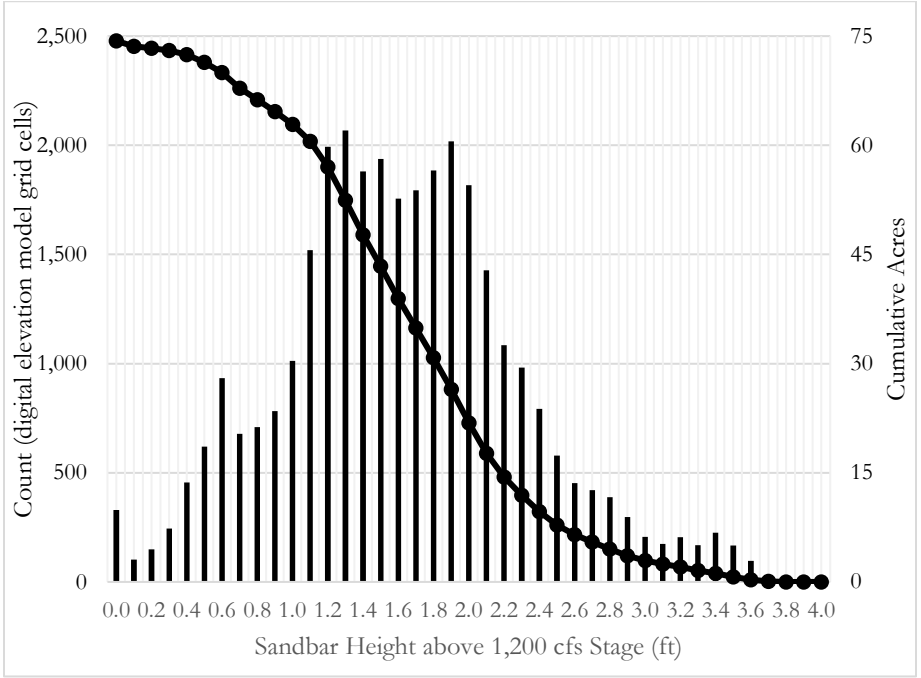


Figure 2. Distribution of emergent sandbar area produced during the 2015 peak flow event in the portion of the AHR downstream of Kearney. The 15,000 cfs event produced 43 acres of sandbar habitat exceeding the minimum height suitability criterion of 1.5 ft above 1,200 cfs stage. Median height of bars was 1.6 ft above 1,200 cfs stage.

What the science says in 2016:

- The original analysis of SDHF performance assumed sandbars build to the water surface during peak flow events. The median height of sandbars formed during natural high flow events in 2010, 2011, 2014, and 2015 was 1.2 – 2.3 ft below peak stage.[1]
- Four peak flow events (2010, 2011, 2013, and 2014) that exceeded SDHF magnitude and duration did not produce sandbar habitat exceeding the minimum height criterion (Figure 1).
- A natural high flow event of 15,000 cfs in 2015 produced sandbars exceeding the minimum height criterion. The median height of sandbars formed in 2015 was 1.6 ft above 1,200 cfs stage (Figure 2).
- Approximately 43 acres of mid-channel bar area ≥1.5 ft above 1,200 cfs stage were present in the portion of the AHR downstream of Kearney in November of 2015 (Figure 2). This equates to 0.8 acres per river mile.

We estimate with confidence that:

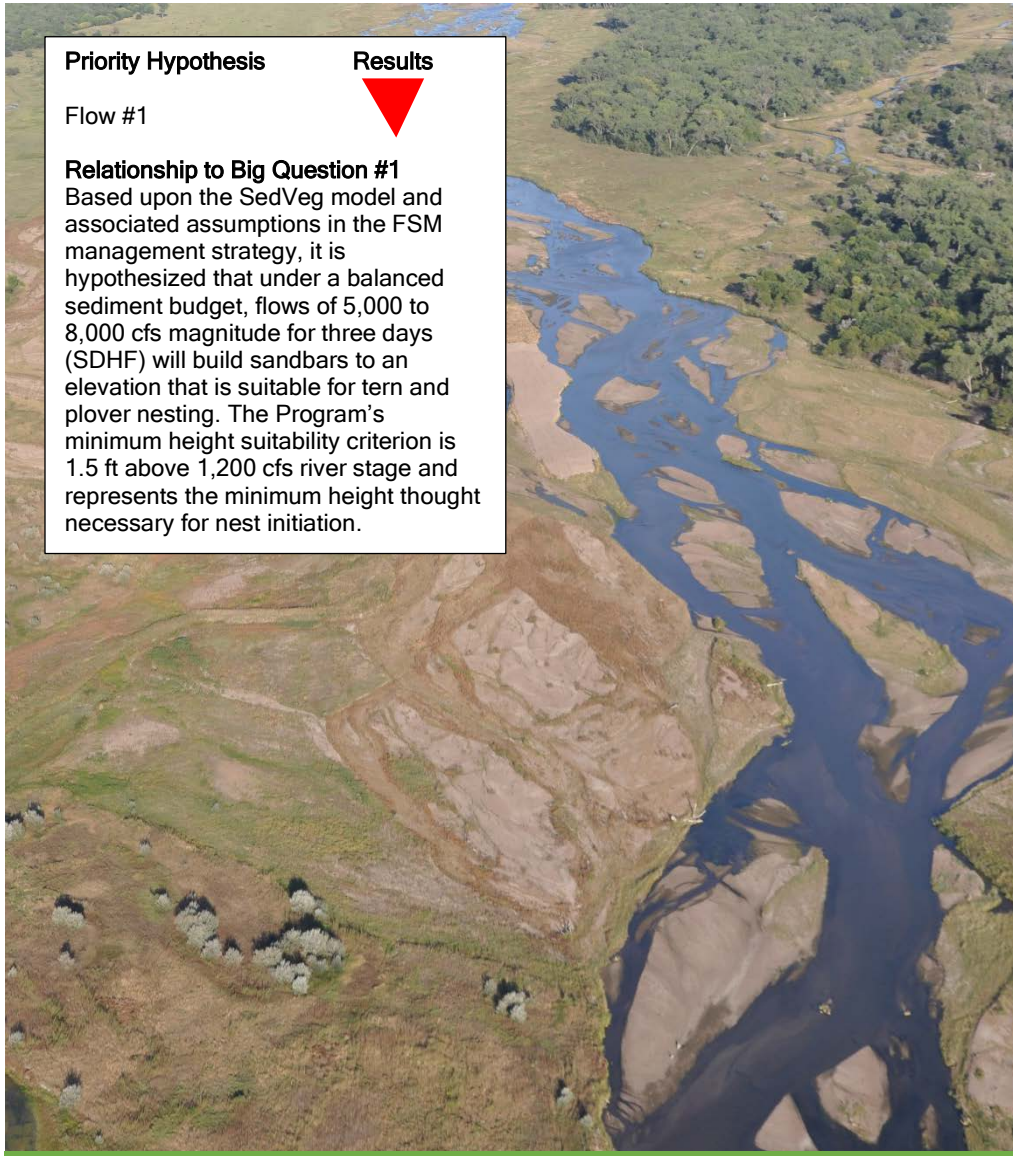
- SDHF magnitude of 5,000 to 8,000 cfs for a duration of three days at peak would not be sufficiently long to mobilize the bed and produce many new sandbars.
- Sandbars created by a full SDHF magnitude of 8,000 cfs would be 0.5 – 1.0 ft lower than the minimum height criterion and would be inundated at flows experienced in the AHR during most nesting seasons.
- Peak flow magnitudes of 15,000 cfs will produce sandbars exceeding the minimum height criterion given sufficiently long duration at peak.
- Even at a discharge magnitude of 15,000 cfs, total suitable sandbar area would be well below the AMP objective of 10 acres per river mile.

Answering BQ #1 during the First Increment

- Six tern/plover habitat synthesis chapters and associated publications serve as the best source for synthesized reference data for this question. Those chapters have been peer reviewed and accepted by the Governance Committee.[2]
- Geomorphic and species monitoring data collected in 2015 are consistent with and support the analyses and conclusions presented in the synthesis chapters.

Management Implications:

- Big Question #1 has been answered with a definitive "two thumbs down." The Governance Committee completed the final "Adjust" stage of adaptive management and decided to maintain 10 acres of on-channel moving complex approach (MCA) islands and to create an additional 60 acres of off-channel nesting habitat.



Big Question #2

Will implementation of Short-Duration High Flow releases produce and/or maintain suitable whooping crane riverine roosting habitat on an annual or near-annual basis?

Channels with unobstructed channel widths ≥650ft and unforested corridor widths ≥1,100ft are highly suitable for whooping crane roosting. See Big Question 5.

2016 Assessment

- Mature phragmites plants or plant patches have a very low probability of being eroded at the highest flow magnitudes and velocities observed in the AHR. A herbicide control program is ongoing.[3]
- Program analyses strongly support the assertion of a positive relationship between peak flow magnitude and unobstructed channel width (UOCW) in the AHR. 40-day mean peak discharge is the best hydrologic predictor of UOCW.
- The comparatively short duration and low volume of SDHF limits the predicted increase in in UOCW to ≤ 12 ft. SDHF duration is not sufficient to maintain UOCWs that are suitable for whooping crane roosting.
- Disking in combination with herbicide application will produce suitably-wide UOCWs. However, the beneficial effects of these management actions are limited to locations where they are applied.

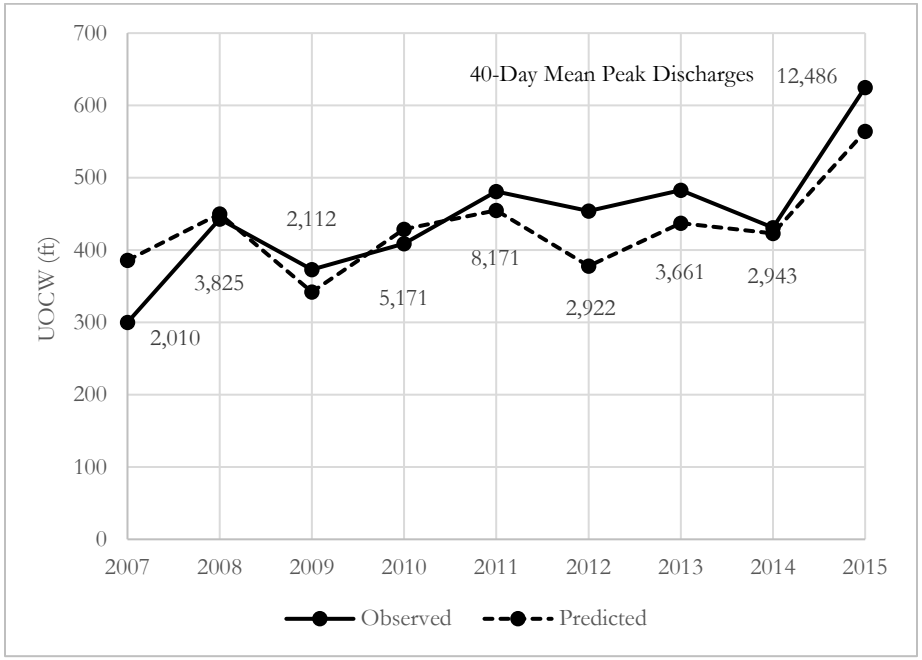


Figure 3. Observed versus predicted mean unobstructed channels widths (UOCW) in the AHR during the period of 2007-2015. Error in predicted UOCW ranged from 2% to 29% of observed and averaged 10%. Accordingly, the UOCW model provides good predictive capacity for evaluating the efficacy of SDHF releases.

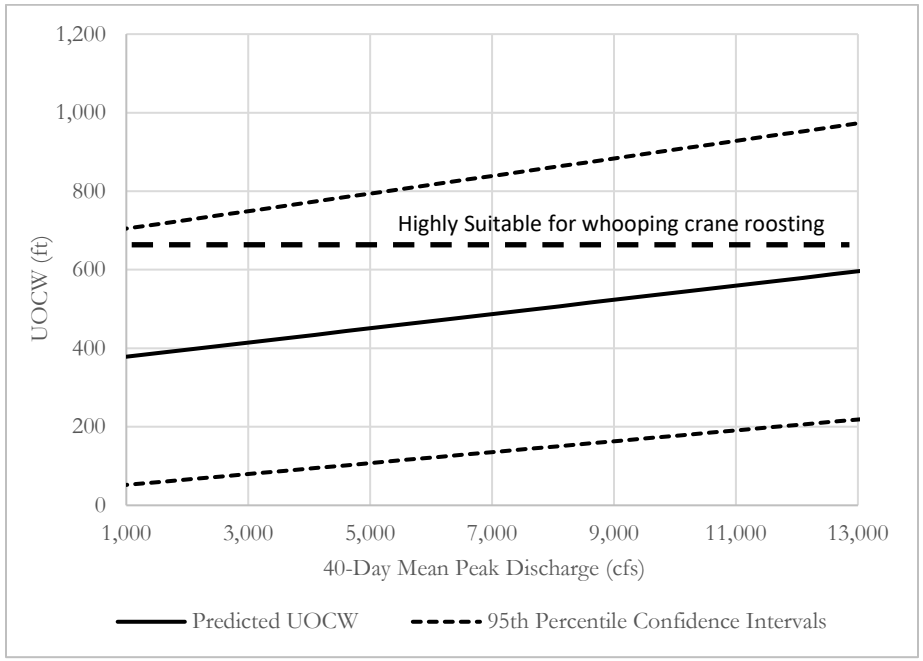


Figure 4. Modeled relationship between 40-day mean peak discharge and UOCW with spraying but no channel disking. The 40-day mean peak discharge for a full SDHF release is approximately 1,300 cfs, resulting in a predicted UOCW of less than 400 ft. UOCWs of ~650 ft are highly suitable for whooping crane roosting.[9,10]

What the science says in 2016:

- Phragmites occurrence and percent cover declined significantly during the period of 2009-2012 and were slightly increasing to stable in 2013-2016. The reduction is positively correlated with herbicide application and not correlated with peak flow magnitude or inundation duration.[4]
- 40-day mean peak discharge is the best hydrologic predictor of UOCW in the AHR. Other metrics useful in predicting UOCW include bankfull wetted width, median bed material grain size, and whether spraying or disking occurred.[5]
- Predictions of mean 2007-2015 UOCW in the AHR based on these metrics are, on average, within 10% of observed, indicating good predictive ability.

We estimate with confidence that:

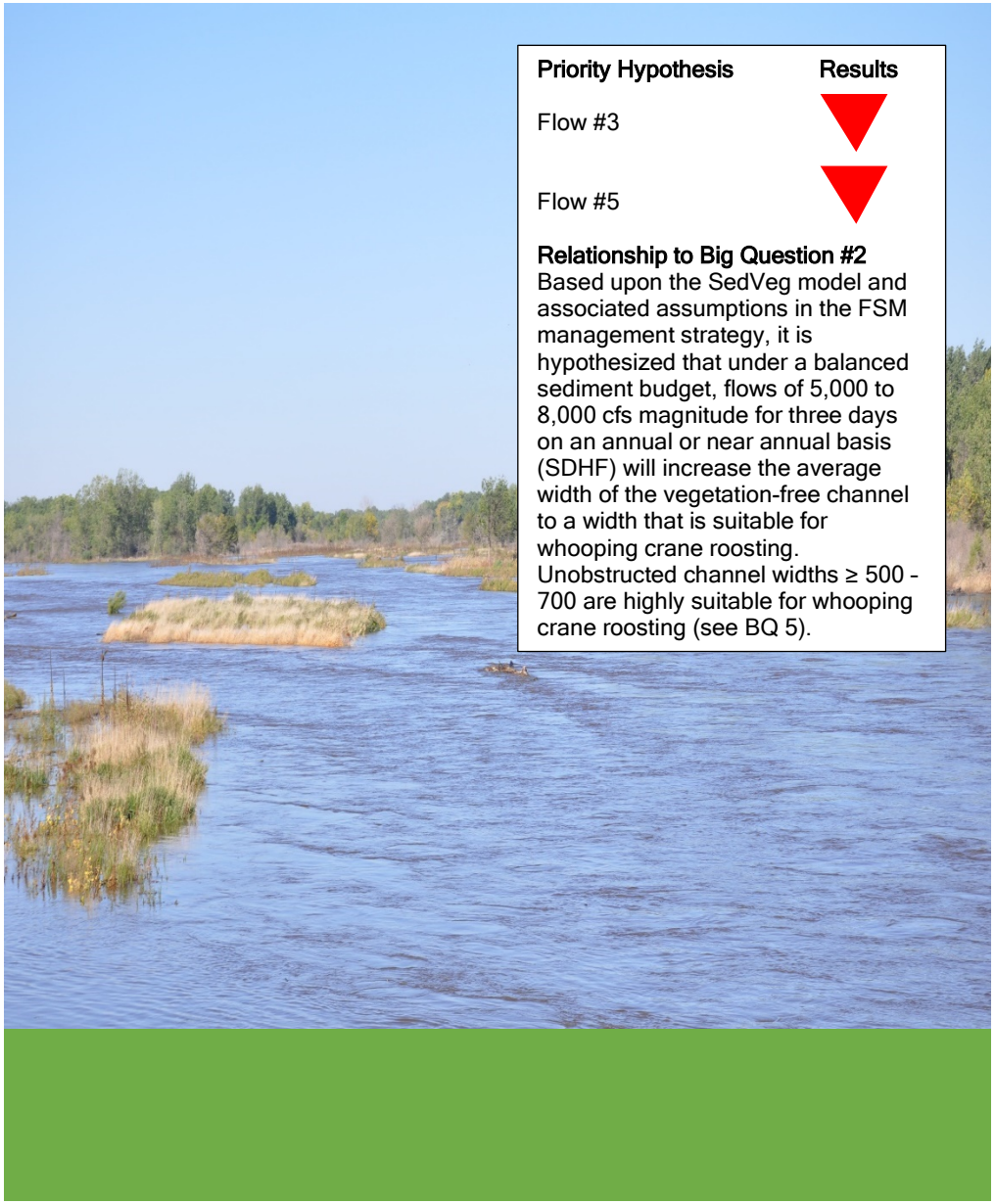
- Implementation of a three to five day SDHF will have a minimal influence on UOCW in the AHR (≤12 ft).
- The limited benefit of SDHF (≤12 ft) is not sufficient to produce suitably-wide UOCWs during dry years.
- During wet years, flow releases are not necessary to produce suitably-wide UOCWs.
- Implementation of disking and herbicide increases UOCW by an average of 126 ft, producing suitably-wide UOCW in all but the driest years.
- Mechanical management actions like disking and herbicide application do not provide the system-scale beneficial effects of natural peak flow events.

Answering BQ #2 during the First Increment

- The Program has published directed scour research which serves as the best source for synthesized reference data for phragmites scour resistance.[3]
- The Program's whooping crane data synthesis chapters serve as the best source for synthesized reference data for the relationship between SDHF and unvegetated channel width. Those chapters have been peer reviewed and accepted by the Governance Committee.[5]

Management Implications:

- Implementation of SDHF releases as currently envisioned will not create and/or maintain suitably-wide UOCWs for whooping cranes.
- Implementation of disking and herbicide application at Program habitat complexes will create and maintain suitably-wide UOCWs for whooping cranes.
- Mechanical management actions like disking and herbicide application at Program habitat complexes do not have the system-scale beneficial effects of natural high flow events.



Big Question #3

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

2016 Assessment

- The south channel reach from the J2 Return to the Overton bridge is incising and narrowing due to degradation from clear water hydropower returns. Downstream from Overton, the large degree of spatial and temporal variability in channel form makes it difficult to draw conclusions about sediment balance.
- South channel degradation has resulted in a portion of that reach transitioning from a wide braided planform to a narrow wandering planform, which is less suitable for use by the Program's target species.
- Augmentation of sediment in the south channel is necessary to slow incision and narrowing and prevent degradation from progressing downstream past the Overton bridge.
- It will be challenging to measure the effectiveness of augmentation given that the desired beneficial effect is slowing and ultimately halting of a long-term trend to prevent degradation downstream of the Overton bridge.

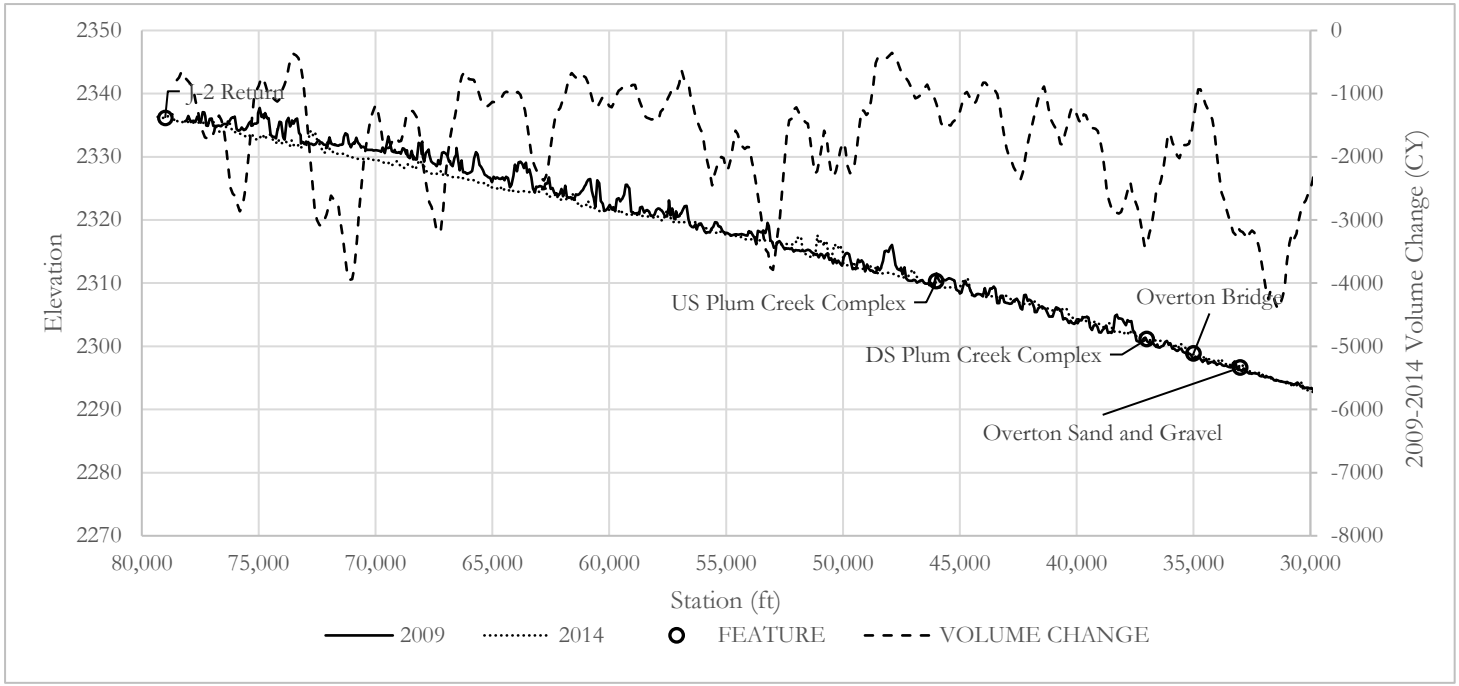


Figure 3. 2009 to 2014 longitudinal profile and volume change for the reach from J2 Return to Overton bridge. Volume change in the reach immediately downstream of the J-2 Return is caused by channel incision. Futher downstream, volume change is due primarily to channel widening.

What the science says in 2016:

- Sediment transport modeling indicates a mean annual sediment deficit of 55,000 tons in the south channel segment extending from the J2 Return downstream to the Overton bridge, ranging from 0 tons in dry years to >100,000 tons in wet years.[6]
- Between 2009 and 2014, that reach lost an average of 159,000 tons of sediment annually due to incision and lateral erosion of banks.[7]
- Incision and associated reduction in channel slope was greatest immediately downstream of the J2 Return and was negligible at the Overton bridge (Figure 3).
- Full-scale sediment augmentation will not be 100% efficient. A proportion (~ 10%) of the augmentation material will either be too coarse to be mobilized from the augmentation site or so fine that it is rapidly transported out of the reach.

We estimate with confidence that:

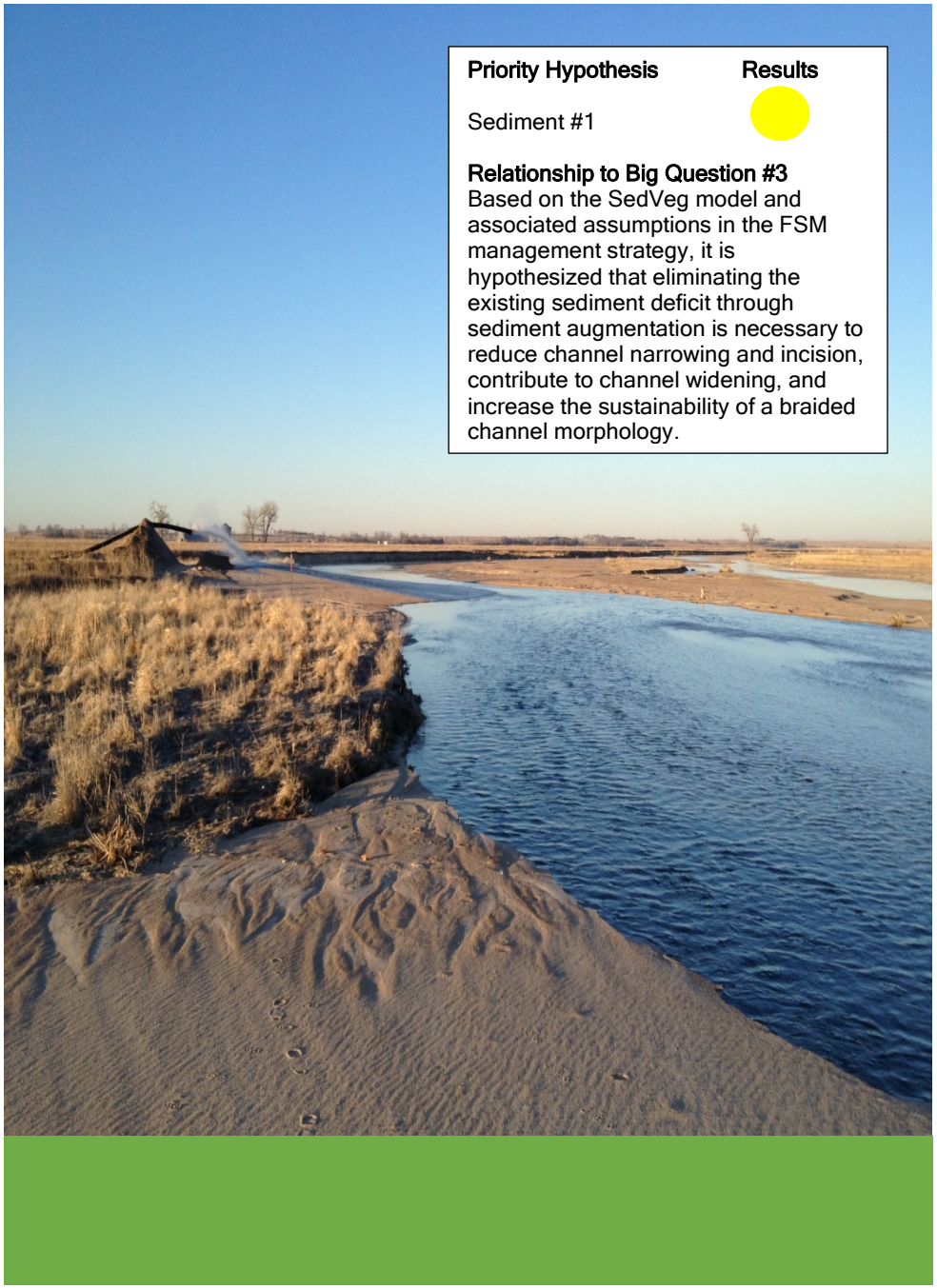
- Observed incision in narrowing and associated planform change in the south channel result in a channel configuration that is not suitable for use by the Program's target species.
- In absence of augmentation to offset the south channel deficit, incision and narrowing will progress downstream past the Overton bridge and negatively affect habitat suitability at the Program's Cottonwood Ranch complex.
- Augmentation of 60,000 to 80,000 tons of sand annually downstream of the J2 return will be sufficient to allow the Program to evaluate augmentation efficiency.
- Measuring augmentation effectiveness will require assessment of changes (or lack thereof) in channel slope, volume, width, and bed material. It may be challenging to quantify beneficial effects.

Answering BQ #3 during the First Increment

- The existence and negative impacts of a sediment deficit downstream of the J2 Return has been well documented by the Program and others.
- The effectiveness of sediment augmentation in offsetting the deficit and halting degradation is not known.
- Full scale operations began in the fall of 2017 and it is anticipated that five to seven years of implementation and response monitoring will be necessary to assess augmentation efficiency and effectiveness.

Management Implications:

- If the south channel sediment deficit persists, incision and narrowing will progress downstream past the Overton bridge, negatively influencing habitat suitability an increasingly larger portion of the AHR.
- Full scale sediment augmentation may be effective in halting the long-term trend of incision and narrowing. The beneficial effects of augmentation need to be assessed through five to seven years of implementation and effectiveness monitoring that will include biannual bathymetric LiDAR collection and analysis.



Big Question #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?

2016 Assessment

- Peak flows in the AHR are generally not sufficient to remove mature woody vegetation or erosion-resistant species like phragmites.
- Mechanical clearing and leveling are necessary to create suitable channel configurations and facilitate channel adjustments to changes in flow and sediment.
- Ongoing mechanical management actions like herbicide application and disking are necessary to maintain suitably-wide unobstructed channel widths (UOCWs) for target species.
- Flow consolidation, a mechanical management action which consists of mechanically confining 90% of total river flow into a single channel, may support the maintenance of suitable UOCWs but is not implementable due to regulatory and legal impediments.

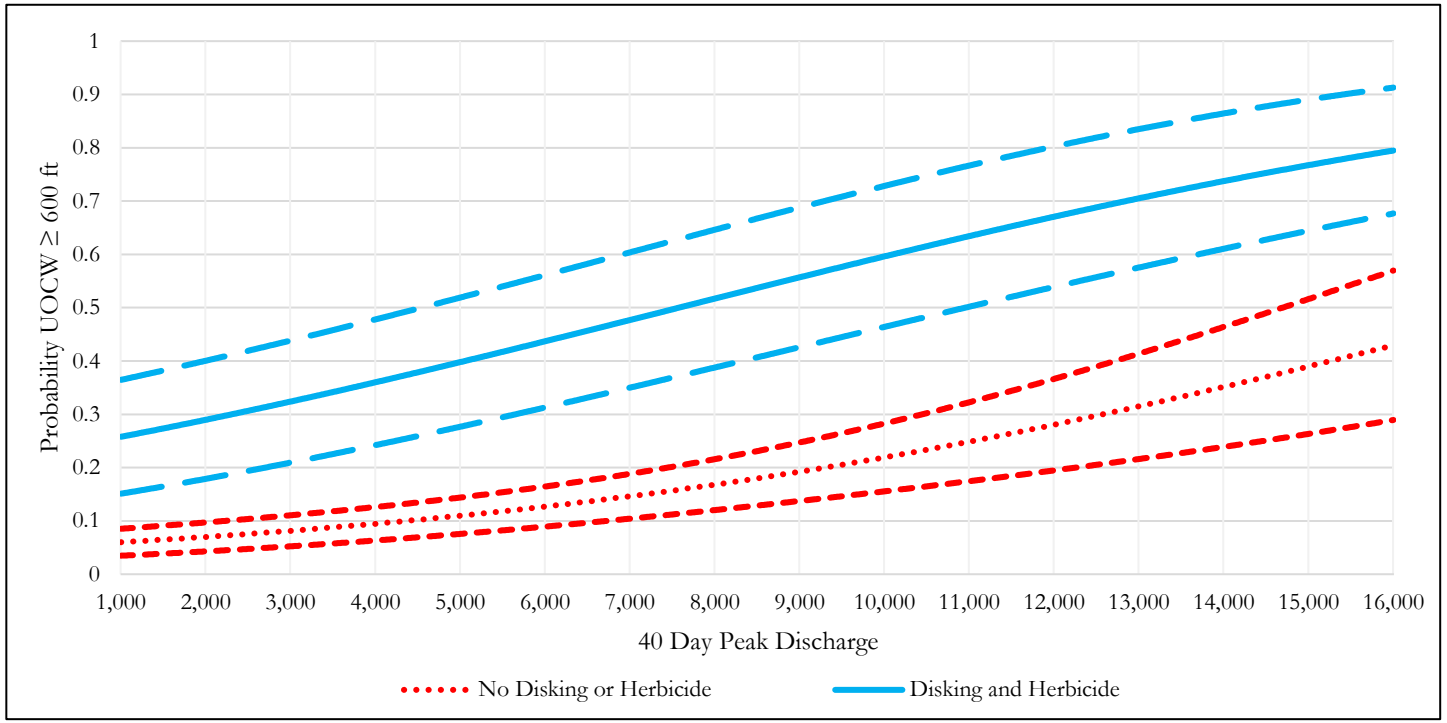


Figure 4. Predicted probability of a transect measuring ≥600 ft in unobstructed channel width (suitable for whooping cranes) in relation to 40-day peak discharge at transects with (blue solid line) or without (red dotted line) mechanical management actions in the AHR from 2007 to 2015. Long and short dashed lines indicate 95% confidence intervals. Disking and herbicide application provides a significantly greater probability of having channels with more than 600 ft of unobstructed channel width.

What the science says in 2016:

- Phragmites is extremely erosion-resistant and SDHF flow depths and velocities are only sufficient to scour the very weakest individual plants. Ability to scour woody vegetation also decreases dramatically in the year following seed germination.[8]
- Locations that are mechanically maintained through herbicide application and disking have a significantly higher probability of being suitably wide for whooping crane roosting (Figure 4).

We estimate with confidence that:

- Mechanical clearing, leveling, and channel widening are necessary to create suitably wide channels at Program habitat complexes.
- Herbicide application and disking are necessary at Program habitat complexes in most years to maintain suitably-wide UOCWs.
- The beneficial effects of mechanical management actions are largely limited to the locations where they are implemented. They do not provide system-scale beneficial effects.

Answering BQ #4 during the First Increment

- The Program has published directed scour research which serves as the best source for synthesized reference data for phragmites scour resistance.[3]
- The Program's whooping crane data synthesis chapters are the best source for synthesized reference data for the relationship between mechanical actions and unvegetated channel width. Those chapters have been peer reviewed and accepted by the Governance Committee.[5]

Management Implications:

- It was originally hypothesized that mechanical actions were necessary to create desired channel configurations that would subsequently be maintained through Short Duration High Flow releases. SDHF has been shown to be ineffective at creating suitable tern and plover nesting habitat and maintaining suitable channel widths for whooping cranes. Accordingly, ongoing mechanical maintenance will be necessary to provide nesting habitat and maintain suitable UOCWs at Program habitat complexes.
- Due to regulatory and legal issues flow consolidation has been abandoned as a potential Program management action.

Priority Hypothesis	Results
Mechanical #2	▲

Relationship to Big Question #4
Based on the SedVeg model and associated assumptions in the FSM management strategy, it is hypothesized that designed mechanical channel alterations like flow consolidation, mechanical clearing and leveling of islands, channel widening, and vegetation clearing from banks are needed to accelerate the creation of, and/or to maintain suitably-wide braided channels in the AHR.

Big Question #5

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

2016 Assessment

- Results of habitat selection analyses within the AHR and throughout the Great Plains indicate whooping cranes select unobstructed channel widths of ~650 feet and unforested corridor widths of ~1,100 disproportionately to availability.[9,10]

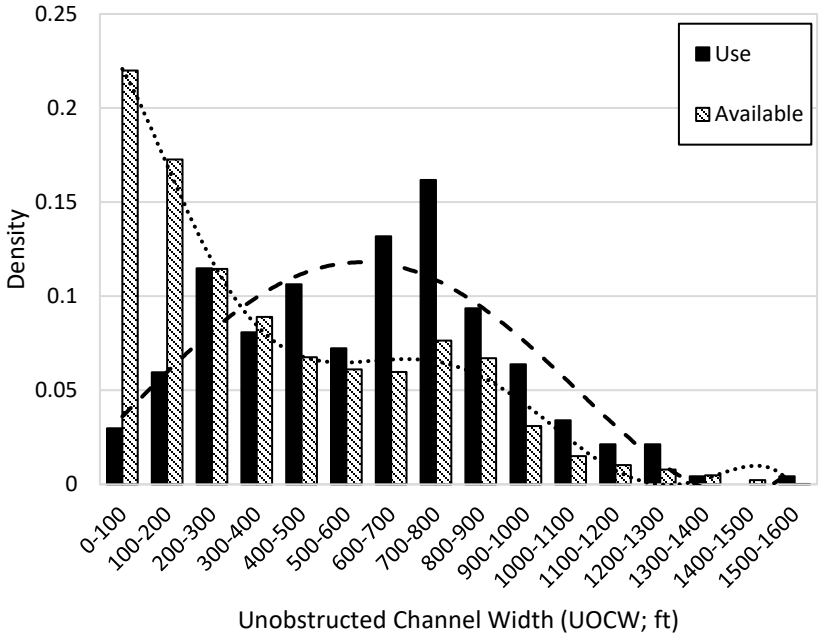


Figure 5. Distribution of unobstructed channel width (UOCW) at use (n=235) and available riverine roost locations in the Associated Habitat Reach (AHR). Use locations were selected disproportionately more than availability from 400-900 ft of UOCW, suggesting UOCWs of ~650 ft are favorable for whooping crane roosting on the central Platte River. Density curves are represented as dashed or dotted lines.

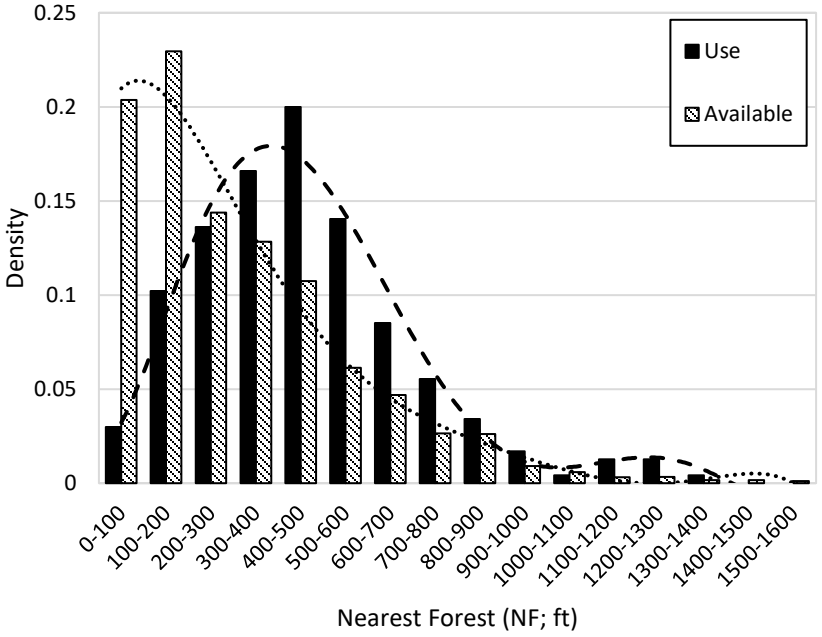


Figure 6. Distribution of nearest forest (NF) at use (n=235) and available riverine roost locations in the Associated Habitat Reach (AHR). Use locations were selected disproportionately more than availability from 400-700 ft of UOCW, suggesting total unforested corridor widths of ~1,100 ft (suitable NF multiplied by 2) are favorable for whooping crane roosting on the central Platte River. Density curves are represented as dashed or dotted lines.

What the science says in 2016:

- First Increment habitat management efforts implemented by the Program to date include, but are not limited to, tree removal and bank line disking to increase unobstructed view widths, channel disking and widening to increase unobstructed channel widths, and flow releases and sediment augmentation to test hypotheses related to increasing river braiding and areas of suitable depth for whooping crane roosting.

We estimate with confidence that:

- Whooping cranes select unobstructed channel widths of ~650 feet and unforested corridor widths of ~1,100 feet disproportionately to availability.[9,10]

Answering BQ #5 during the First Increment

- Detailed habitat selection analyses have been completed and have undergone the Program's independent third-party peer review.[9,10] The Program accepted the whooping crane habitat synthesis chapters and the WEST whooping crane report and peer reviews as final and thus Program staff consider results of these analyses to be sufficient evidence to change the assessment for this Big Question to 2 thumbs down.

Management Implications:

- Based on findings of habitat selection analyses, the Program should continue to manage to provide unobstructed channel widths that are ≥650ft and unforested corridor widths that are ≥1,100ft.

Big Question #6

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

2016 Assessment

- Long-term monitoring and data analyses indicate there is a strong positive correlation between Program-defined suitable off-channel ***nesting*** habitat and tern and plover breeding pair counts within the AHR.[11,12] During the Program's First Increment, the tern and plover populations on the central Platte River have increased significantly and proportionately to increases in habitat availability.

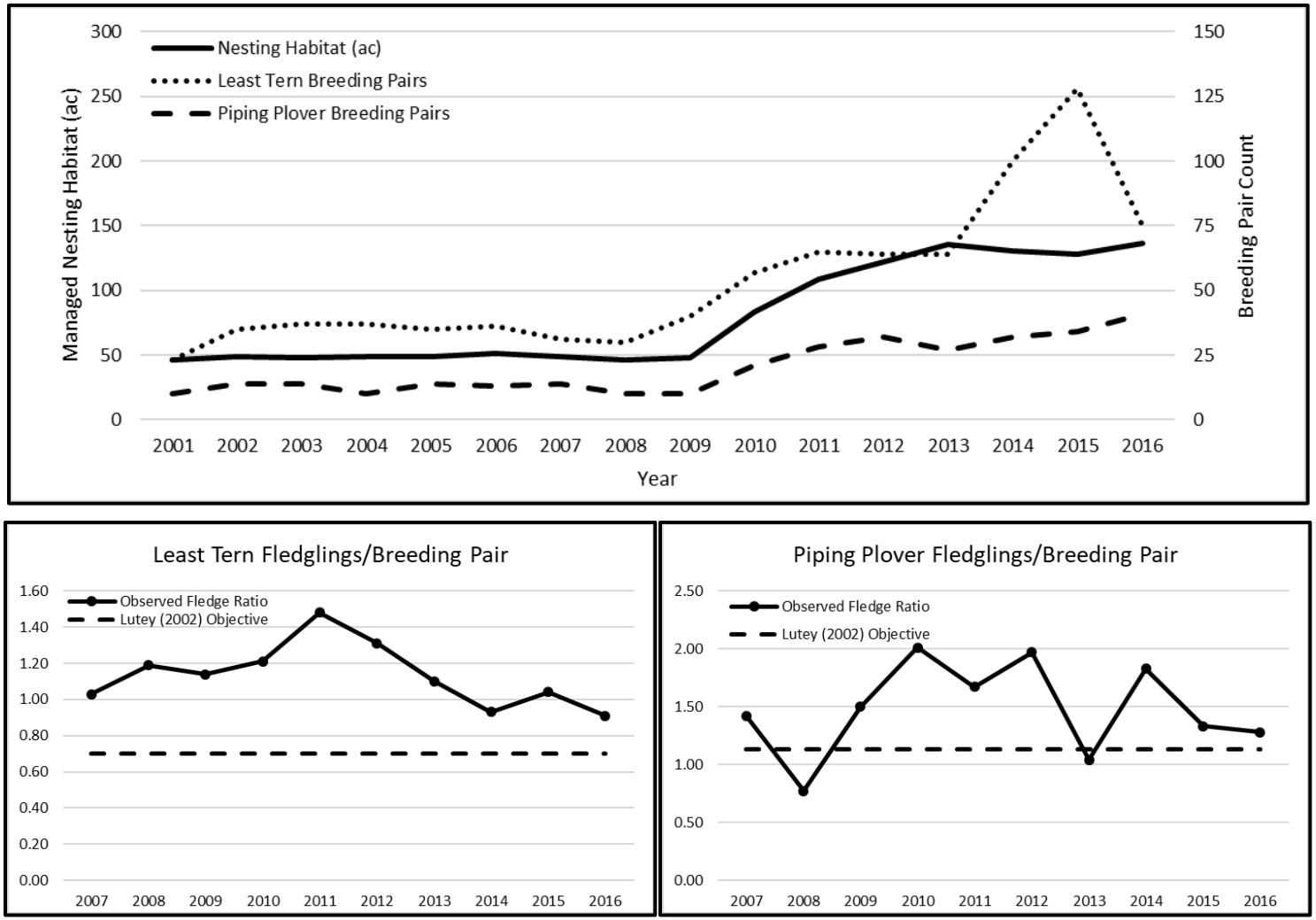


Figure 7. Tern (dotted line; top) and plover (dashed line; top) total breeding pair counts and Program (90 ac) and non-Program (45 ac) managed habitat availability (solid line) based on Program habitat availability assessments and tern (bottom left) and plover (bottom right) reproductive success as compared to the Lutey (2002) objectives, 2007-2016. Increased habitat availability and high reproductive success within the AHR are believed to be responsible for the increases tern and plover populations on the central Platte River.

What the science says in 2016:

- The Program and its partners have created in-channel (sandbars) and off-channel (sandpits) nesting habitat to evaluate hypothesized relationships between habitat availability and tern and plover use and productivity within the Program Associated Habitat Area. The Program has created and maintained ~90 acres of off-channel and ~65 acres of in-channel nesting habitat for terns and plovers.[11] In addition, Program partners have constructed and/or managed ~60 acres of off-channel and ~25 acres of in-channel nesting habitat.
- Numbers of tern and plover breeding pairs have increased 4-fold within the AHR since 2001 while increases of similar magnitude have not been observed on Lake McConaughy (Dave Zorn, personal communication) or the Missouri River (http://moriverrecovery.usace.army.mil/mrrp/f?p=136:6:0::NO); although recent increases have been observed on the Missouri River. While overall numbers of tern and plover breeding pairs within the AHR have increased significantly, habitat availability and use of non-Program habitat has remained steady[11]. We have observed a high, positive correlation between tern and plover breeding pair counts and habitat availability. Program data also indicate breeding pair counts increase at a similar rate as habitat availability.
- Reproductive success, as measured by fledglings/breeding pair, have remained high and generally above the Lutey (2002) objective for maintaining stable to increasing populations within the AHR.

We estimate with confidence that:

- There is a high correlation between habitat availability and breeding pair counts and as the Program increases suitable off-channel nesting habitat, numbers of tern and plover breeding pairs within the AHR will increase until habitat availability exceeds population demands.

Answering BQ #6 during the First Increment

- Tern and plover data collected to date and published in the 2015 Breeding Pair publication[12] and 2017 tern and plover habitat selection publication[13] serves as the best source data for this question.
- The 2016 Tern and Plover Monitoring and Research Report[11] has also been reviewed and accepted by the Program and serves as additional evidence of the ongoing increasing trend in tern and plover use of the AHR.

Management Implications:

- Based on results of Program analyses, the Program should continue to increase off-channel habitat availability until numbers of terns and plovers within the AHR no longer continues to increase.

Big Question #7

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

2016 Assessment

- Long-term monitoring and data analyses indicate both in-channel and off-channel *nesting* habitats are not necessary to maintain the central Platte River population of terns and plovers. During the Program's First Increment the increase in tern and plover populations on the central Platte River is the result of use and productivity at off-channel nesting habitats.[11] River survey and observational data, however, indicate the river is a valuable source of *forage* for both species as forage availability appears to be lower on off-channel habitats.[14]

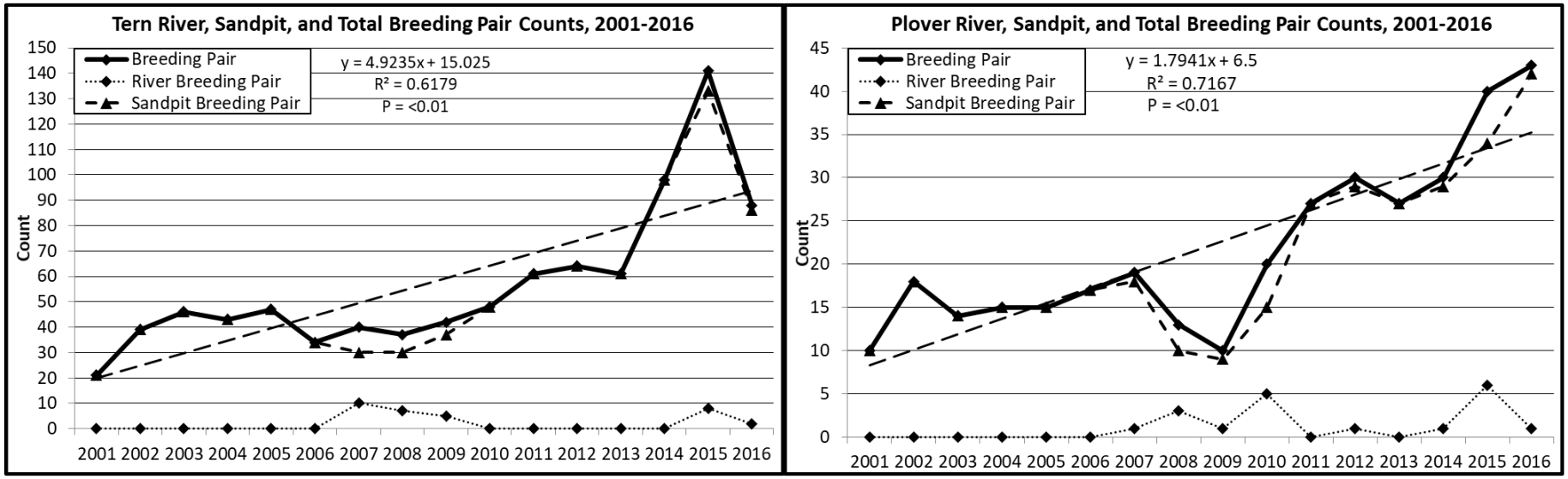


Figure 7. Annual tern (left plot) and plover (right plot) total (solid line), riverine (dotted line), and sandpit breeding pair counts (short dashed line), 2001-2016. Trend lines (long dashed lines) represent significant increases in tern and plover breeding pair counts during 2001-2016 with the most substantial increases occurring since inception of the Program. Reproductive success on and use of sandpits is believed to be responsible for the increase.

What the science says in 2016:

- The Program and its partners created in-channel (sandbars) and off-channel (sandpits) nesting habitat to evaluate hypothesized relationships between in- and off-channel habitat availability and selection of terns and plovers. Early Program efforts largely focused on off-channel nesting sites as flows and permitting challenges precluded construction of in-channel nesting islands. Program efforts in recent years were directed at maintaining off-channel nesting habitat and constructing and maintaining suitable in-channel habitat.
- The creation and maintenance of off-channel nesting habitat resulted in substantial use and productivity since 2001. During this same timeframe, in-channel habitat availability and tern and plover nesting and productivity have been sporadic and thus has not contributed to the maintenance of the central Platte River populations. Despite the limited use and productivity of in-channel nesting habitat, we observed significant increases in the numbers of tern and plover breeding pairs within the AHR from 2001-2016.[11]
- Since 2001, breeding pair counts for terns increased nearly 4-fold (21 to 88) while plover counts also increased 4-fold (10 to 43); both of which represent significant increases.[11] Though populations of both species increased during this timeframe, increases of similar magnitude have not been observed on Lake McConaughy (Dave Zorn, personal communication) or the Missouri River (http://moriverrecovery.usace.army.mil/mrrp/f?p=136:6:0::NO); though recent increases have been observed on the Missouri River.
- Efforts to create and maintain suitable in-channel nesting habitat have necessarily been opportunistic, but extensive. Though in-channel nesting habitat has contributed little to the reproductive success of both populations, ephemeral islands and river channels appear to provide an important source of forage for both terns and plovers.

We estimate with confidence that:

- Off-channel nesting habitat is necessary to maintain central Platte River tern and plover populations.
- Although an important forage source, direct maintenance of in-channel nesting habitat is not necessary to maintain tern and plover populations within the AHR.

Answering BQ #7 during the First Increment

- Tern and plover monitoring data collected to date and the 2015 Breeding Pair publication[12] serve as the best source data for this question and indicate use of off-channel habitat resulted in increases in breeding pair counts and productivity within the AHR.
- The 2016 Tern and Plover Monitoring and Research Report[11] has also been reviewed and accepted by the Program and serves as additional evidence of the ongoing increasing trend in tern and plover use of the AHR attributable to use of and productivity on off-channel sites.

Management Implications:

- The Program should continue to increase and maintain off-channel nesting habitat for tern and plover production and population stability along the central Platte River.

Big Question #8

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

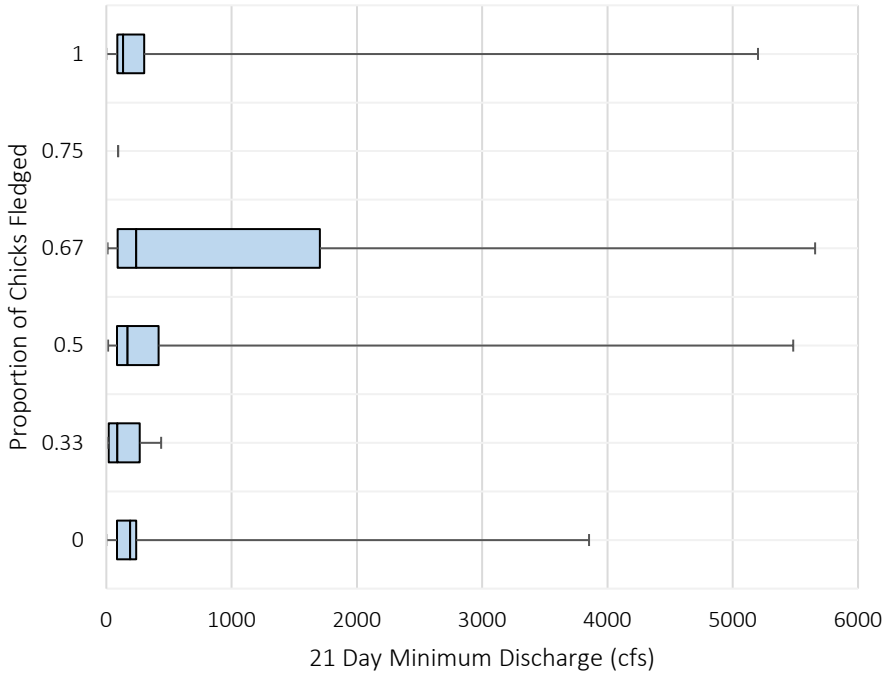


Figure 9. Proportion of fledglings for each brood ($\frac{number\ of\ chicks\ fledged}{number\ of\ chicks\ hatched}$) compared to 21-day minimum discharge. Due to wide variation of flows observed for different documented fledging successes, no model resulted in better predictions of fledging success than the null model, which indicates fledging success is independent of all flow variables tested.

2016 Assessment

- Analyses of flow versus productivity[15] indicate there is no relationship between flow and tern productivity and we suspect analyses of data linking forage availability or flow and plover productivity would yield similar results. Given tern and plover productivity is high and a majority of confirmed mortalities have been attributed to adverse weather and predation, there is no evidence the forage base along the central Platte River limits tern and plover productivity. Further evaluations would involve capturing and weighing tern and plover chicks on multiple occasions to establish a more direct link between growth rates and forage abundance; however, Program stakeholders decided these additional expenses, efforts, and risk of injury to chicks are not warranted.

What the science says in 2016:

- Detailed analyses have been completed and the resulting manuscript is in publication. In the manuscript, we synthesize independent sets of data and found no relationship between tern productivity and flow during the nesting and brood rearing season.[15]
- Given the high levels of productivity observed on the central Platte River, it is unlikely flow, and thus forage fish abundance, limits tern productivity. We were unable to establish the hypothesized link between flow and productivity and have used results of our retrospective analyses to definitively answer this Big Question.
- Further evaluations of BQ #8 would likely entail system-wide, intensive, summer-long forage sampling, tern and plover behavioral studies, and potentially capturing and weighing chicks on multiple occasions to attempt to establish relationships between forage abundance, flow, productivity, and long-term survival. Program stakeholders previously indicated additional expenses, efforts, and risk of injury to chicks are not warranted as it appears forage abundance and reproductive success are adequately high to support central Platte River tern and plover populations.

We estimate with confidence that:

- Forage availability does not limit tern and plover productivity on the central Platte River.

Answering BQ #8 during the First Increment

- The forage fish manuscript[15] serves as the best source for synthesized reference data for this question. The results of these analyses indicate flow, and thus forage availability, does not limit tern and plover productivity within the AHR. Program staff will consider results of these analyses to be sufficient evidence to change the assessment for this Big Question to two thumbs down in 2016.
- A similar synthesis of data could be developed for plovers; however, given results of the Foraging Habits Study and high levels of productivity observed to date, there is a complete lack of evidence forage abundance limits plover productivity.

Management Implications:

- Data analysis and synthesis do not support Program summer flow releases to maintain the 800 cfs target.
- Based on these data, a revised summer flow target in the range of 200-600 cfs would likely be sufficient to meet the objective of an abundant and diverse forage base for terns.

Big Question #9

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

Credit: USFWS

2016 Assessment

- The GC approved the following motion in 2012: *The Governance Committee accepts the Technical Advisory Committee recommendation to accept the Lower Platte River Stage Change Study Peer Review and Lower Platte River Stage Change Study as final without revisions, with the understanding that the tool can be subsequently used to evaluate Program actions but is not a statement on Program policy implications for pallid sturgeon.*[16]
- Stage Change Study[16] analyses concluded central Platte River flow management actions are likely to avoid adverse impacts to pallid sturgeon in the lower Platte River because the relative change in habitat due to Program water management activities would be small to undetectable.
- Any potential Impacts could be avoided through development of operational rules that prohibit Program diversions when lower Platte River discharges fall below 4,000 cfs.
- The EDO followed the established process to assess this Big Question as answered with two thumbs up in 2014. In 2016, the Service concluded they "do not support two thumbs up at this time for Big Question 9 because of lingering uncertainties."
- The premise of this Big Question has changed in practice.
- There is uncertainty about pallid sturgeon use of lower Platte, and there has been substantial new learning about pallid sturgeon and their use of lower Platte (evidence they are there all year, spawning ground, larval drift, etc.) since the Stage Change Study was completed. At the time of Stage Change Study, the primary issue was use of the lower Platte River by a small number of adult fish.
- In September 2016, the GC agreed to begin a step-wise, incremental process to refine goals, hypotheses and objectives, possibly re-state this Big Question, develop decision criteria, and possibly do additional pallid sturgeon research.
- Until that process is complete and uncertainties are resolved, this remains an open question for the Program and the EDO believes the Big Question is not helpful to current discussions.

What the science says in 2016:

- The general conclusion of the Program's Final Stage Change Study[16] is that Program water management activities will not result in measurable changes on flows in the lower Platte River and thus will result in little change to the amount of habitat available to pallid sturgeon.
- 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 above 4,000 cfs, results of the stage change study 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.

We estimate with confidence that:

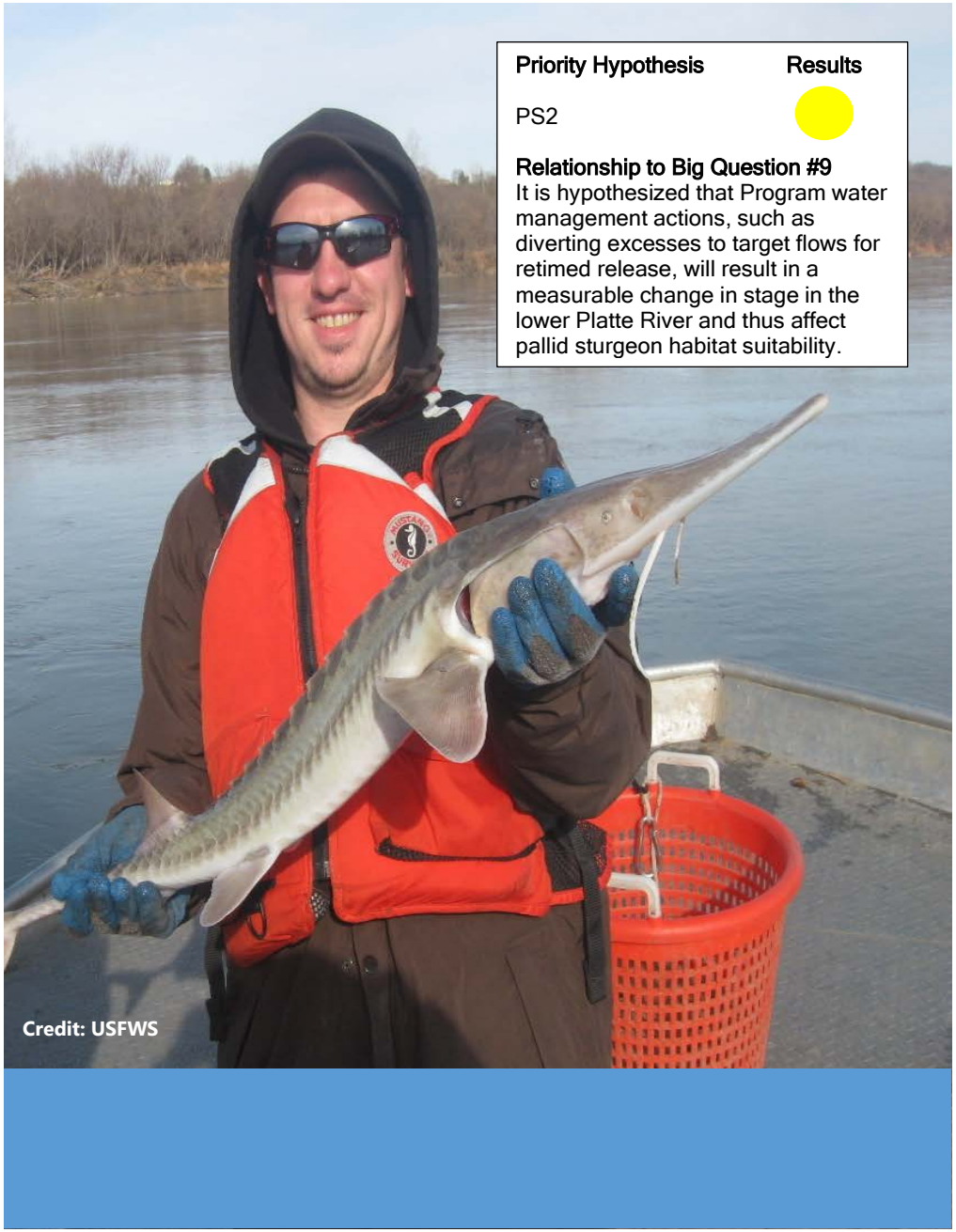
- Flow diversions or releases by the Program would result in very small and undetectable changes in stage in the lower Platte River.
- As identified in the stage change study, these stage changes reside in the noise of gage error on the lower Platte River and thus will not result in a measurable change in lower Platte River stage.
- By extension, flow management actions that will not result in a measurable change in stage in the lower Platte River will not result in significant adverse effects on pallid sturgeon.

Answering BQ #9 during the First Increment:

- This question is not likely to be answered until the First Increment Extension. The GC began a facilitated Pallid Sturgeon Process in 2017 to help guide activities that will keep the question open until sometime during the potential First Increment Extension. That process is ongoing as of March 2018.

Management Implications:

- The primary Program water management actions that are hypothesized to result in flow and fish impacts in the lower Platte River are short-duration high flows (SDHF), target flow releases, and diverting target flow excesses.
- The Program is undergoing a process to develop flow management actions for the potential First Increment Extension.
- Central Platte River flow releases or diversions that could plausibly be detected in the lower Platte River during the remainder of the First Increment are not anticipated.



Big Question #10

Do Program management actions in the central Platte River cumulatively produce detectable changes in the physical environment (i.e. habitat) that are associated with a detectable increase in tern, plover and whooping crane use of the Associated Habitats?

The Program implements both on- and off-channel habitat creation and maintenance for the target species. The BQ 10 assessment will focus on the habitat creation strategy that has been most effective for each species. In the case of least terns and piping plovers, off-channel habitat has been most effective. In the case of whooping cranes, on-channel habitat has been most effective.

2016 Assessment for Least Tern and Piping Plover Off-Channel (OCSW) Habitat

- There is a strong positive correlation between Program-defined suitable nesting habitat and tern and plover breeding pair counts within the AHR. See BQ 6 Assessment.[11]
- During the First Increment, tern and plover populations on the central Platte River have increased significantly and proportionately to increases in habitat availability due to Program off-channel habitat creation efforts. See BQ 6 Assessment.[11]

Habitat: 

Species Response: 

2016 Assessment for On-Channel Whooping Crane Habitat

- Maximum unvegetated channel widths (important whooping crane habitat metric) have been significantly wider on Program lands since 2013. See Figure 10.
- There has been no discernable trend in whooping cranes roosting on Program lands since 2007.

Habitat: 

Species Response: 

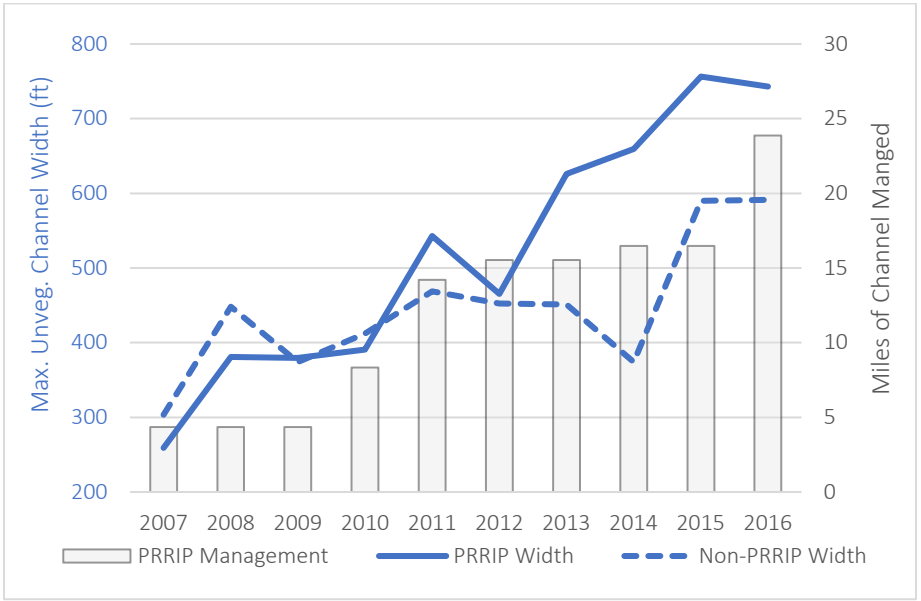


Figure 10. Unobstructed channel width (UOCW), an important whooping crane habitat suitability metric, has been wider on Program-managed lands since 2011 and significantly wider since 2013. Program lands are generally now more suitable for whooping crane roosting than non-Program lands.

What the science says in 2016:

- During the First Increment of the Program, tern and plover populations on the central Platte River have increased significantly and proportionally to increases in off-channel nesting habitat creation efforts.
- On-channel nesting habitat creation efforts have not been successful and have largely been abandoned.
- During the First Increment of the Program, UOCW on Program lands transitioned from significantly narrower than non-Program lands in 2010 to significantly wider in 2013 through 2016.
- There has been no discernable trend in the proportion of the whooping crane population roosting on Program lands since 2007. There has been a significant increase in the proportion of the population using the AHR as a whole during the spring migration, but not during the fall migration period.
- Whooping cranes have not used the off-channel palustrine wetland sites created and maintained by the Program during the First Increment.

We estimate with confidence that:

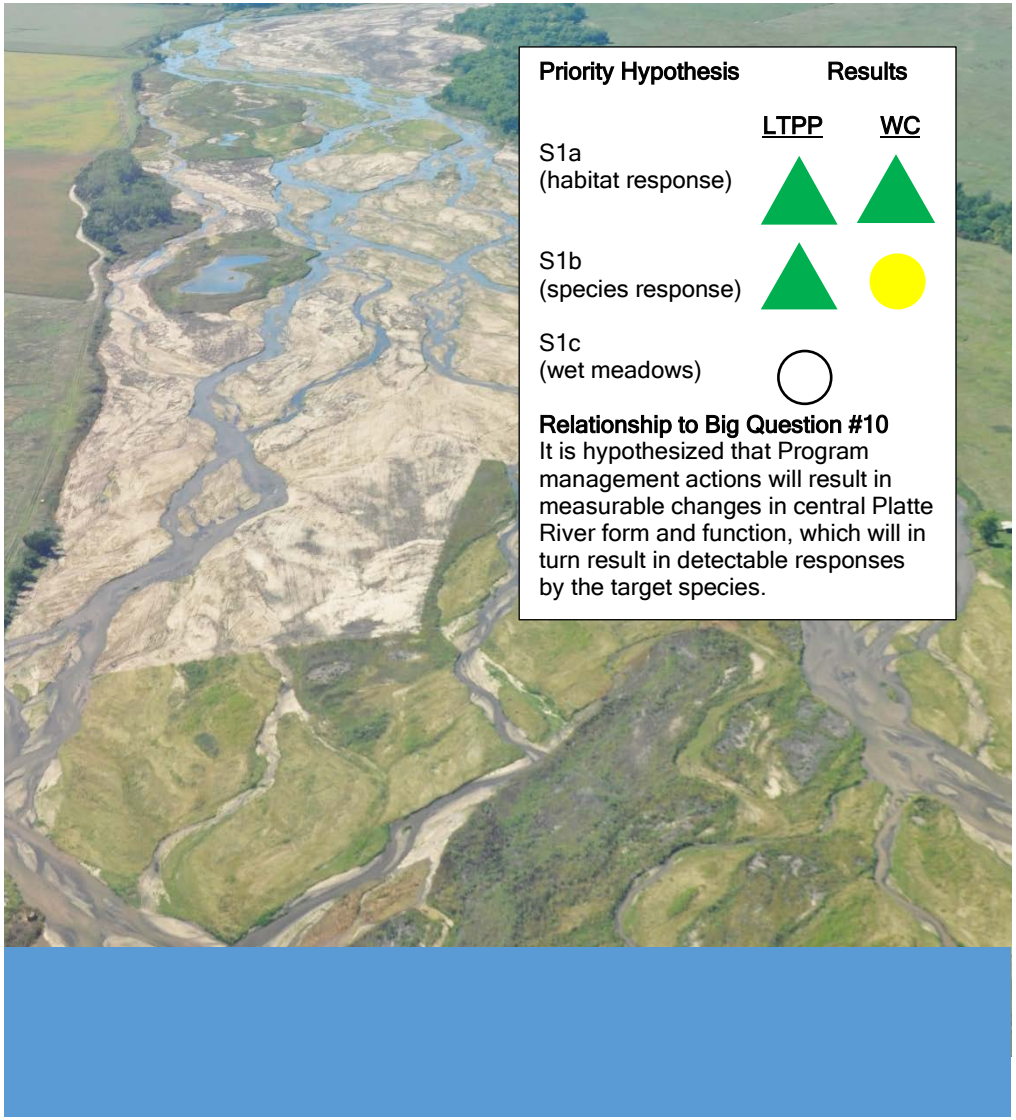
- Program efforts to create and maintain off-channel nesting habitat have been successful.

Answering Big Question #10 during the First Increment:

- Evaluation of the underlying Priority Hypotheses related to this Big Question will continue during the remainder of the First Increment.
- The EDO believes trends related to the tern and plover hypotheses can be reported by the end of the First Increment. However, additional time will be needed to discern any detectable change in whoooping crane use of Program managed river channels.
- The Program is currently negotiating a 13-year Extension of the First Increment due in part to the fact that water objective of reducing annual shortages to target flows by 130,000-150,000 acre-feet has not been met.
- A complete answer to this Big Question most likely will not be obtained until additional flow management actions are implemented and evaluated during the Extension.

Management implications:

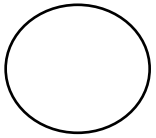
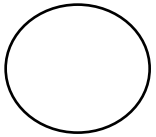
- Synthesis of multiple lines of evidence related to this Big Question and the underlying system-level hypotheses should provide guidance to the GC regarding Program land and water management toward the end of the First Increment and into the Extension.

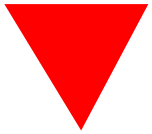
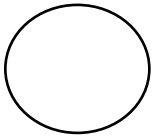


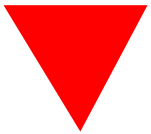
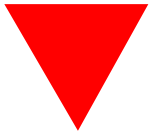
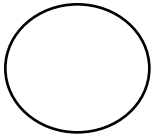
APPENDIX A

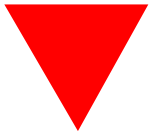
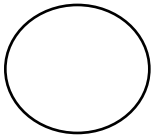
2016 State of the Platte Priority Hypotheses Status Table

2016 State of the Platte Priority Hypotheses Status Table. Status of AMP priority hypotheses, as listed in Table 2 of the Adaptive Management Plan (Page 70). See shape coding key at end of table.

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
System							
S1	The Platte River form can be modified by either mechanical/sediment/flow management (i.e., clear/level/pulse) or mechanical means along with non-Program managed flows (i.e., clear/level/mechanical).		#10	Geomorphology and vegetation monitoring, LiDAR and other aerial imagery, EDO analyses		Collecting the data necessary to answer all S1 hypotheses. To date, *State of the Platte* evaluations focused on BQ #1-#9. The S1 hypotheses and BQ #10 will be addressed in years 2017-2019.	
S1a	Program channel habitat restoration actions will result in detectable change to Platte River form and function.	Cannot detect a significant effect on indicators.	#10	Geomorphology and vegetation monitoring, LiDAR and other aerial imagery, EDO analyses		*2016 State of the Platte* – During the First Increment of the Program, UOCW on Program lands transitioned from significantly narrower than non-Program lands in 2010 to significantly wider in 2013 through 2016.	
S1b	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	#10	Geomorphology and vegetation monitoring, LiDAR and other aerial imagery, bird monitoring, EDO analyses		*2016 State of the Platte* – Monitoring and analyses indicate there is a strong positive correlation between Program-defined suitable ***nesting*** habitat and tern and plover breeding pair counts within the AHR. Less of a correlation for whooping cranes.	
S1c	Program actions will increase functional wet meadows in habitat complexes during the First Increment.		#10	N/A		*2016 State of the Platte* – TBD	
S2	Implementing Program land and water management actions (i.e., habitat complexes and clear/level/pulse) will have a detectable effect on other species use of the associated habitats.	Within the overall management objectives for whooping cranes, terns and plovers, and pallids sturgeon, benefits can be provided to non-target listed species and non-listed species of concern thereby reducing the likelihood of future listing and improve overall ecosystem diversity.	N/A	N/A			

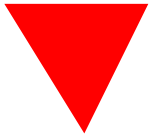
X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
Terns and Plovers							
T1	Additional bare sand habitat will increase the number of adult least terns.	Bare sand is not currently limiting number of adults.	#6	PRRIP tern/plover monitoring protocol, EDO analyses, tern/plover habitat synthesis chapters		*2015 State of the Platte* – Monitoring and analyses indicate there is a strong positive correlation between Program-defined suitable ***nesting*** habitat and tern and plover breeding pair counts within the AHR.	
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.	#8	Districts' forage fish monitoring protocol, USGS foraging habits study, EDO analyses and publication		*2016 State of the Platte* – Monitoring and analyses indicate there is no relationship between tern use and productivity and flow (i.e. forage fish) within the AHR.	
T2a	Flow rates influence the number and species diversity in tern prey base (fish).	Tern productivity not affected by fish community species diversity.	N/A	N/A			
P1	Additional bare sand habitat will increase the number of adult piping plovers.	Bare sand is not currently limiting number of adults.	#6	PRRIP tern/plover monitoring protocol, EDO analyses, tern/plover habitat synthesis chapters and associated publications		*2015 State of the Platte* – Monitoring and analyses indicate there is a strong positive correlation between Program-defined suitable ***nesting*** habitat and tern and plover breeding pair counts within the AHR.	
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.	#8	Districts' forage fish monitoring protocol, USGS foraging habits study, EDO analyses		*2016 State of the Platte* – Monitoring and analyses indicate there is likely no relationship between plover use and productivity and flow (i.e. forage fish) within the AHR.	

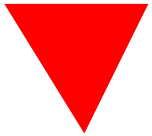
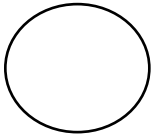
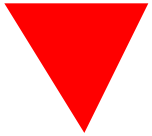
X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
TP 1	Interaction of river and sandpit habitat.	LT and PP show no preference for the river over sandpits.	#7	PRRIP tern/plover monitoring protocol, EDO analyses		*2015 State of the Platte* – Monitoring and analyses indicate both in-channel and off-channel ***nesting*** habitats are not necessary to maintain the central Platte River population of terns and plovers. However, the river is a valuable source of ***forage*** for both species as forage availability is lower on off-channel habitats.	
TP 2	The central Platte River may act as a source or sink for terns and plovers.	Currently not a sink.	N/A	PRRIP tern/plover monitoring protocol, EDO analyses		*2015 State of the Platte* – Given population growth within the AHR and fledge ratios that exceed all numbers hypothesized to result in population growth, the hypothesis is almost certainly rejected.	
TP 4d	Correlation between river island habitat and flow.		N/A	Tern/plover habitat synthesis chapters		No need to test as sandbars are not suitably high for nesting.	
TP 5	Use of riverine islands by least terns and piping plovers will increase with active channel width.	Use will not increase with channel width.	#1	Tern/plover habitat synthesis chapters		Hypothesis affirmed in Tern/plover synthesis chapter 4.	

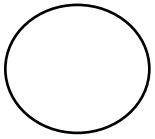
X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
Whooping Cranes							
WC 1	Whooping crane use will increase as function of Program land and water management activities.	Whooping crane use will not increase as function of Program land and water management activities.	N/A	WEST habitat selection report, whooping crane habitat synthesis chapters		Evidence points to accepting this hypothesis. Peer review of key documents is underway and this will change to a conclusive answer in the *2016 State of the Platte*.	
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 (preferred depth?) and channel width (define as wetted width, open width, other?).	WC use of areas is not directly linked to FWS habitat suitability values.	#5	WEST habitat selection report, whooping crane habitat synthesis chapters		*2016 State of the Platte* – Whooping cranes select channel widths of 600-700 ft and unforested corridor widths of 1,100 ft.	
WC 4	Whooping crane use of the central Platte River study area will increase proportionally to an increase in wet meadows.	WC do not use wet meadows currently and are unlikely to respond to increases in wet meadow area.	N/A	N/A		Evidence points to rejecting this hypothesis. Peer review of key documents will likely result in a conclusive answer in a future *State of the Platte Report*.	
WC 5	Whooping cranes are adversely affected by nocturnal disturbances that lead to flushing (walking or flying) which could lead to potential mortality.	WC are not negatively impacted by nocturnal disturbances.	N/A	N/A			

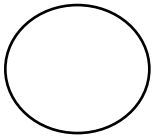
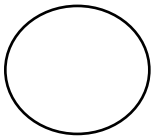
X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
Pallid Sturgeon							
PS-1	Program flow/sediment management will result in a positive species response by the pallid sturgeon in the lower Platte River.	Program flow/sediment management will result in no increase in species use/occurrence by the plaid sturgeon in the lower Platte River.	N/A	N/A		The Program is in the process of determining next steps on pallid sturgeon Big Questions, hypotheses, and issues for the First Increment and First Increment Extension through the facilitated Pallid Sturgeon Process. Determining linkages between Program hypotheses, management actions, and pallid sturgeon response will be part of that process.	
PS-2	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.	#9	Stage change study		The Program is in the process of determining next steps on pallid sturgeon Big Questions, hypotheses, and issues for the First Increment and First Increment Extension through the facilitated Pallid Sturgeon Process. Determining linkages between Program hypotheses, management actions, and pallid sturgeon response will be part of that process.	
PS-4	Flows in the lower Platte will affect pallid sturgeon habitat suitability.	Flows in the lower Platte River will have no effect on pallid sturgeon habitat suitability.	N/A	N/A		The Program is in the process of determining next steps on pallid sturgeon Big Questions, hypotheses, and issues for the First Increment and First Increment Extension through the facilitated Pallid Sturgeon Process. Determining linkages between Program hypotheses, management actions, and pallid sturgeon response will be part of that process.	

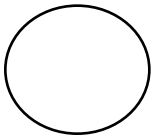
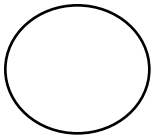
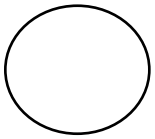
X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
PS-5	Pallid sturgeon habitat suitability is maximized between water temperatures of X and Y in the lower Platte River.	Pallid sturgeon use is independent of river water temperature.	N/A	N/A		The Program is in the process of determining next steps on pallid sturgeon Big Questions, hypotheses, and issues for the First Increment and First Increment Extension through the facilitated Pallid Sturgeon Process. Determining linkages between Program hypotheses, management actions, and pallid sturgeon response will be part of that process.	
PS-6	Increasing flow in the lower Platte will affect pallid sturgeon habitat availability.	Increasing flow in the lower Platte River will have no effect on pallid sturgeon habitat availability.	N/A	N/A		The Program is in the process of determining next steps on pallid sturgeon Big Questions, hypotheses, and issues for the First Increment and First Increment Extension through the facilitated Pallid Sturgeon Process. Determining linkages between Program hypotheses, management actions, and pallid sturgeon response will be part of that process.	
PS-7	Increasing habitat availability in the lower Platte will increase pallid sturgeon use.	Pallid sturgeon use is independent of lower Platte River habitat availability.	N/A	N/A		The Program is in the process of determining next steps on pallid sturgeon Big Questions, hypotheses, and issues for the First Increment and First Increment Extension through the facilitated Pallid Sturgeon Process. Determining linkages between Program hypotheses, management actions, and pallid sturgeon response will be part of that process.	

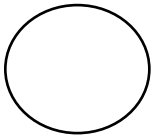
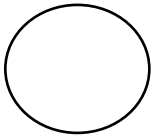
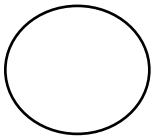
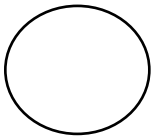
X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
PS-9	Increasing Program flow releases will decrease water temperatures in the lower Platte River.	River water temperature is independent of flow rate in the lower Platte River Increases in program flow releases will increase water temperatures on the lower Platte River.	N/A	N/A			
PS-11	Non-Program actions (e.g. harvest, stocking, Missouri River conditions) determine the occurrence of pallid sturgeon in the lower Platte River.	Program actions will affect the rate of occurrence of pallid sturgeon in the lower Platte River such that use is disproportionate to external factors (e.g., stocking, harvest, local conditions) relative to local population.	N/A	N/A			
Physical Processes – Flow							
Flow #1	Increasing the variation between river stage at peak (indexed by Q1.5 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.	Flow magnitudes and channel compilations are insufficient to generate bars high enough to provide habitat for LT and PP. Bars may quickly vegetate making them poor habitat for target species. Bars can be created/maintained by mechanical/other means.	#1	Geomorphology and vegetation monitoring, tern/plover monitoring, tern/plover habitat synthesis chapters		*2016 State of the Platte* – Full SDHF magnitude of 8,000 cfs is not sufficient to create sandbars exceeding the PRRIP's minimum height suitability criterion. Sandbars created by SDHF releases will be inundated during the nesting season in most years.	

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
Flow #3	Increasing 1.5-yr Q with Program flows will increase local boundary shear stress and frequency of inundation at existing green line (elevation at which riparian vegetation can establish). These changes will increase riparian plant 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.	#2	Directed scour research, whooping crane habitat synthesis chapters		*2016 State of the Platte* – The comparatively short duration and low volume of SDHF limits the predicted increase in UOCW to ≤12 ft. SDHF duration is not sufficient to create and maintain UOCWs that are suitable for whooping crane roosting.	
Flow #4	Annual riparian seedling mortality greater than 90% is required to prevent riparian encroachment on exposed bars, thereby increasing (maintaining at least 10 acres/mile) exposed bars between Overton and Grand Island that are usable as LT and PP habitat.	Riparian seedling mortality greater than 90% is needed to increase exposed bar area. Other factors drive exposed bar area instead of seedling mortality. Plant mortality can be achieved by other means.	N/A	N/A			
Flow #5	Increasing magnitude and duration of a 1.5-yr flow will increase riparian plant mortality along the margins of the river. There will be different relations (graphs) for different species.	Insufficient Program flows to maintain required flow durations. Plant mortality can be achieved by other means.	#2	Directed scour research, whooping crane habitat synthesis chapters		*2016 State of the Platte* – Mature phragmites plants or plant patches have a very low probability of being eroded at the highest flow magnitudes and velocities observed in the AHR. An herbicide control program is ongoing	

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
Physical Processes – Sediment							
Sediment #1	Average sediment augmentation at Overton of 185,000 tons/yr. under existing flow regime and 225,000 tons/yr. under Governance Committee 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.	#3	Sediment transport modeling, results of sediment augmentation Proof of Concept experimental implementation		Augmentation of sediment in the south channel is necessary to slow incision and narrowing and prevent degradation from progressing downstream past the Overton bridge. It will be challenging to measure the effectiveness of augmentation given that the desired beneficial effect is slowing and ultimately halting of a long-term trend.	
Sediment #2	A balanced sediment budget (sediment augmentation of 225,000 tons/year near Overton under proposed Governance Committee flows) when implemented with mechanical actions (channel consolidation & widening) in anastomosed reaches will promote braided channel morphology with an average braiding index in the main channel of greater than 3.	Flows and sediment augmentation are insufficient to achieve desired braiding index.	N/A	N/A			

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
Sediment #3	Increasing the average braiding index of the main channel by achieving a balanced sediment budget, increases the active unvegetated width of the main channel at an index flow of 2,000 cfs (at Overton).	Width will not change with increasing braiding index.	N/A	N/A			
Sediment #4	Increasing the average braiding index to greater than 3 for the main channel in the sediment deficient reach near Overton will increase and maintain exposed bar area greater than 1.5 acres in the reach between Overton and Kearney at an index flow of 1,200 cfs (at Overton).	There is no relationship between braiding index and area of exposed bars. Exposed bars may be created (maintained) through mechanical means without need to change braiding index.	N/A	N/A			
Physical Processes – Mechanical							
Mechanical #2	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.	#4	Directed scour research, whooping crane habitat synthesis chapters		*2016 State of the Platte* – Peak flows in the AHR are generally not sufficient to remove mature woody vegetation or erosion-resistant species like phragmites. Mechanical clearing and leveling are necessary to create suitable channel configurations and facilitate channel adjustments to changes in flow and sediment.	

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
Mechanical #3	Reducing the number of channels in a transect to 3 or less under balanced sediment budget will convert anastomosed reaches of the Platte River between Overton and Chapman to a braided channel morphology. With proposed flow regime, should occur with greater number of channels.	Reducing the number of channels in a transect to 1 or 2 is necessary to achieve an average braiding index in the main channel of greater than 3.	N/A	N/A			
Mechanical #4	Increasing the average braiding index to greater than 3 in the main channel by channel manipulation will promote in the Platte River at the mechanically changed sites a total main channel wetted width exceeding 500 to 750 ft at an index flow of 1,700 cfs (at Overton).	A braiding index greater than 4 is needed to achieve a width greater than 500 ft. There is no relation between braiding index and channel width.	N/A	N/A			
Mechanical #5	Increasing the average braiding index to greater than 3 for the main channel by mechanical channel manipulation, will increase and maintain exposed bar area greater than 1.5 acres at mechanical changed sites at an index flow of 1,200 cfs (at Overton).	Mechanically consolidating flows will have no effect on areal extent of bars.	N/A	N/A			

X-Y Graph Number	Description of hypothesis	Description of alternative/competing hypotheses	Link to PRRIP Big Questions	Data Source(s)	Hypothesis Test Results [i]	Notes	Comments from TAC/AMWG
Wet Meadows							
WM-2	Wet meadows producing the optimum productivity and diversity of macro-invertebrates potentially consumed by WC exhibit certain characteristic combinations of soils, hydrology, size and location. Mormon Island and adjacent to Rowe Sanctuary have some of best existing combinations	There are too many possible combinations of site characteristics to allow for a meaningful characterization of "desirable" conditions.	N/A	N/A			
WM-3	Shallow surface water and groundwater in March and April support high productivity and diversity of macroinvertebrates as potential food sources to WC in wet meadows.		N/A	N/A			
WM-4	A predominance of organic-rich soils supports the productivity and diversity of macro-invertebrates as potential WC food sources in bottomland grasslands.	Wet meadows and their soils are too complex and variable to allow this individual factor to be effectively assessed.	N/A	N/A			
WM-8a	As the spring depth to groundwater increases, surface soils stay frozen longer. Where groundwater is closer to the surface soils thaw sooner.		N/A	N/A			

[i] Hypothesis Test Results are indicated as one of the following categories:

 Hypothesis answered conclusively – affirmed.

 Hypothesis answered conclusively – rejected.

 Hypothesis not yet answered – ongoing implementation, analysis, and synthesis.

 Not currently being addressed through implementation of the AMP and related data analysis and synthesis.

APPENDIX B

PRRIP Peer Reviewed Papers & Reports

REFEREED PUBLICATIONS

Baasch, D.M, P.D. Farrell, J.M. Farnsworth, and C.B. Smith. 2017. Nest-site selection by Interior Least Terns and Piping Plovers at managed, off-channel sites along the Central Platte River in Nebraska, USA. Journal of Field Ornithology 88:236–249.

Farnsworth, J.M., D.M. Baasch, C.B. Smith, and K.L. Werbylo. 2017. Reproductive ecology of interior least tern and piping plover in relation to Platte River hydrology and sandbar dynamics. Ecology and Evolution 10:3579–3589. doi: 10.1002/ece3.2964.

Farrell P.D., D.M. Baasch, J.M Farnsworth, and C.B. Smith. 2018. Least tern and piping plover nest success and brood survival at off channel sites in the Central Platte River. Avian Conservation and Ecology 13:1. https://doi.org/10.5751/ACE-01133-130101.

Baasch, D.M., P.D. Farrell, J.M. Farnsworth, and C.B. Smith. 2017. Interior least tern productivity in relation to flow in the central Platte River valley. Great Plains Research 27:35–42.

Smith, C.B., J.M. Farnsworth, D.M. Baasch, and J.F. Kenny. 2016. Adaptive Management and Governance Lessons from a Semiarid River Basin: A Platte River Case Study. In: Miller, K.A., Hamlet, A.F., Kenney, D.S., Redmond, K.T. (eds.), Water Policy and Planning in a Variable and Changing Climate: Insights from the Western United States, CRC Press.

Pearse, A.T., M.J. Harner, D.M. Baasch, G.D. Wright, A.J. Caven, and K.L. Metzger. 2016. Evaluation of nocturnal roost and diurnal sites used by whooping cranes in the Great Plains, United States. Open File Report 2016–1209.

Werbylo, K.L., J.M. Farnsworth, D.M. Baasch, and P.D. Farrell. 2016. Investigating the accuracy of estimated unvegetated channel widths in a braided river system: a Platte River case study. Geomorphology 278:163–178. https://doi.org/10.1016/j.geomorph.2016.11.003

Farnsworth, J.M., J.F. Kenny, and C.B. Smith. 2015. Comment on "Progressive abandonment and planform changes of the central Platte River in Nebraska, central USA, over historical timeframes". Geomorphology 250:437–439. https://doi.org/10.1016/j.geomorph.2014.12.014

Pearse, A.T., D.A. Brandt, W.C. Harrell, K.L. Metzger, D.M. Baasch, and Hefley, T.J., 2015, Whooping crane stopover site use intensity within the Great Plains: U.S. Geological Survey Open-File Report 2015–1166, 12 p., http://dx.doi.org/10.3133/ofr20151166.

Baasch, D.M., T.J. Hefley, and S.D. Cahis. 2015. A comparison of breeding population estimators using nest and brood monitoring data. Ecology and Evolution 5:4197–4209. doi: 10.1002/ece3.1680

Hefley, T.J., D.M. Baasch, A.J. Tyre and E.E. Blankenship. 2015. Use of opportunistic sightings and expert knowledge to predict and compare Whooping Crane stopover habitat. Conservation Biology29:1337–1346. doi: 10.1111/cobi.12515

Hefley, T.J., D.M. Baasch, A.J. Tyre, and E.E. Blankenship. 2014. Correction of location errors for species distribution models. Methods in Ecology and Evolution 5:207–214.

Hefley, T.J., A.J. Tyre, D.M. Baasch and E.E. Blankenship. 2013. Non-detection sampling bias in marked presence-only data. Ecology and Evolution 3:5225–5236.

Smith, C.B. 2011. Adaptive management on the central Platte River – science, engineering, and decision analysis to assist in the recovery of four species. Journal of Environmental Management 92:1414–1419.

Smith, C.B. 2009. Active adaptive management on the Platte River. Water Resources IMPACT, Journal of the American Water Resources Association 11:8–10.

PEER REVIEWED SYNTHESIS REPORTS

Executive Director's Office. 2017. Whooping Crane Habitat Synthesis Chapters. Prepared for the Governance Committee of the Platte River Recovery Implementation Program.

Executive Director's Office. 2015. Interior Least Tern and Piping Plover Habitat Synthesis Chapters. Prepared for the Governance Committee of the Platte River Recovery Implementation Program.

APPENDIX C

PRRIP Progress – Land & Water Objectives

Land Objective

The Program's First Increment land objective is to acquire, protect, and restore 10,000 acres of habitat for the three target avian species.

As of 2016, the Program has exceeded the 10,000-acre First Increment land objective by 2,650 acres. Most of the Program's habitat lands are located in blocks referred to as habitat complexes. There are five primary habitat complexes (Cottonwood Ranch, Elm Creek, Pawnee, Fort Kearny, and Shoemaker Island) with additional complex habitat at three other locations (Plum Creek, Minden to Gibbon, and Alda to Grand Island). In addition, the Program manages 645 acres of non-complex lands comprised of four OCSW and two palustrine wetlands sites as well as 25 acres set aside for Clean Water Act compliance. A map of Program properties can be found on page 2 of this report.

Habitat Lands	Number of Acres
Cottonwood Ranch	3,552
Fort Kearny	2,190
Shoemaker Island	1,940
Elm Creek	1,570
Plum Creek	866
Gibbon to Minden	834
Pawnee	742
Alda to Grand Island	286
Total Complex Land	**11,980**
Off-Channel Sand and Water	391
Palustrine Wetlands	254
Total Non-Complex Land	**645**
Clean Water Act Land	**25**
Grand Total	**12,650**

Water Objective

The Program's First Increment water objective is to reduce deficits to USFWS target flows by an average of 130,000 – 150,000 acre-ft annually.

As of 2016, Program water projects reduce deficits to USFWS target flows by an average of 87,120 acre-ft annually. This includes the three original state projects with a total score of 80,000 acre-feet per year (AFY) and the four-scored water action plan (WAP) projects (Phelps County Canal Recharge, Cook Recapture Well, Pathfinder Municipal Lease, and No-Cost Net Controllable Conserved) with a score of 7,120 AFY. Other WAP projects are active but have yet to be scored including Central Nebraska Public Power and Irrigation District surface water and recharge, Nebraska Public Power District recharge, and Elwood Reservoir recharge. It is anticipated that these projects will increase the water project score by approximately 10,000 AFY. A large portion of the remaining First Increment water objective was going to be provided by the J-2 Regulating Reservoir, but this project has been put on hold due to cost, land acquisition and other concerns. Consequently, the water objective will not be met prior to 2019 and Program Signatories have agreed to pursue a 13-year First Increment Extension. Projects to be implemented during the end of the First Increment and during the First Increment Extension include but are not limited to: broad-scale recharge projects, slurry wall storage facilities, and acquire and retire. These projects will be used to achieve a total score of 120,000 AFY. Research will then be conducted to evaluate the need for the remaining 10,000 acres prior to implementation of the projects that would be necessary to achieve the First Increment water objective.

Water Project	Score (AFY)
Three State Projects	80,000
Phelps Co. Canal Recharge	2,700
Cook Recapture Well	260
Pathfinder Municipal Lease	4,000
No-Cost Net Controllable Conserved	260
Total	**87,120**
Other operational WAP projects that have yet to be scored	**~10,000**

ENDNOTES

[1] Program. 2016. Analysis of sandbar height distributions following First Increment peak flow events. Prepared for the Platte River Recovery Implementation Program.
[2] Program. 2015. Least tern and piping plover habitat synthesis chapters. Prepared for the Platte River Recovery Implementation Program.
[3] Bankhead et al. 2016. A combined field, laboratory and numerical study of the forces applied to, and the potential for removal of, bar top vegetation in a braided river. Earth Surface Processes and Landforms, 42(3), 439-459.
[4] Tetra Tech Inc. 2017. 2016 Final Data Analysis Report Platte River Geomorphology and In-Channel Vegetation. Prepared for the Platte River Recovery Implementation Program
[5] Program. 2017. Whooping Crane Data Synthesis Chapters. Prepared for the Platte River Recovery Implementation Program.
[6] Tetra Tech Inc. 2015. Model Results, Platte River Sediment-transport Modeling, South Channel at Jeffery Island. Prepared for the Platte River Recovery Implementation Program.
[7] Program. 2016. Proof-of-Concept Sediment Augmentation Implementation and Effectiveness Analyses Methods. Prepared for the Platte River Recovery Implementation Program.
[8] Pollen-Bankhead et al. 2012. Can Short Duration High Flows be used to Remove Vegetation from Bars in the Central Platte River. Prepared for the Platte River Recovery Implementation Program.
[9] See WEST Report titled Correlates of Whooping Crane Habitat Selection and Trends in Use in the Central Platte River 02-16-16.
[10] See the Whooping Crane Synthesis Chapters 2 and 3.
[11] See PRRIP 2016 Tern and Plover Monitoring Report.
[12] Baasch et al. 2015. A comparison of breeding population estimators using nest and brood monitoring data.
[13] Baasch et al. 2017. Nest-site selection by Interior Least Terns and Piping Plovers at managed, off-channel sites along the Central Platte River in Nebraska, USA.
[14] Sherfy et al. 2012. Foraging Ecology of Least Terns and Piping Plovers Nesting on Central Platte River Sandpits and Sandbars.
[15] Baasch et al. 2017. Interior Least Tern Productivity in Relation to Flow in the Central Platte River.
[16] PRRIP Final Stage Change Study.