ADAPTIVE MANAGEMENT ON THE PLATTE RIVER


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Platte River Recovery Implementation Program
Adaptive Management Plan
2007-2010 Synthesis Report – DRAFT Version 3.0

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PRRIP Adaptive Management Plan 2007-2010 Synthesis Report DRAFT – Version 3.0

What is this document?

The 2007-2010 Synthesis Report is a summary of what we know so far about certain critical scientific uncertainties related to target species and the responses of those species and riverine physical processes to management actions conducted by the Platte River Recovery Implementation Program ("Program" or "PRRIP"). Key uncertainties are presented as Program "big questions", identified in the Program's Adaptive Management Plan (AMP) as broad hypotheses. Information for the questions addressed in this report is presented in a *weight of evidence* approach, with several fine-scale hypotheses and performance measures evaluated and summarized for each question. Where possible, we have provided preliminary answers or conclusions to these questions. The intended audience for this document is the Program's Governance Committee (GC) as a focused transmission of an extensive amount of detailed scientific information in a manner intended to help inform Program decision-making.

Relationship to other AMP-related documents

While the AMP and associated big questions lay a strong foundation for adaptive management, the Program's Independent Scientific Advisory Committee (ISAC) recommended development of additional guidance documents to chart a more robust course through implementation (ISAC, 2009). These documents and others provide the bulk of information related to the application and outcomes of Program science. The following matrix provides a window into the main contents of each AMP-related document. These documents are available on the Program web site (www.PlatteRiverProgram.org) or through the Executive Director's Office (EDO).

AMP Documents Matrix	AMP	Synthesis Report	Annual "State of the Platte" Report	Implementation Plan	Data Analysis Plan	Monitoring & Research Protocols	Annual Monitoring & Research Reports
Priority hypotheses	X						
Tier 1 hypotheses		X	X				X
Critical uncertainties = Big Questions	X	X	X	X	X	X	X
Information hierarchy		X			X		
Experimental design							
Contractor guidance for implementation				X			
Data collection methods						X	
Data analysis methods					X		
Decision analysis tree		X					
Management objectives	X						
Management strategies	X						
Conceptual models	X	X					
Synthesis of data		X					
Annual raw data							X
Annual data analysis			X				

Executive Summary

In 2007, the Platte River Recovery Implementation Program ("Program" or "PRRIP") began its 13-year First Increment and implementation of an Adaptive Management Plan ("AMP") to learn more about the physical processes of the central Platte River and the response of four target species to management actions: interior least tern (*Sterna antillarum*), piping plover (*Charadrius melodus*), whooping crane (*Grus americana*), and pallid sturgeon (*Scaphirhynchus albus*).

The Program designs and implements management actions falling under two broader management strategies: 1) Flow-Sediment-Mechanical ("FSM"), and 2) Mechanical Creation and Maintenance ("MCM"). These strategies represent fundamental differences of opinion about the best way to address species needs in the central Platte and are aimed at both addressing critical uncertainties affecting Program decisions and are the selected methods for meeting several *management objectives*. Those objectives include:

1. Improve production of the least tern and piping plover from the central Platte River.
2. Contribute to the survival of whooping cranes during migration.
3. Avoid adverse impacts from Program actions on pallid sturgeon populations.
4. Within overall objectives 1-3, provide benefits to non-target listed species and non-listed species of concern and reduce the likelihood of future listing.

Activities in 2010 were the fourth year in a 13-year program (2007-2019). It is important to "check in' periodically to evaluate and synthesize Program data and indicate progress toward meeting management objectives and addressing major uncertainties. This report is the first comprehensive synthesis of Program data and serves as a template for future synthesis reviews.

The AMP includes a set of broad hypotheses that are largely statements of the major scientific and technical uncertainties facing the Program. The Program's Technical Advisory Committee ("TAC") held a series of workshops in 2010 to sequence a set of 47 fine-scale priority hypotheses. Through that process, a subset of the broad hypotheses was identified as "Big Questions" that serve as a condensed version of Program critical uncertainties. The ten big questions are:

1) Do terns, plovers, and whooping cranes use Program habitat complexes and/or habitat meeting Program minimum criteria in proportions greater than their availability?

2) What is the relationship between concurrently available riverine and sandpit nesting habitat and tern and plover use and productivity?

3) What is the relationship between availability of riverine nesting habitat meeting Program minimum criteria and tern and plover use and reproductive success?

4) What is the relationship between availability of whooping crane roosting habitat meeting Program minimum criteria and whooping crane use?

5) How does tern, plover, and whooping crane use of the central Platte River relate to overall population recovery objectives?

6) How do short-duration high flows (SDHF), restoring sediment balance, and mechanical channel alterations contribute to the maintenance of channel width and creation of a braided river channel?

7) What is the relationship between SDHF, sediment balance, and tern and plover riverine nesting habitat meeting Program minimum criteria?

8) What is the relationship between SDHF, sediment balance, and whooping crane habitat meeting Program minimum criteria?

9) Have Program water-related activities avoided adverse impacts to pallid sturgeon in the lower Platte River?

10) What uncertainties exist at the end of the First Increment, and how might the Program address those uncertainties in the Second Increment?

The following paragraphs summarize what we know so far about big questions 1-9. Question 10 will be evaluated toward the end of the First Increment. Where feasible, summary performance measures were used in a "strong inference" or "weight of evidence" approach, synthesizing an extensive amount of processed data collected in raw form through numerous monitoring and research efforts. We attempted to provide preliminary answers to questions where possible, linking performance measures to specific hypotheses.

1) Do terns, plovers, and whooping cranes use Program habitat complexes and/or habitat meeting Program minimum criteria in proportions greater than their availability?

The Program will conduct a comprehensive analysis of available habitat in 2011 for terns and plovers and whooping cranes, based on collected data from 2007-2010. The results of this analysis will enable comparisons between all bare sand available for terns and plovers and all open channel available for whooping cranes, all sandbars for tern and plover nesting meeting Program minimum criteria and all channel areas for whooping crane roosting meeting Program minimum criteria, and habitat actually utilized by the target bird species during 2007-2011. The results of this analysis will be reported in early 2012 and will provide the best information to date regarding this question. Habitat availability analysis will be conducted annually starting in 2012, which will provide an annual update for this question.

2) What is the relationship between concurrently available riverine and sandpit nesting habitat and tern and plover use and productivity?

Early indications are that as riverine and sandpit habitat increase, tern and plover use as measured in nesting pairs increases. Increased Program management actions in 2011 and beyond should result in the increased availability of both riverine and sandpit habitat which will provide an opportunity to explore this relationship more thoroughly. Evaluations of productivity in the form of fledge ratios for both species is underway and will add to the knowledge base for this question. More years of monitoring are required to more completely address this question.

3) What is the relationship between availability of riverine nesting habitat meeting Program minimum criteria and tern and plover use and reproductive success?

The number of tern and plover pairs and metrics of reproductive success (fledge ratio, nest success, etc.) will be paired with the results of the habitat availability analyses described in big question #1 above starting in 2011 to evaluate tern and plover response to habitat availability.

4) What is the relationship between availability of whooping crane roosting habitat meeting Program minimum criteria and whooping crane use?

The number of whooping cranes utilizing the channel in the central Platte will be paired with the results of the habitat availability analyses described in big question #1 above starting in 2011 to evaluate whooping crane response to habitat availability.

5) How does tern, plover, and whooping crane use of the central Platte River relate to overall population recovery objectives?

For terns and plovers, banding is imperative to identify individual birds and track movements between river systems like the central Platte, lower Platte, Loup, Niobrara, and Missouri and beyond. Program-sponsored banding efforts that began in 2009 and observations made during 2010 revealed fidelity and migration/winter-ground survival rates of at least 50% (5 of 10 returned) and 9% (3 of 25 returned) for adult and juvenile plovers banded on the central Platte River, respectively. One plover banded as a chick on the Platte River during 2009 was observed on the Loup River during 2010. Thus, we know at least 12% (4 of 25) of the plovers banded on the central Platte as chicks during 2009 survived migration and over-wintering. In 2010, we observed 1.28 tern fledglings/pair and 1.86 plover fledglings/pair which is believed to be a high enough reproductive rate to sustain and even grow the population of terns and plovers on the central Platte River.

The Program provided partial funding for a range-wide whooping crane telemetry project that began in 2009. Only a small number of cranes have been radio-tagged and the data from the first two years of field efforts will be analyzed in late 2011. Continued funding of this project and analysis of data for use of the central Platte River by radio-tagged birds should provide valuable information about whooping crane use of the central Platte as well as how that use relates to the health of the overall whooping crane population.

6) How do short-duration high flows (SDHF), restoring sediment balance, and mechanical channel alterations contribute to the maintenance of channel width and creation of a braided river channel?

Sediment augmentation will begin in 2011 with a pilot-scale management action. Depending on water availability, the status of Program water projects, and the effects of anticipated high flows through much of 2011, implementation of the first SDHF might occur in 2012. Mechanical actions to widen the channel have been implemented at only one Program complex (Cottonwood Ranch), though additional mechanical actions are planned for the Elm Creek Complex in 2011. Thus, this question largely cannot be addressed until the full suite of Program management actions are implemented simultaneously at one or more Program complexes.

The FSM "proof of concept" experiment at the Elm Creek Complex, scheduled to begin in 2011, will be the first and only full-scale test at this point of the physical process results of a simultaneous SDHF, sediment balance, and flow consolidation and the species responses to the presence or absence of subsequent habitat creation and maintenance. The Program will host an experimental design workshop with the Independent Scientific Advisory Committee (ISAC) in July 2011 to develop a comprehensive design for island building, other mechanical actions in the channel, modeling, monitoring, and other associated activities at Elm Creek. Several years of monitoring and data analysis at this site will be required to fully understand the impacts of FSM implementation on physical processes and species at the Elm Creek Complex. Ideally, one or more replicates of this design would be implemented at other Program complexes.

The only Program research completed to this point with bearing on this question is the Directed Vegetation Research. Results of that project suggest SDHF as currently envisioned (8,000 cfs at Overton for three days) would only be able to remove cottonwood and willow seedlings the same year as seedling germination. Older plants can likely not be removed by scour and drag alone, thus requiring mechanical removal. This will have to factor into planning for implementation of SDHF from 2012-2019. Additional research on lateral scour is anticipated to determine the importance of undercutting vegetation as a removal mechanism.

7) What is the relationship between SDHF, sediment balance, and tern and plover riverine nesting habitat meeting Program minimum criteria?

This question will be evaluated as the management actions (SDHF and sediment balance) are implemented concurrently and sites evaluated for the response of metrics like sandbar height to flows and sediment. The FSM "proof of concept" experiment at the Elm Creek Complex, scheduled to begin in 2011, will be the first and only full-scale test at this point of the physical process results of a simultaneous SDHF, sediment balance, and flow consolidation and the tern and plover response to the presence or absence of subsequent habitat creation and maintenance. This experiment will provide an initial window into the interaction of management actions, physical processes, and species response, though the relationships will have to be evaluated over several years of implementation.

8) What is the relationship between SDHF, sediment balance, and whooping crane habitat meeting Program minimum criteria?

This question will be evaluated as the management actions (SDHF and sediment balance) are implemented concurrently and sites evaluated for the response of metrics like wetted width to flows and sediment. The FSM "proof of concept" experiment at the Elm Creek Complex, scheduled to begin in 2011, will be the first and only full-scale test at this point of the physical process results of a simultaneous SDHF, sediment balance, and flow consolidation and the whooping crane response to the presence or absence of subsequent habitat creation and maintenance. This experiment will provide an initial window into the interaction of management actions, physical processes, and species response, though the relationships will have to be evaluated over several years of implementation.

9) Have Program water-related activities avoided adverse impacts to pallid sturgeon in the lower Platte River?

Early indications are that Program water-related activities will not adversely impact pallid sturgeon in the lower Platte River based on the results of the Program's stage change study. However, given that the stage change study suggests short-term connectivity could be problematic under certain but infrequent hydrological conditions and assuming the biological significance of habitat connection for pallid sturgeon above 4,000 cfs, the study tool could be used by the Program to implement proactive measures (e.g. altering excess-to-target-flow diversion timing or duration) to prevent potential negative impacts on habitat connectivity. Use of the tool for this purpose would be greatly enhanced if additional data were collected and analyzed regarding what defines pallid sturgeon habitat in the lower Platte and how that habitat is being utilized. The stage change study will be peer reviewed in 2011 and the results of that review will be discussed with the GC before considering further action regarding this question.

10) What uncertainties exist at the end of the First Increment, and how might the Program address those uncertainties in the Second Increment?

This question will be addressed in the final Synthesis Report at the end of the First Increment. The answer will be based on the totality of science learning that occurred during the First Increment and progress made toward addressing the other critical uncertainties listed above.

Conclusions

Four years into the Program there are insufficient data to conclusively answer any of the big questions. Major management actions such as SDHF and sediment augmentation have not yet been implemented. However, five Program land complexes are assembled or nearly complete and major management actions are anticipated to begin in 2011. Several species and physical process monitoring protocols have been or are being refined to ensure they provide the most relevant data to address Tier 1 hypotheses and the big questions. The lag time in physical process results from management actions and the subsequent species responses dictates that many more years of implementation, monitoring, and analysis are required to better address all of the big questions.

There are no **red** warning flags thus far in the Program. Some **yellow** warning flags are evident based on the results of early Program monitoring and focused investigations:

- Initial vegetation research suggests that SDHF will have limited ability to scour vegetation as previously assumed in the development of the FSM management strategy. SDHF will still be implemented, but the role of water versus mechanical actions in removal of vegetation requires further investigation.
- Modeling conducted during the Sediment Augmentation Feasibility Analysis pointed to a smaller sediment deficit (152,000 tons/year) than that considered in development of the Program's Environmental Impact Statement and Final Document (185,000-225,000 tons/year). However, none of the options explored for augmenting sediment result in an annual full contribution of the 152,000 tons/year. This will require careful examination of

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1.0 Introduction & Background

The Program initiated on January 1, 2007 and is the result of a Cooperative Agreement negotiating process that started in 1997 between the states of Colorado, Wyoming, and Nebraska; the Department of Interior; water users; and conservation groups. The Program is intended to address issues related to the Endangered Species Act (ESA) and loss of habitat in the river in central Nebraska (see Figure 1) by managing certain land and water resources following the principles of adaptive management to provide benefits for four "target species": the endangered whooping crane (Grus americana), interior least tern (Sterna antillarum), and pallid sturgeon (Scaphirhynchus albus); and the threatened piping plover (Charadrius melodus). The Program is led by a Governance Committee that is assisted by several standing Advisory Committees as well as an Executive Director (ED) and staff. The Program's 13-year First Increment began in 2007. The Program is estimated, in 2005 dollars, to cost roughly $320 million, with the monetary portion of that being $187 million; the total cost of the Program in terms of cash, water, and land will be shared equally between the federal government and the states.

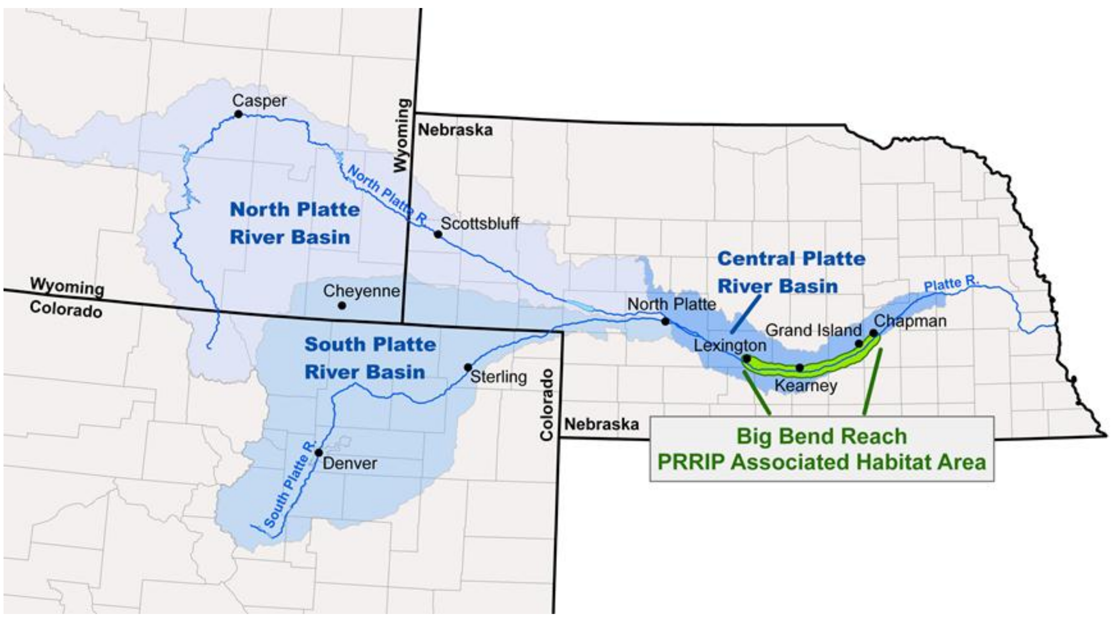


Figure 1.1 Platte River basin and PRRIP associated habitats.

The Program is to be implemented in increments, with the First Increment extending through 2019. The First Increment objectives set measurable and easily-identifiable milestones for water and land resources at the Program's disposal:

1) Reduce shortages to target flows by an average of 130,000 to 150,000 acre-feet per year at Grand Island, through reregulation and water conservation/supply projects.
2) Protect, restore where appropriate, and maintain at least 10,000 acres of habitat in the central Platte River area between Lexington and Chapman, Nebraska.

These milestones define the Program's land and water "boxes". Management objectives serve as the desired outcomes of implementation of the two management strategies (Table 1.1) identified in the AMP.

PRRIP management strategies and actions	
Strategy #1 ***Flow-Sediment-Mechanical Strategy*** ***("Clear/Level/Pulse" or "FSM")*** This strategy attempts to rehabilitate the Platte River toward braided channel morphology as the underpinnings of restoring habitat for key management species. • Create and maintain where possible a wide braided channel with a high width/depth ratio. • Offset the existing sediment imbalance by increasing sediment inputs to the habitat area. • Use the Environmental Account (EA) and other Program water to create annual peaks as large as can be sustained over many years.	***Management Actions*** • **Flow Management Action –** Using EA water and the ability of the Program to deliver 5,000 cfs of Program water at Overton, generate short-duration near bankfull flows in the habitat reach in the spring or at other times outside of the main irrigation season; includes pulse flows of EA water and flexibility in canal and reservoir system operations. • **Sediment Augmentation Management Action –** Sediment is mechanically placed into the river at a rate that will eliminate the sediment deficiency and restore a balance sediment budget; includes pushing sand into the river from banks, islands, and out-of-bank areas. • **Mechanical Management Action –** To increase the acreage of channel area greater than 750 feet wide by 30% over the 1998 baseline conditions for the study area, and restore channel habitat toward Land Plan Table 1 characteristics; includes consolidating flow and river channels, cutting banks and lowering islands, and clearing vegetation off islands and banks.
Strategy #2 ***Mechanical Creation and Maintenance Approach*** ***("Clear/Level/Plow" or "MCM")*** This strategy attempts to achieve similar management objectives by mechanical creation and maintenance of habitat for target species, which may or may not depend on the Platte River. • Improve least tern and piping plover production by management of sandpits and riverine islands developed and maintained by mechanical and other means (e.g., herbicides, grazing, burning) without the need for pulse flows. • Improve survival of whooping cranes by providing non-riverine wetlands, upland habitats, and open channel habitats maintained with mechanical and other means without the need for pulse flows.	***Management Actions*** • **Sandpit Management Action –** To increase the amount of nesting habitat available to least terns and piping plovers the Program will acquire 200 acres of sandpits that will include at least 40 acres of bare sand; includes application of predator management techniques. • **Restore, Create, and Maintain Bare Sand Riverine Island and Channel Width Management Action –** Islands will be created using the same methods as in FSM except for EA augmented pulses, and channels of 750 feet wide will be created and maintained using mechanical means similar to methods in FSM except for released pulses; includes mechanical maintenance and predator management. • **Create and Maintain Inundated Wetlands and Upland Areas Management Action –** Each 0.5 miles of linear wetlands (sloughs, backwater) constructed on Program lands will include at least one area that has a shallow water area with a minimum water surface area of 500 feet by 500 feet; Program acquired agricultural fields not previously wetlands should be planted to corn; the Program will utilize the remaining 400 acres of non-complex land to create 300 acres of palustrine wetlands.

Table 1.1 Adaptive Management Plan management strategies and associated management actions that will be implemented on the ground in the central Platte River

1.1 Experimental Design

The Program has developed a set of experimental actions that will allow for the collection of data relevant to the most important hypotheses and uncertainties. In short, the management actions outlined in the AM Plan for the two management strategies will be applied in three general experimental categories:

Bird response – On Program lands throughout the 90-mile study area, an effort will be made to let the bird target species – least terns, piping plovers, and whooping cranes – tell the Program what habitat is most appealing on the central Platte River through habitat selection studies (e.g. sandbar elevation, sandbar area, distance to trees, channel width, etc.). These studies are paired with annual, intensive occurrence and productivity monitoring. For terns and plovers, islands of different elevations, sizes, and other parameters will be constructed and bird use will be monitored to determine selection through a multi-model inference framework. For whooping cranes, parameters will include channel and unobstructed-view widths and management actions will include widening the channel and removing trees.

Paired design – A feature of the central Platte River landscape is sandpits, which provide broad expanses of clean sand for nesting terns and plovers off the main channel. At each location where the Program constructs in-channel nesting islands, the Program will also construct new or manage existing off-channel nesting habitat to evaluate differences in productivity. The paired design will provide insight as to whether terns and plovers select or are more productive on one type of habitat versus the other.

Flow-Sediment-Mechanical "Proof of Concept" – The flow-sediment-mechanical strategy includes flow releases, sediment augmentation, and a need to consolidate flow into a single channel to increase stream power. The difficulty of implementing these actions, particularly flow consolidation, makes it difficult to implement this strategy and extract useful data. For example, flow consolidation is likely to entail the movement of material in or around the channel, thus requiring a permit, and downstream landowners are concerned about any flow diversions upstream. There is, however, one location on the river adjacent to an existing Program habitat complex with existing consolidation because old dike structures exist on the banks. Experimental actions at this location will include leveling macroforms in the channel to a pre-determined elevation as well as augmenting flow and sediment to determine the extent of sandbar formation and maintenance, vegetation control, channel width, and other parameters. Implementing research in this reach of river will help determine whether hypothesized sandbar heights or vegetation changes occur with this management strategy.

2.0 Uncertainties

2.1 Big Questions

This Synthesis Report addresses major Program scientific and technical uncertainties identified as "broad hypotheses" on Pages 14-17 of the AMP. Through several hypothesis-sequencing workshops in 2010 and internal evaluation, the EDO condensed the longer list of broad hypotheses into a set of ten "Big Questions" that represent uncertainties related to target species use of the central Platte River, Program implementation and target species response, and assessing the results of management actions during the First Increment. Additional questions and uncertainties may enter the mix during the First Increment, but the list of questions in Table 2.1 provides a template for linking specific hypotheses and performance measures to management objectives and the overall goals of the Program.

Big Questions = What we don't know but want to learn
Target Species Use
1) Do terns, plovers, and whooping cranes use Program habitat complexes and/or habitat meeting Program minimum criteria in proportions greater than their availability?
2) What is the relationship between concurrently available riverine and sandpit nesting habitat and tern and plover use and productivity?
3) What is the relationship between availability of riverine nesting habitat meeting Program minimum criteria and tern and plover use and reproductive success?
4) What is the relationship between availability of whooping crane roosting habitat meeting Program minimum criteria and whooping crane use?
5) How does tern, plover, and whooping crane use of the central Platte River relate to overall population recovery objectives?
Physical Processes, Management Actions, & Species Response
6) How do short-duration high flows (SDHF), restoring sediment balance, and mechanical channel alterations contribute to the maintenance of channel width and creation of a braided river channel?
7) What is the relationship between SDHF, sediment balance, and tern and plover riverine nesting habitat meeting Program minimum criteria?
8) What is the relationship between SDHF, sediment balance, and whooping crane habitat meeting Program minimum criteria?
9) Have Program water-related activities avoided adverse impacts to pallid sturgeon in the lower Platte River?
Next Steps
10) What uncertainties exist at the end of the First Increment, and how might the Program address those uncertainties in the Second Increment?

Table 2.1 The Program's "Big Questions". These questions represent critical uncertainties about Program target species, physical processes, and the response of target species to management actions that will be the focus of the application of rigorous adaptive management in the First Increment. These Big Questions are generally based on statements of broad hypotheses on pages 14-17 of the AMP. These questions are a subset of those broad hypotheses; the subset was identified through a series of Technical Advisory Committee workshops in 2010 that focused on sequencing Program hypotheses and through subsequent development of this Synthesis Report.

The remainder of this report addresses what we know so far about these big questions and information is presented according to uncertainties grouped in the following manner: tern and plover; whooping crane; and physical process/management action.

2.2 Tern and Plover Uncertainties

Several big questions address tern and plover use of the central Platte and the response of both species to Program management actions. Those uncertainties emanate from the tern and plover conceptual model drafted by Program participants in the AMP and recently revised by the Technical Advisory Committee and EDO (Figure 2.1).

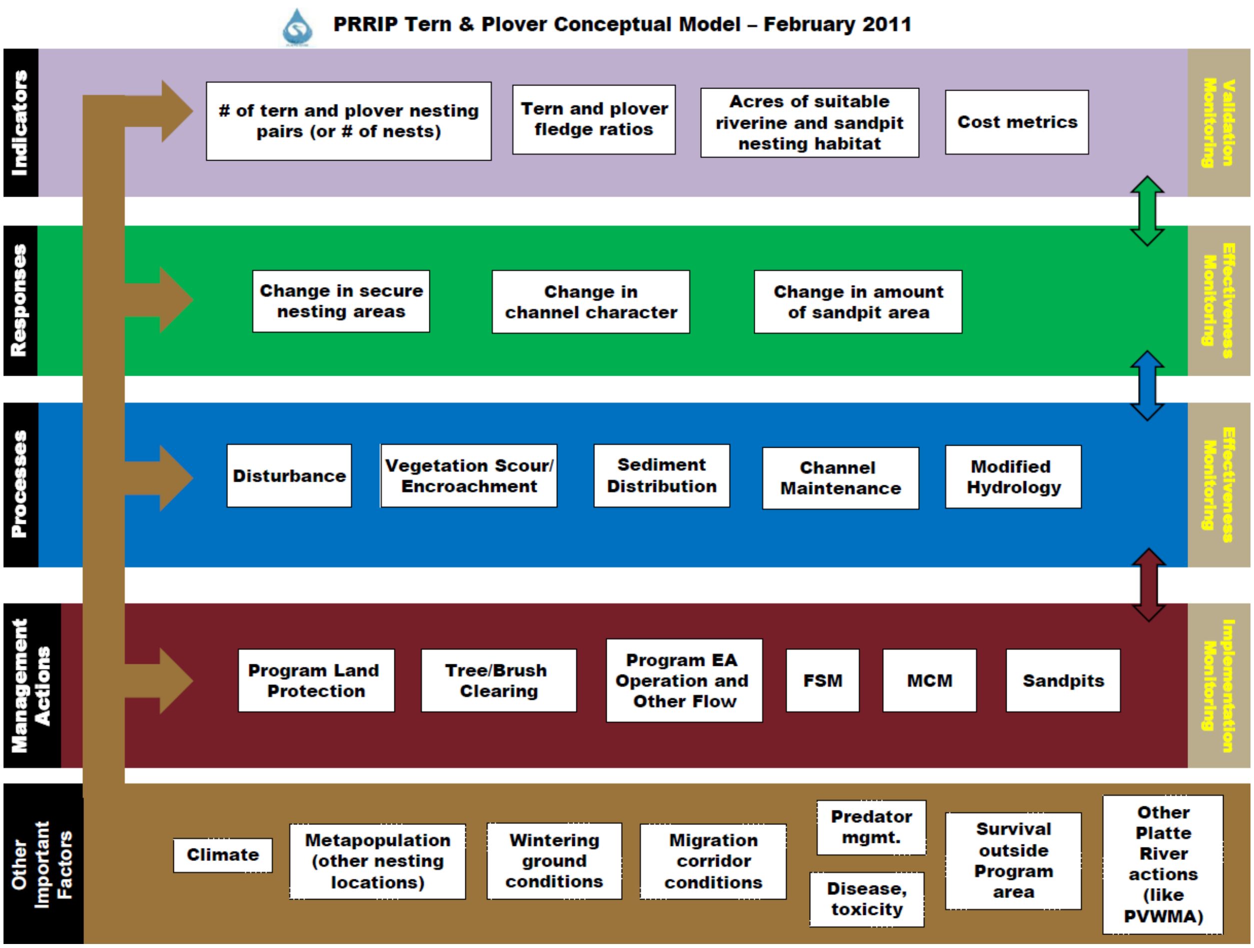


Figure 2.1 PRRIP tern & plover conceptual model. The model was developed during the Cooperative Agreement process and was revised by PRRIP workshop participants and the EDO. The model presents conceptual tern& plover responses to **various PRRIP management actions.** Implementation of these actions will result in certain **geomorphic and riverine processes** that will in turn result in **habitat responses** leading to **indicators of hypothesized tern & plover responses.** **Factors in brown on the bottom row** are beyond the control of the Program but are likely to have significant effects on management actions, processes, responses, and tern & plover indicators. These "other" factors will be operating concurrently with Program actions generating cumulative and likely confounding effects; to the extent possible, AMP experimental design and monitoring efforts will have to account for these factors and provide spatial and temporal controls to create contrast.

The conceptual model is a visual framework representing hypothetical relationships between Program management actions, riverine processes, and tern and plover response to those actions and processes. Because the conceptual model is conjecture, significant uncertainty exists regarding linkages between the layers of the model. Those uncertainties are stated as broad hypotheses in the AMP and as big questions in this Synthesis Report. As the big questions are explored and answered, the tern and plover conceptual model can be updated and improved to represent the latest understanding of the relationships it represents.

In addition, the "Indicators" listed in the top line of the conceptual model are addressed later in this Synthesis Report as performance measures linked to specific hypotheses. Some hypotheses are also addressed with additional performance measures, but the indicators from the conceptual model form the basic set of metrics to assess hypotheses and big questions and will afford another opportunity to refine the model during the First Increment.

The four tern and plover big questions are:

- **Big Question #1** – Do terns and plovers use Program habitat complexes and/or habitat meeting Program minimum criteria in proportions greater than their availability?
- **Big Question #2** – What is the relationship between concurrently available riverine and sandpit nesting habitat to tern and plover use and productivity?
- **Big Question #3** – What is the relationship between availability of riverine nesting habitat meeting Program minimum criteria and tern and plover use and reproductive success?
- **Big Question #5** – How does tern and plover use of the central Platte River relate to overall population recovery objectives?

2.2.1 Tier 1 Tern and Plover Hypotheses

The AMP contains nine priority hypotheses related to terns and plovers. In 2010, the Technical Advisory Committee (TAC) conducted a hypothesis sequencing workshop and narrowed that list down to four "Tier 1" hypotheses that will be the initial focus of attention through adaptive management implementation during the First Increment. Three of those Tier 1 hypotheses relate to tern and plover use of the central Platte and the potential response of both species to increased habitat. The fourth hypothesis (TP5) is more directly related to channel characteristics linked to management actions and is addressed in Section 2.4 below (Physical Process/Management Action Uncertainties). No Tier 1 hypotheses have been identified for Big Question #5, but data collected for the other Tier 1 hypotheses and big questions and through annual implementation of the Program's tern and plover monitoring protocol can be analyzed to provide insight into this question.

During the hypothesis sequencing workshop, the TAC identified several performance measures for each Tier 1 hypothesis that can be used to "test" the hypotheses. Most of the performance measures are also included in the tern and plover conceptual model. Generally, these performance measures are metrics tied to target species ecology (tern and plover fledge ratios, number of nests, etc.) and habitat characteristics of interest (acreage of sandbars or sandpits, etc.). The conceptual model indicator of "cost metrics" is addressed in Section 5.0 of this Synthesis Report (decision analysis tree). The AMP includes an X-Y graph for each hypothesis that visualizes the projected relationship and suggests additional performance measures. Table 2.2 below summarizes the candidate performance measures for each Tier 1 hypothesis, associated benchmarks to indicate significant responses, the projected timeline for seeing a response, and issues that still need to be resolved or investigated as the hypothesis is tested.

Tier 1 hypothesis	Performance measures	Benchmarks	Time to detect response	Issues to be resolved
T1: Additional bare sand habitat will increase the number of adult least terns.	**Birds** = # of nesting pairs **Sandbars** = acres of suitable habitat **Sandpits** = acres of suitable habitat	For every increase of 1.5 acres in habitat, expect increase of one nesting pair	Expect nesting response to new habitat 1-2 years after creation	Validity of benchmark Habitat analysis in 2011 to determine more accurate acreage numbers
P1: Additional bare sand habitat will increase the number of adult piping plovers.	**Birds** = # of nesting pairs **Sandbars** = acres of suitable habitat **Sandpits** = acres of suitable habitat	For every increase of 5-6 acres in habitat, expect increase of one nesting pair	Expect nesting response to new habitat 1-2 years after creation	Validity of benchmark Habitat analysis in 2011 to determine more accurate acreage numbers
TP1: Interaction of river and sandpit habitat.	**Birds** = # of nesting pairs **Birds** = fledge ratios **Sandbars** = acres of suitable habitat **Sandpits** = acres of suitable habitat	For every increase of 1.5 acres (terns) and 5-6 acres (plovers) in habitat, expect increase of one nesting pair **Discuss fledge ratios**	Expect nesting response to new habitat 1-2 years after creation Fledge ratios calculated annually so can detect change quickly	Validity of benchmark Habitat analysis in 2011 to determine more accurate acreage numbers Fledge ratio benchmarks = tied to recovery plans?

Table 2.2 Tier 1 tern and plover hypotheses. These hypotheses will receive priority attention in the First Increment and the performance measures listed in the table will be analyzed to help assess both the specific hypotheses and the associated big questions.

2.2.2 Information Hierarchy

Figure 2.2 below presents a schematic representation of the flow of information between Tier 1 hypotheses, the tern and plover management objective in the AMP, big questions, and the relevant portion of the overall Program goal. In addition, this schematic links in the Program's minimum habitat criteria for tern and plover habitat on the river and on sandpits. These minimum criteria were developed by the TAC in 2008 to help define tern and plover "habitat" for annual acreage calculations and other purposes. These criteria are also utilized in the phrasing of the big questions to provide a clear statement of what the Program means by tern and plover "habitat" and how habitat is calculated and analyzed.

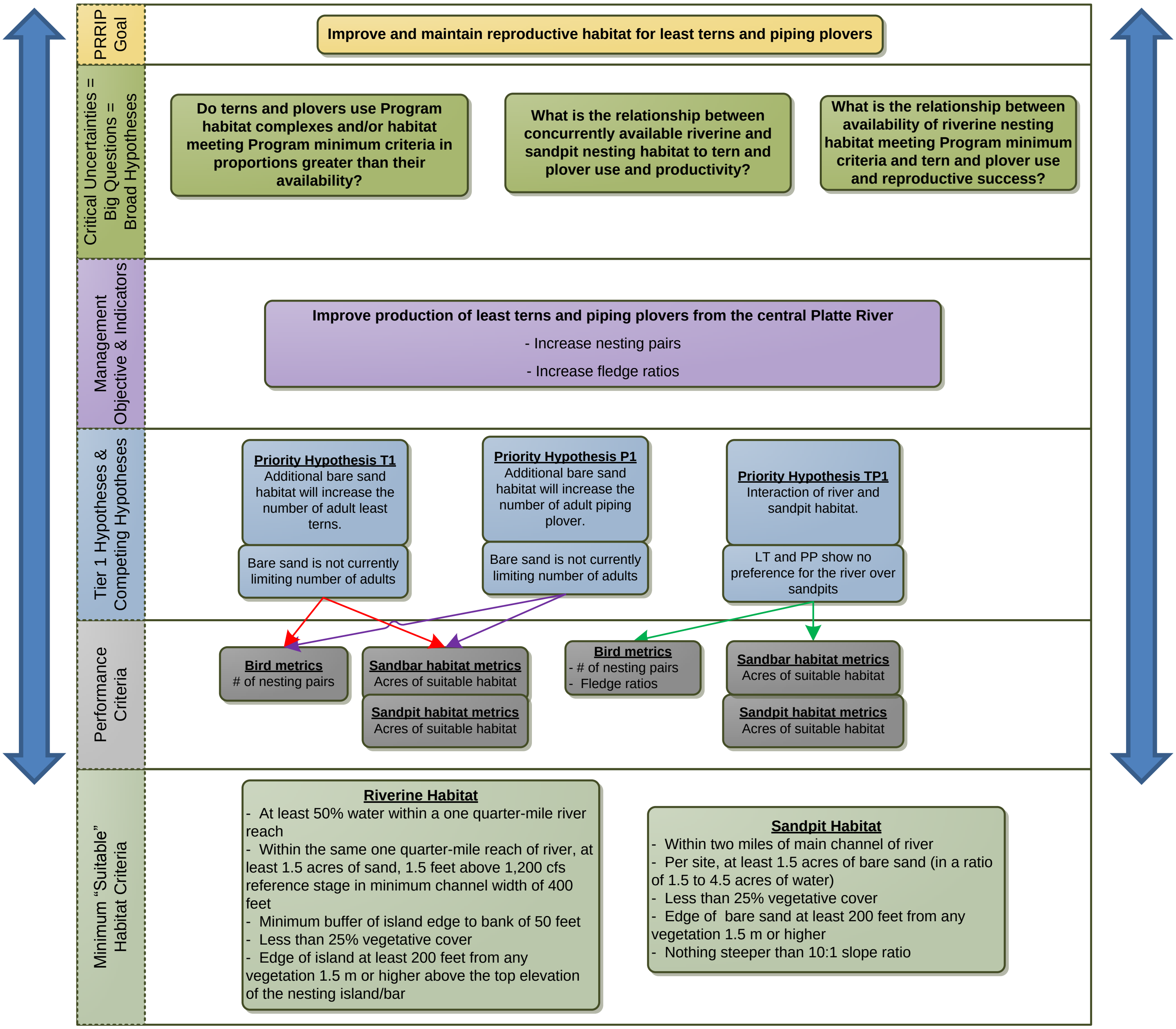


Figure 2.2 Information hierarchy related to critical tern and plover uncertainties. This schematic is provided to represent the flow of information back and forth between Tier 1 tern and plover hypotheses and related uncertainties, objectives, and goals.

2.3 Whooping Crane Uncertainties

Several big questions address whooping crane use of the central Platte and the response of whooping cranes to Program management actions. Those uncertainties emanate from the whooping crane conceptual model drafted by Program participants in the AMP and recently revised by the Technical Advisory Committee and EDO (Figure 2.2).

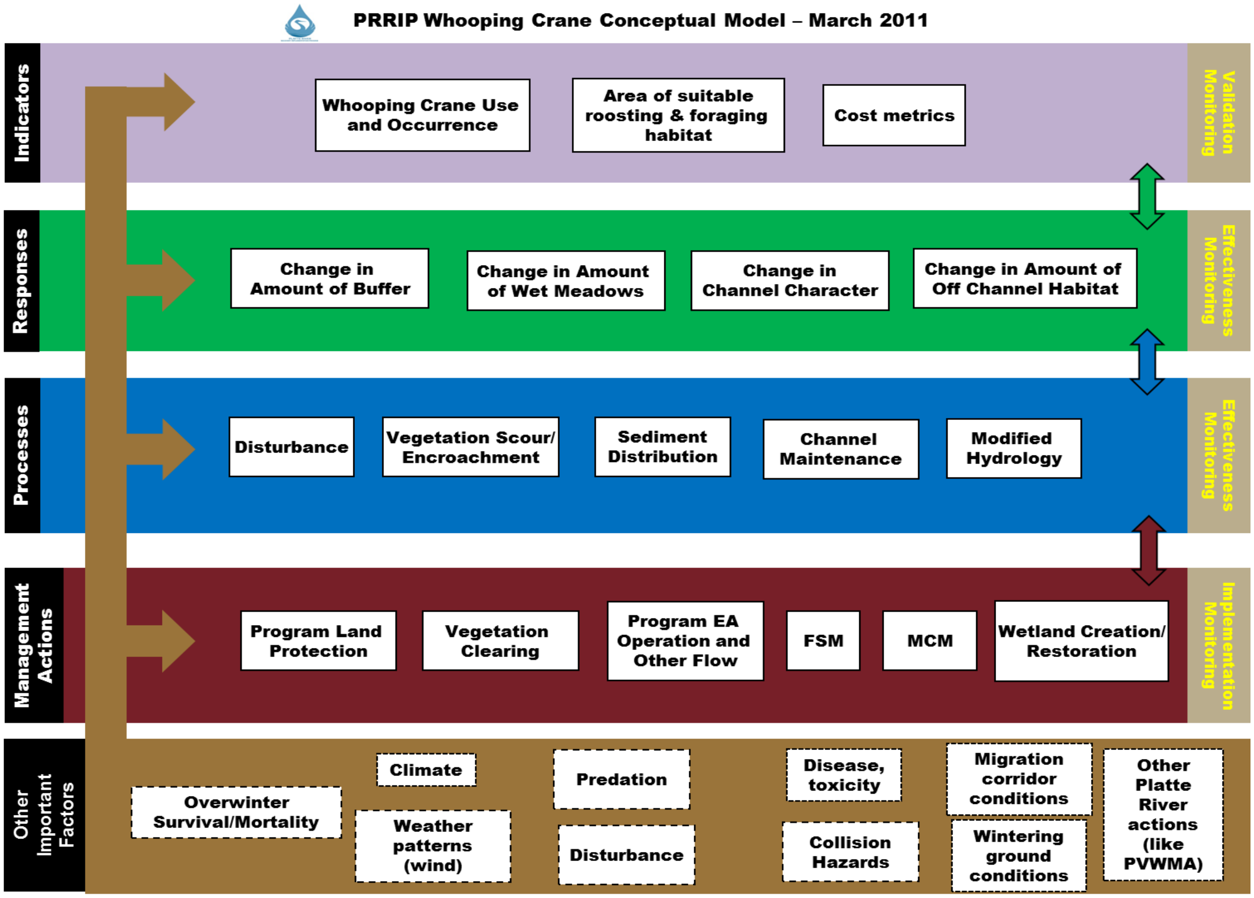


Figure 2.3 PRRIP whooping crane conceptual model. The model was developed during the Cooperative Agreement process and was revised by PRRIP workshop participants and the EDO. The model presents conceptual whooping crane responses to **various PRRIP management actions.** Implementation of these actions will result in certain **geomorphic and riverine processes** that will in turn result in **habitat responses** leading to **indicators of hypothesized whopping crane responses.** **Factors in brown on the bottom row** are beyond the control of the Program but are likely to have significant effects on management actions, processes, responses, and whooping crane indicators. These "other" factors will be operating concurrently with Program actions generating cumulative and likely confounding effects; to the extent possible, AMP experimental design and monitoring efforts will have to account for these factors and provide spatial and temporal controls to create contrast.

The conceptual model is a visual framework representing hypothetical relationships between Program management actions, riverine processes, and whooping crane response to those actions and processes. Because the conceptual model is conjecture, significant uncertainty exists regarding linkages between the layers of the model. Those uncertainties are stated as broad hypotheses in the AMP and as big questions in this Synthesis Report. As the big questions are explored and answered, the whooping crane conceptual model can be updated and improved to represent the latest understanding of the relationships it represents. In addition, the "Indicators" listed in the top line of the conceptual model are addressed later in this Synthesis Report as performance measures linked to specific hypotheses. Some hypotheses are also addressed with additional performance measures, but the indicators from the conceptual model form the basic set of metrics to assess hypotheses and big questions and will afford another opportunity to refine the model during the First Increment.

The three whooping crane big questions are:

- **Big Question #1** – Do whooping cranes use Program habitat complexes and/or habitat meeting Program minimum criteria in proportions greater than their availability?
- **Big Question #4** – What is the relationship between availability of whooping crane roosting habitat meeting Program minimum criteria and whooping crane use?
- **Big Question #5** – How does whooping crane use of the central Platte River relate to overall population recovery objectives?

2.3.1 Tier 1 Whooping Crane Hypotheses

The AMP contains four priority hypotheses related to terns and plovers. In 2010, the Technical Advisory Committee (TAC) conducted a hypothesis sequencing workshop and narrowed that list down to two "Tier 1" hypotheses that will be the initial focus of attention through adaptive management implementation during the First Increment. Both Tier 1 hypotheses relate to whooping crane use of the central Platte and the potential response of whooping cranes to increased habitat. No Tier 1 hypotheses have been identified for Big Question #5, but data collected for the other Tier 1 hypotheses and big questions and through annual implementation of the Program's whooping crane monitoring protocol can be analyzed to provide insight into this question.

During the hypothesis sequencing workshop, the TAC identified several performance measures for each Tier 1 hypothesis that can be used to "test" the hypotheses. Most of the performance measures are also included in the whooping crane conceptual model. Generally, these performance measures are metrics tied to target species ecology (# of use days) and habitat characteristics of interest (average depth, average wetted width, etc.). The conceptual model indicator of "cost metrics" is addressed in Section 5.0 of this Synthesis Report (decision analysis tree). The AMP includes an X-Y graph for each hypothesis that visualizes the projected relationship and suggests additional performance measures. Table 2.3 below summarizes the candidate performance measures for each Tier 1 hypothesis, associated benchmarks to indicate significant responses, the projected timeline for seeing a response, and issues that still need to be resolved or investigated as the hypothesis is tested.

Tier 1 hypothesis	Performance measures	Benchmarks	Time to detect response	Issues to be resolved
WC-1: Whooping crane use will increase as a function of Program land and water management activities.	**Birds** = # use days **Habitat** = area of suitable channel habitat	Greater than 50% of riverine crane use days in central Platte on sites meeting minimum Program criteria	Expect to see annual response in crane use	Validity of benchmark Habitat analysis in 2011 to determine more accurate acreage numbers
WC-3: Whooping crane use is related to habitat suitability. The prediction of habitat suitability for whooping crane is channel habitat as a function of water depth (preferred depth?) and channel width (define as wetted width, open width, other?).	**Birds** = # of use days **Depth** = average depth at use sites **Wetted channel width** = average wetted width at use sites	Greater than 50% of riverine crane use days in central Platte on sites 750-1,000 feet wide and less than 1 foot deep	Expect to see annual response in crane use	Validity of benchmark Habitat analysis in 2011 to determine more accurate acreage numbers

Table 2.3 Tier 1 whooping crane hypotheses. These hypotheses will receive priority attention in the First Increment and the performance measures listed in the table will be analyzed to help assess both the specific hypotheses and the associated big questions.

2.3.2 Information Hierarchy

Figure 2.3 below presents a schematic representation of the flow of information between Tier 1 hypotheses, the whooping crane management objective in the AMP, big questions, and the relevant portion of the overall Program goal. In addition, this schematic links in the Program's minimum habitat criteria for in-channel whooping crane habitat. These minimum criteria were developed by the TAC in 2008 to help define whooping crane "habitat" for annual availability calculations and other purposes. These criteria are also utilized in the phrasing of the big questions to provide a clear statement of what the Program means by whooping crane "habitat" and how habitat is calculated and analyzed.

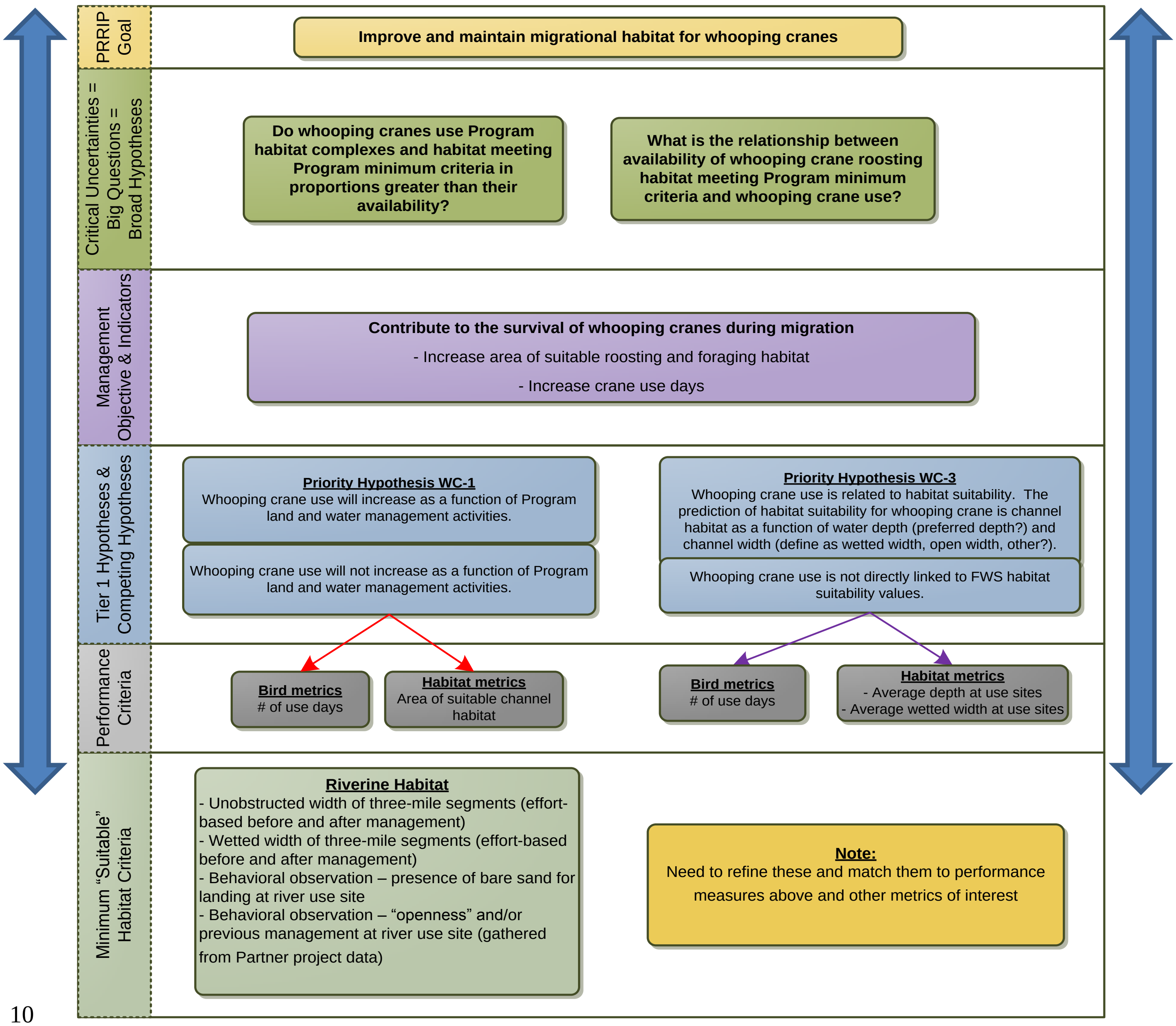


Figure 2.4 Information hierarchy related to whooping crane uncertainties. This schematic is provided to represent the flow of information back and forth between Tier 1 whooping crane hypotheses and related uncertainties, objectives, and goals.

2.4 Physical Process/Management Action Uncertainties

Several big questions address physical processes on the central Platte and the response of the target species to those processes and Program management actions. Those uncertainties largely emanate from the Flow-Sediment-Mechanical ("FSM") conceptual model drafted by Program participants in the AMP and recently revised by the Technical Advisory Committee and EDO (Figure 2.3). Learning related to physical processes on the central Platte will be linked to uncertainties in the FSM conceptual model as well as to species-specific uncertainties in the tern and plover and whooping crane conceptual models.

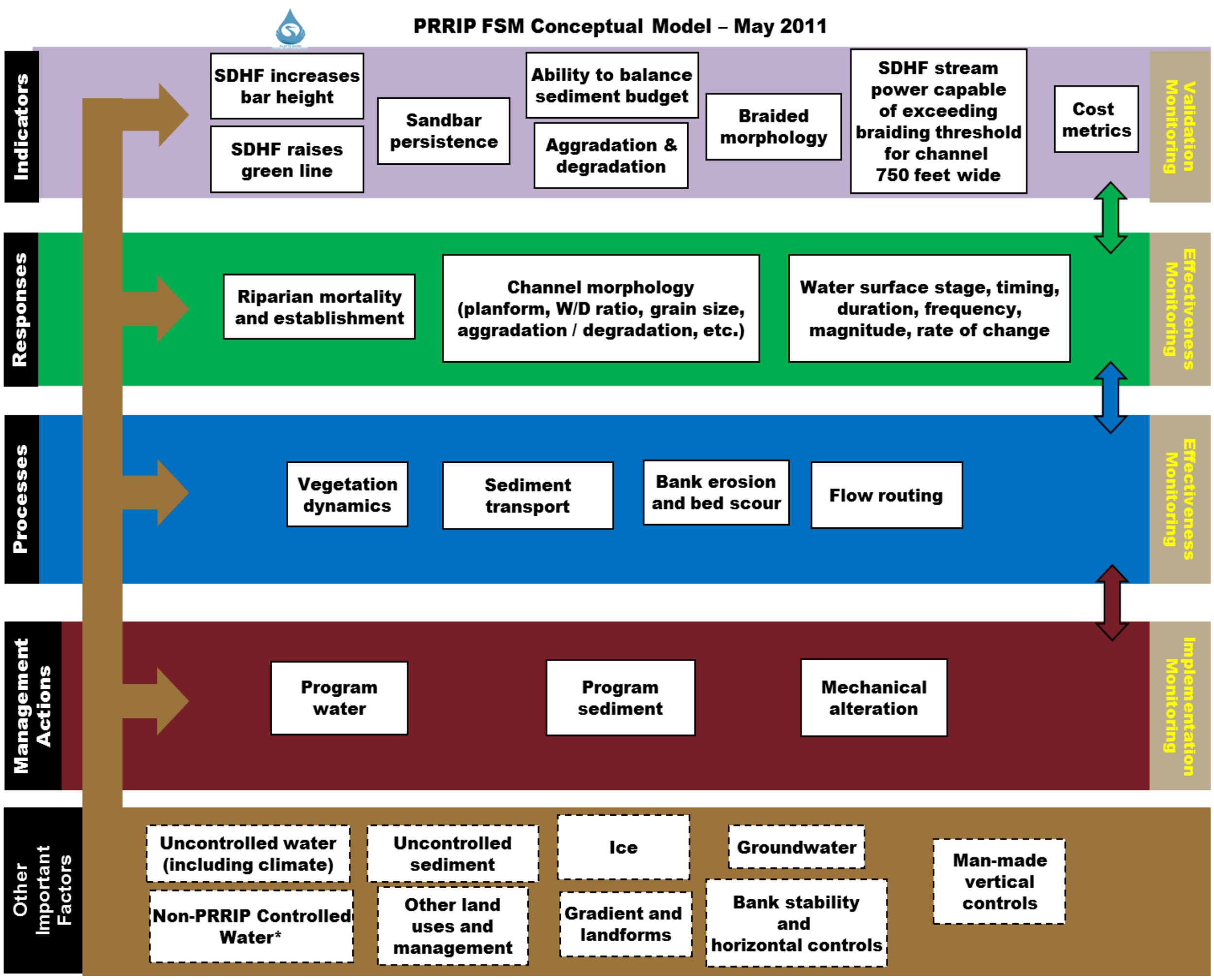


Figure 2.5 PRRIP FSM conceptual model. The model was developed during the Cooperative Agreement process and was revised by PRRIP workshop participants and the EDO. The model presents conceptual central Platte River responses to **various PRRIP management actions.** Implementation of these actions will result in certain **geomorphic and riverine processes** that will in turn result in **habitat responses** leading to **indicators of hypothesized river responses.** **Factors in brown on the bottom row** are beyond the control of the Program but are likely to have significant effects on management actions, processes, responses, and indicators. These "other" factors will be operating concurrently with Program actions generating cumulative and likely confounding effects; to the extent possible, AMP experimental design and monitoring efforts will have to account for these factors and provide spatial and temporal controls to create contrast.

The conceptual model is a visual framework representing hypothetical relationships between Program management actions and riverine processes. Because the conceptual model is conjecture, significant uncertainty exists regarding linkages between the layers of the model. Those uncertainties are stated as broad hypotheses in the AMP and as big questions in this Synthesis Report. As the big questions are explored and answered, the FSM conceptual model can be updated and improved to represent the latest understanding of the relationships it represents.

In addition, the "Indicators" listed in the top line of the conceptual model are addressed later in this Synthesis Report as performance measures linked to specific hypotheses. Some hypotheses are also addressed with additional performance measures, but the indicators from the conceptual model form the basic set of metrics to assess hypotheses and big questions and will afford another opportunity to refine the model during the First Increment.

The four physical process/management action big questions are:

- **Big Question #6** – How do short-duration high flows (SDHF), restoring sediment balance, and mechanical channel alterations contribute to the maintenance of channel width and creation of a braided river channel?
- **Big Question #7** – What is the relationship between SDHF, sediment balance, and tern and plover riverine nesting habitat meeting Program minimum criteria?
- **Big Question #8** – What is the relationship between SDHF, sediment balance, and whooping crane habitat meeting Program minimum criteria?
- **Big Question #9** – Have Program water-related activities avoided adverse impacts to pallid sturgeon in the lower Platte River?

2.4.1 Tier 1 Physical Process Hypotheses

The AMP contains numerous priority hypotheses related to physical processes. In 2010, the Technical Advisory Committee (TAC) conducted a hypothesis sequencing workshop and narrowed that list down to five "Tier 1" hypotheses that will be the initial focus of attention through adaptive management implementation during the First Increment. During the hypothesis sequencing workshop, the TAC identified several performance measures for each Tier 1 hypothesis that can be used to "test" the hypotheses. Most of the performance measures are also included in the FSM conceptual model. Generally, these performance measures are metrics tied to the response of physical processes in the central Platte River to management actions (SDHF, sediment augmentation, etc.). Ultimately, these responses will be tied to habitat characteristics of interest for the target species. The conceptual model indicator of "cost metrics" is addressed in Section 5.0 of this Synthesis Report (decision analysis tree). The AMP includes an X-Y graph for each hypothesis that visualizes the projected relationship and suggests additional performance measures. Table 2.4 below summarizes the candidate performance measures for each Tier 1 hypothesis, associated benchmarks to indicate significant responses, the projected timeline for seeing a response, and issues that still need to be resolved or investigated as the hypothesis is tested.

Tier 1 hypothesis	Performance measures	Benchmarks	Time to detect response	Issues to be resolved
Flow #1 (sandbar height): Increasing the variation between river stage at peak and average flows by increasing the stage of the peak flow through Program flows will increase sandbar height by 30-50%.	SDHF increases sandbar height	Yes/No	Expect response post-event	Impact of SDHF vs. natural flows
Flow #3 (green line): Increasing the 1.5-year Q with Program flows will increase riparian plant mortality and raise the green line.	SDHF raises green line	Yes/No	Expect response post-event	Impact of SDHF vs. natural flows
Flow #5 (vegetation scour): Increasing the magnitude and duration of a 1.5-year flow will increase riparian plant mortality along river margins.	Sandbar persistence	Less than two years (ephemeral)	Expect vegetation and sandbar response post-event	Impact of SDHF vs. natural flows
Sediment #1 (sediment balance): Sediment augmentation near Overton will result in a sediment balance to Kearney.	Ability to balance sediment budget	Yes/No	Maintain annual sediment balance with stable aggradation and degradation trends	Ability to balance the sediment budget annually
	Aggradation and Degradation	Stable		
Mechanical #2 (flow consolidation): Increasing the Q1.5 in the main channel by consolidation 85% of the flow, and aided by Program flows and sediment balance, flows will convert main channel from meander to braided morphology.	Braided morphology	Braiding index greater than 3	Expect changes in braiding index in 3-5 years	Ability to consolidate flows; ability to provide multiple consolidation replicates
	SDHF stream power capable of exceeding braiding threshold for channel 750 feet wide	Yes/No		

Table 2.4 Tier 1 physical process hypotheses. These hypotheses will receive priority attention in the First Increment and the performance measures listed in the table will be analyzed to help assess both the specific hypotheses and the associated big questions.

2.4.2 Information Hierarchy

Figure 2.4 below presents a schematic representation of the flow of information between Tier 1 hypotheses, big questions, and the relevant portion of the overall Program goal.

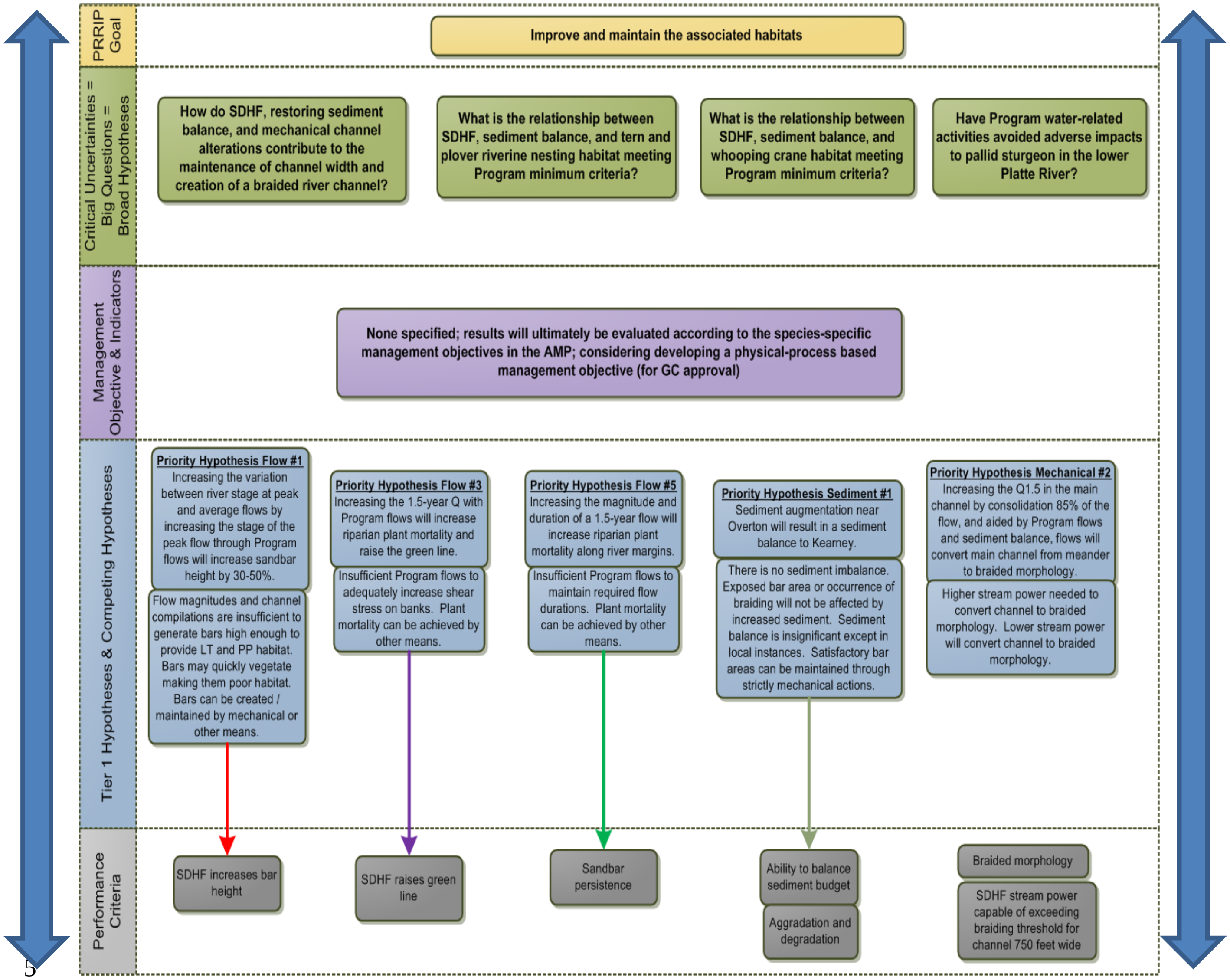


Figure 2.6 Information hierarchy related to physical process uncertainties. This schematic is provided to represent the flow of information back and forth between Tier 1 physical process hypotheses and related uncertainties, objectives, and goals.

3.0 Results

3.1 Tern and Plover Uncertainties

Program monitoring and research efforts generated a large amount of raw data. That data has been processed by the EDO, Program partners, and/or contractors to assist with analyses and the generation of the tables, graphs, charts, and other visualizations in this Synthesis Report. The information below is presented as summary metrics to address relevant big questions and related Tier 1 hypotheses.

3.1.1 Big Question #1 – Do terns and plovers use Program habitat complexes and/or habitat meeting Program minimum criteria in proportions greater than their availability?

Habitat metrics

- To be addressed in conjunction with the habitat availability analysis being conducted with 2007-2010 data in 2011
- Consider this question when developing protocol for habitat availability analysis; need to visualize availability at two scales – total amount of bare sand available each year and total amount of bare sand meeting Program minimum habitat criteria each year
- Report by both bridge segment and Program complexes

Bird metrics

- Utilize tern and plover rapid prototype and/or results of Jamie McFadden modeling to make predictions of response for comparative purposes

Synthesis of results

3.1.2 Big Question #2 – What is the relationship between concurrently available riverine and sandpit nesting habitat to tern and plover use and productivity?

Sandbars and Sandpits

Riverine and off-channel sand and water (“sandpits” or “OCSW”) nesting habitat in the form of acres was calculated by the EDO utilizing CIR imagery collected through implementation of the Program’s aerial photography protocol and by ground-truthing in the field. Acreages were totaled by the ten bridge segments comprising the central Platte associated habitats.

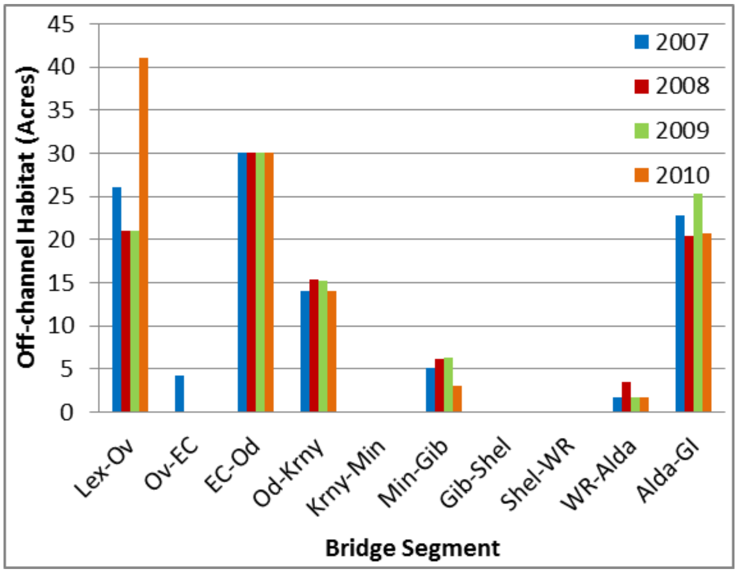


Figure 3.x Off-channel sand and water tern and plover nesting habitat from 2007-2010, by bridge segment.

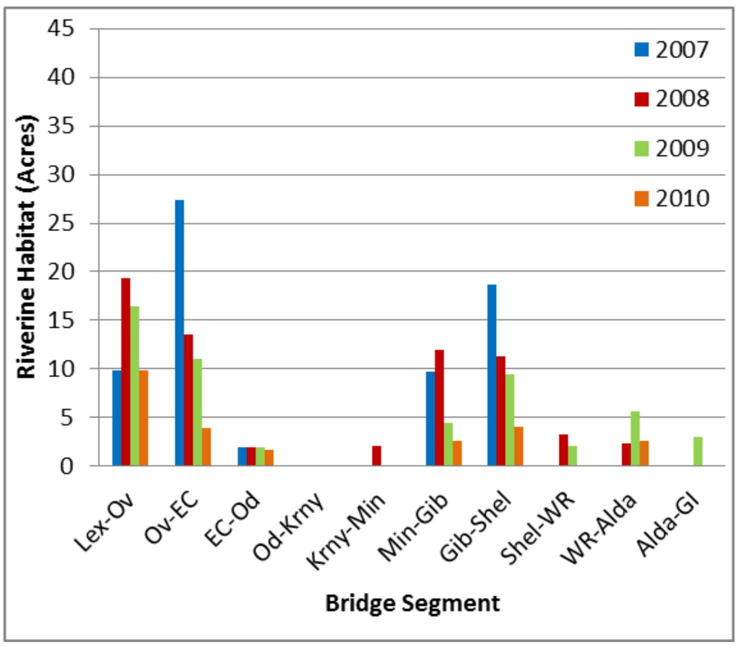


Figure 3.x Riverine tern and plover nesting habitat from 2007-2010, by bridge segment.

Habitat totals

Figure 3.x below represents a summary graph of habitat acres for combined riverine and sandpit tern and plover nesting habitat.

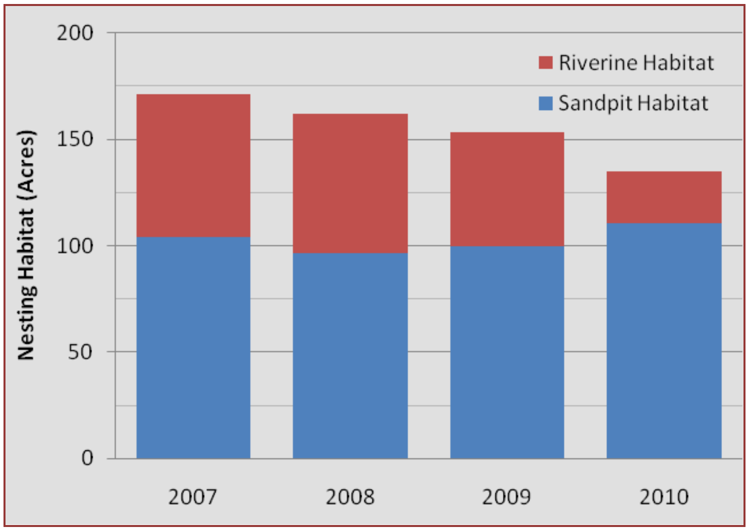


Figure 3.x Combined riverine and off-channel sand and water tern and plover nesting habitat, 2007-2010.

Bird metrics

Table 3.x presents the fledge ratios and number of nesting pairs for both terns and plovers on sandbars and sandpits on the central Platte from 2007-2010. This data was collected through the Program's tern and plover monitoring protocol, and fledge ratios were calculated by the EDO.

	Tern				Plover			
Reproductive Parameter *	2007	2008	2009	2010	2007	2008	2009	2010
Total Nests Observed	49	63	56	76	20	21	14	35
Successful Nests	22	31	31	48	15	8	9	21
Apparent Nest Success	0.45	0.49	0.55	0.63	0.75	0.38	0.64	0.60
Daily Nest Survival Rate	0.97	0.98	0.99	0.98	0.99	0.98	0.99	0.98
Incubation-period Survival Rate	0.55	0.61	0.73	0.64	0.71	0.58	0.67	0.54
Chicks Observed	49	61	68	122	45	26	30	76
Hatch Ratio (Chicks/Nest)	1.00	0.97	1.21	1.61	2.25	1.24	2.14	2.17
Chicks (15 Days old)	40	44	44	76	27	10	12	50
Fledglings (21/28 Days old)	-----	-----	-----	75	-----	-----	-----	41
Historic Fledge Ratio(15 Days	0.82	0.70	0.79	1.00	1.35	0.48	0.86	1.43
Fledge ratio (21/28 Days old)	-----	-----	-----	0.99	-----	-----	-----	1.17
Daily Brood Survival Rate	-----	0.98	0.98	0.98	-----	0.94	0.98	0.99
Brooding-period Survival Rate	-----	0.75	0.79	0.72	-----	0.42	0.79	0.70

Table 3.x Fledge ratios and number of tern and plover nesting pairs on the central Platte associated habitats by type (sandbars and sandpits), 2007-2010. **(SAMPLE ONLY; NEED TO REPLACE WITH CORRECT TABLE)**

Synthesis of Results

Figures 3.x and 3.x represent the observed trend in the number of tern and plover nesting pairs related to on- (sandbars) and off-channel habitat (sandpits). This relationship is based on 2007 through 2010 monitoring data and is heavily dependent on the amount of habitat classified via CIR imagery as "suitable". A more complete Habitat Availability Analysis will be conducted during 2011 to assess the accuracy and precision of acreage calculations. For these graphs, the Y-intercept of the trend line was fixed at 1 pair/0 acres of habitat. Negative correlation coefficients indicate the slope of the trend line was inverted by fixing the Y-intercept.

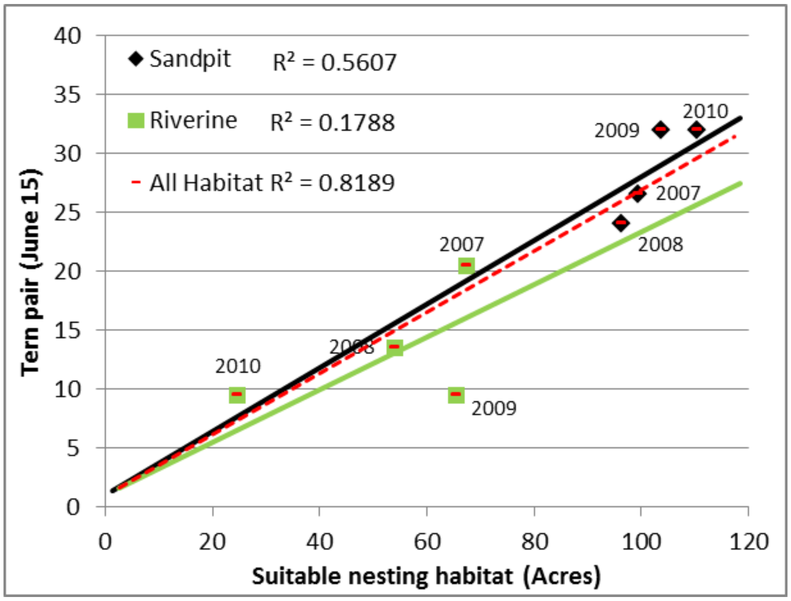


Figure 3.x Observed trend in tern nesting pairs plotted against suitable nesting habitat acres, 2007-2010.

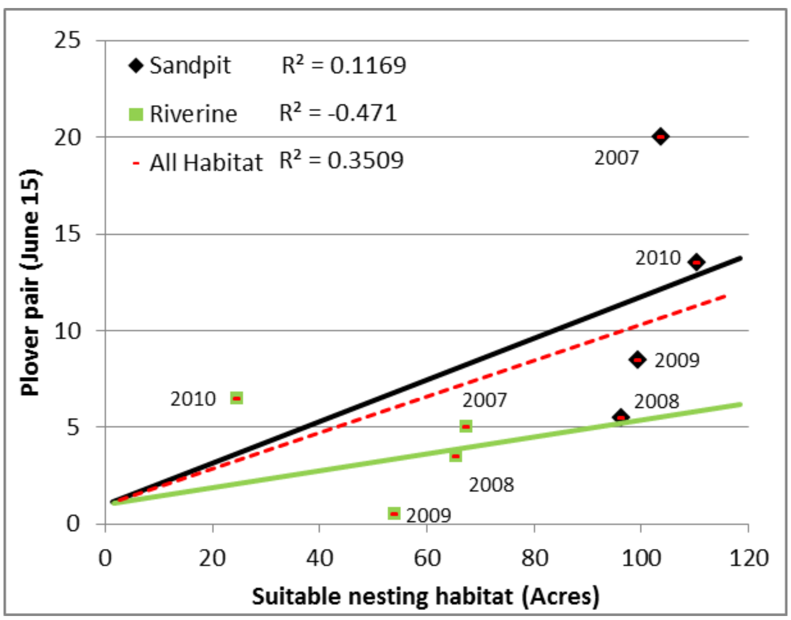


Figure 3.x Observed trend in plover nesting pairs plotted against suitable nesting habitat acres, 2007-2010.

Figures 3.x and 3.x represent the calculated exponential trend in the number of tern and plover nesting pairs related to on- (sandbars) and off-channel habitat (sandpits). This relationship is based on 2007 through 2010 monitoring data and is heavily dependent on the amount of habitat classified via CIR imagery as "suitable". A more complete Habitat Availability Analysis will be conducted during 2011 to assess the accuracy and precision of acreage calculations. For these graphs, the Y-intercept of the trend line was fixed at 1 pair/0 acres of habitat. Negative correlation coefficients indicate the slope of the trend line was inverted by fixing the Y-intercept.

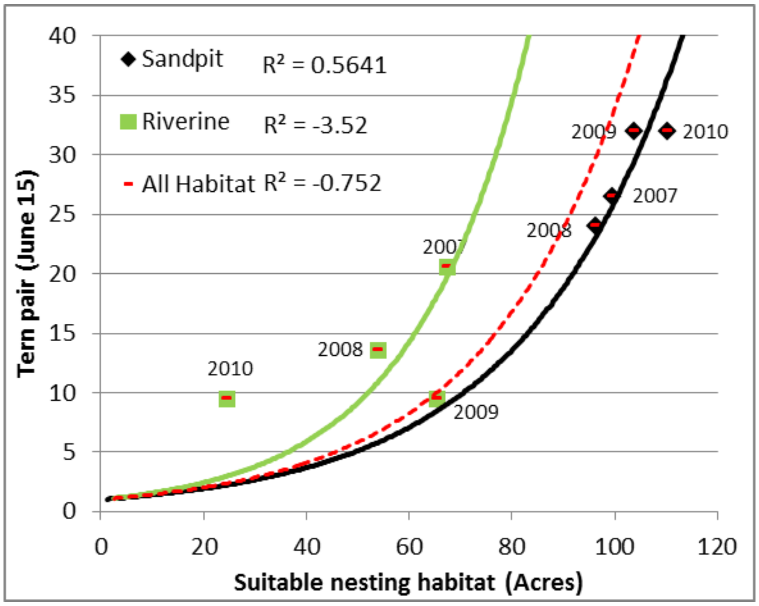


Figure 3.x Exponential trend in tern nesting pairs plotted against suitable nesting habitat acres.

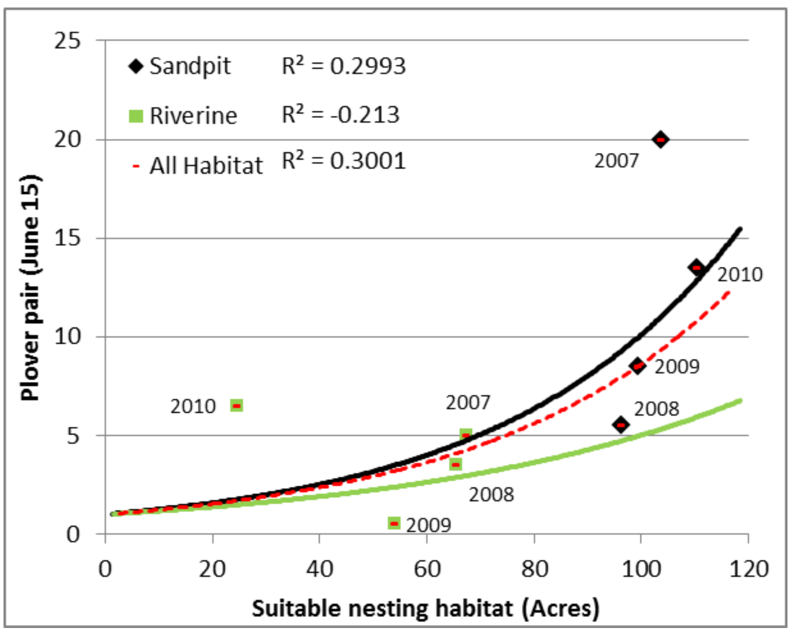


Figure 3.x Exponential trend in plover nesting pairs plotted against suitable nesting habitat acres.

3.1.3 Big Question #3 – What is the relationship between availability of riverine nesting habitat meeting Program minimum criteria and tern and plover use and reproductive success?

Habitat metrics

- To be addressed in conjunction with the habitat availability analysis being conducted with 2007-2010 data in 2011
- Consider this question when developing protocol for habitat availability analysis; need to visualize availability at two scales – total amount of bare sand available each year and total amount of bare sand meeting Program minimum habitat criteria each year
- Report by both bridge segment and Program complexes

Bird metrics

- Utilize tern and plover rapid prototype and/or results of Jamie McFadden modeling to make predictions of response for comparative purposes

Synthesis of results

3.1.4 Big Question #5 – How does tern and plover use of the central Platte River relate to overall population recovery objectives?

Central Platte bird metrics

Tern and plover population metrics

- Need to explore current thinking on role of central Platte in tern and plover recovery plans
- What is definition of recovery on the central Platte? What is definition of population recovery?
- Continue annual banding efforts
- Cooperate with range-wide plover meta-population study

Synthesis of results

3.2 Whooping Crane Uncertainties

Program monitoring and research efforts generated a large amount of raw data. That data has been processed by the EDO, Program partners, and/or contractors to assist with analyses and the generation of the tables, graphs, charts, and other visualizations in this Synthesis Report. The information below is presented as summary metrics to address relevant big questions and related Tier 1 hypotheses.

3.2.1 Big Question #1 – Do whooping cranes use Program habitat complexes and/or habitat meeting Program minimum criteria in proportions greater than their availability?

Habitat metrics

- To be addressed in conjunction with the habitat availability analysis being conducted with 2007-2010 data in 2011
- Consider this question when developing protocol for habitat availability analysis
- Report by both bridge segment and Program complexes

Bird metrics

- Utilize whooping crane rapid prototype to make predictions of response for comparative purposes

Synthesis of results

3.2.2 Big Question #4 – What is the relationship between availability of whooping crane roosting habitat meeting Program minimum criteria and whooping crane use?

Habitat metrics

Whooping crane habitat availability is being calculated through the habitat availability analysis being conducted with 2007-2010 data in 2011.

Bird metrics

Figure 3.x below provides a visualization of the percentage of the whooping crane population utilizing the central Platte River during the 207-2010 spring and fall migrations, as well as an overall trend. Generally, this figure suggests that the percentage of the whooping crane population utilizing the central Platte increased during the time period 2007-2010.

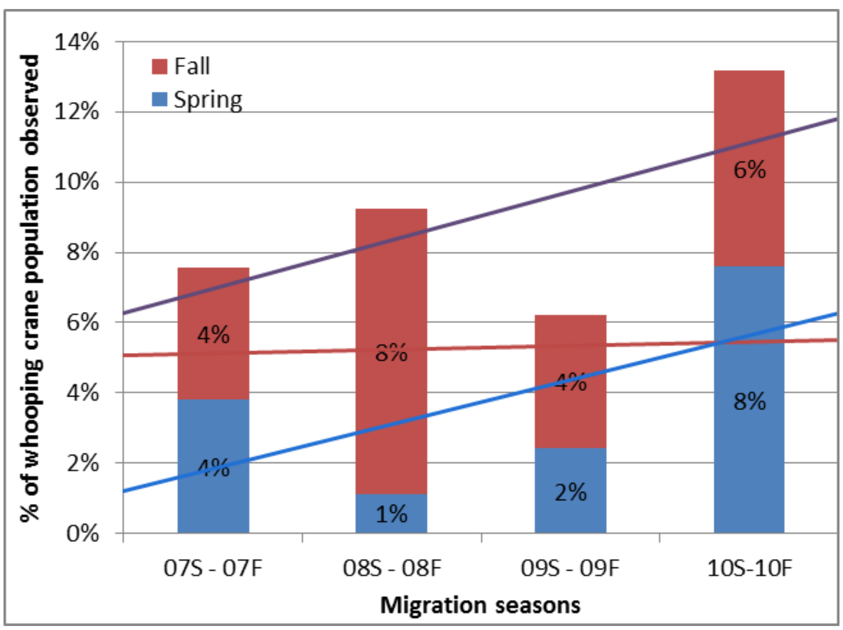


Figure 3.x Spring migration, fall migration, and overall trend in percentage of whooping crane population utilizing the central Platte River from 2007-2010.

Synthesis of results

3.2.3 Big Question #5 – How does whooping crane use of the central Platte River relate to overall population recovery objectives?

Central Platte bird metrics

- Need to explore current thinking on role of central Platte in whooping crane recovery plan
- What is definition of whooping crane recovery?

- Continue to cooperate with telemetry effort and explore how to analyze/visualize date for importance to central Platte critical uncertainties

Whooping crane bird metrics

Synthesis of results

3.3 Physical Process/Management Action Uncertainties

Program monitoring and research efforts generated a large amount of raw data through efforts like geomorphology/in-channel vegetation monitoring and projects like the Directed Vegetation Research. That data has been processed by the EDO, Program partners, and/or contractors to assist with analyses and the generation of the tables, graphs, charts, and other visualizations in this Synthesis Report. The information below is presented as summary metrics to address relevant big questions and related Tier 1 hypotheses.

3.3.1 Big Question #6 – How do short-duration high flows (SDHF), restoring sediment balance, and mechanical channel alterations contribute to the maintenance of channel width and creation of a braided river channel?

FSM Implementation Status

Short-Duration High Flows

Short-duration high flow (SDHF) releases are the focal point of the FSM management strategy. Full implementation of the strategy requires flows approaching 8,000 cfs for three consecutive days in two out of three years. Flows of this magnitude and duration can be natural, Program released, or release of Program flows to augment natural flow events. As of 2011, the Program does not have the capacity to implement full-scale SDHF releases. However, natural flow events have significantly exceeded FSM SDHF flow requirements for the period of 2008 – 2010.

YEAR	3-DAY PEAK FLOW AT GRAND ISLAND GAGE (CFS)	PEAK FLOW EVENT VOLUME (AF)	EVENT DATE RANGE	SDHF EVENT MINIMUM REQUIREMENTS MET?
2007	5,543	123,000	2/15 - 3/11	NO
2008	10,900	262,000	5/23 - 6/15	YES
2009	3,180	53,000	4/16 - 4/28	NO
2010	8,540	288,000	6/12 - 7/4	YES
FULL SDHF RELEASE	8,000	50,000 – 70,000	SPRING	

Table 3.X SDHF-related hydrologic data 2007-2010.

Sediment

The Program is preparing to implement a pilot-scale sediment augmentation management action as a first step toward restoring sediment balance near the upper end of the associated habitats. Modeling conducted as a part of the sediment augmentation feasibility study predicted that the sediment deficit currently extends to approximately Odessa. Comparison of the 2009 and 2010 geomorphology transect monitoring data indicates that in 2009 - 2010, the sediment deficit extended downstream to approximately Shelton.

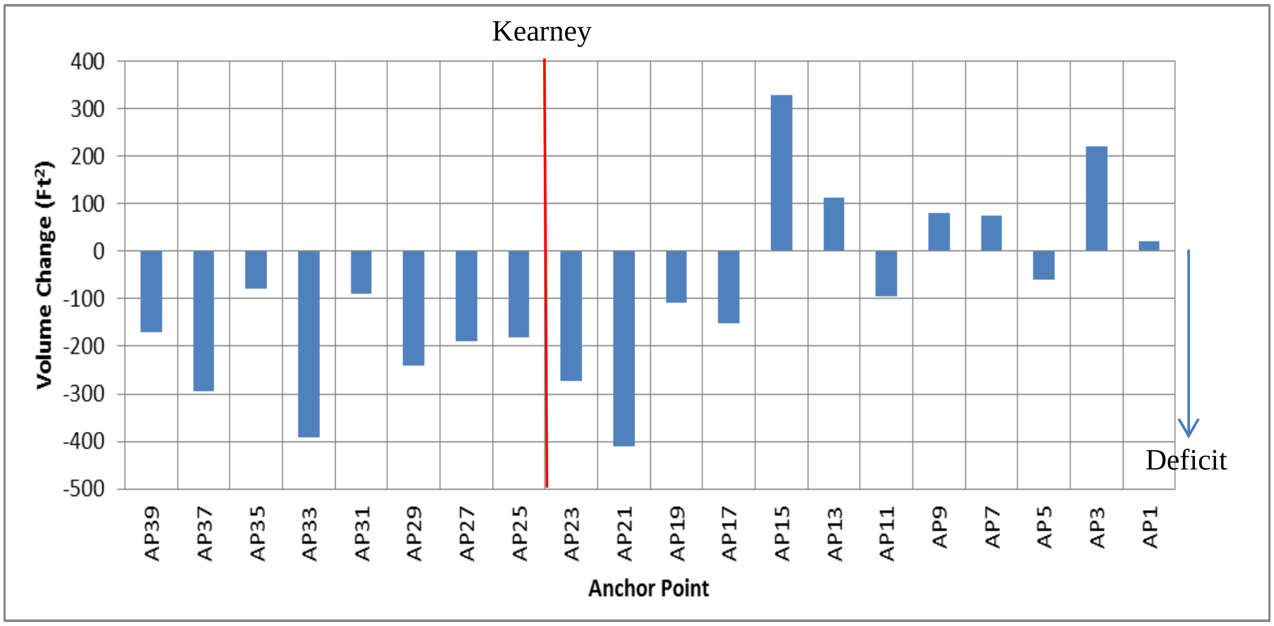


Figure 3.X 2010 to 2009 Channel Volume Change at Pure Panel Anchor Point Locations (EXAMPLE BASED ON PARTIAL DATA ANALYSIS: 1 TRANSECT PER ANCHOR POINT)

Mechanical

The mechanical component of the FSM management strategy includes flow consolidation and mechanical clearing and leveling of the channel. Flow is considered to be consolidated if 85% of 8,000 cfs is confined to a single active channel. Portions of the associated habitats are naturally consolidated or have been consolidated through infrastructure development. Mechanical clearing and leveling is intended to remove mature vegetation and "reset" the channel to be maintained by SDHF releases. Portions of the associated habitats are routinely disked during dry years when vegetation encroaches into the active channel. For the purposes of this analysis, those areas are considered to have been cleared and leveled. Figure 3.X presents FSM flow, sediment, and mechanical management action implementation status by anchor point and reflects natural events/conditions as well as actions taken by the Program and other entities.

FSM COMPONENT	PURE PANEL ANCHOR POINT NUMBER																			
	39	37	35	33	31	29	27	25	23	21	19	17	15	13	11	9	7	5	3	1
FLOW (8,000 cfs 2 out of 3 Years)	NO	NO	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
SEDIMENT (Sediment Balance)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	MAR	MAR	YES	YES	YES	YES	YES	YES	YES	YES
MECHANICAL (Flow Consolidated)	NO	NO	NO	MAR	MAR	YES	YES	NO	NO	MAR	MAR	YES	YES	MAR	MAR	NO	NO	YES	NO	YES
MECHANICAL (Clear and Level)	NO	NO	YES	YES	NO	YES	NO	NO	YES	YES	YES	NO	YES	YES	YES	YES	NO	NO	YES	NO
	Lexington			Cottonwood Ranch Complex		Elm Creek Complex			Fort Kearny Complex	Rowe Sanctuary	Gibbon	Shelton		Wood River	Alda	Mormon Island		Highway 34		Chapman
MAR = Marginal	FSM IMPLEMENTATION CRITERIA NOT MET										FSM IMPLEMENTATION CRITERIA MET									

Table 3.X 2009 – 2010 FSM Management Strategy Implementation Status by Anchor Point (EXAMPLE BASED ON PARTIAL DATA ANALYSIS)

Table 3.X indicates that in 2009-2010, the minimum requirements for implementation of the FSM management strategy were achieved in portions of the reach from Gibbon downstream to Chapman. This is primarily the result of favorable natural hydrology combined with ongoing management of a significant portion of the reach by conservation organizations.

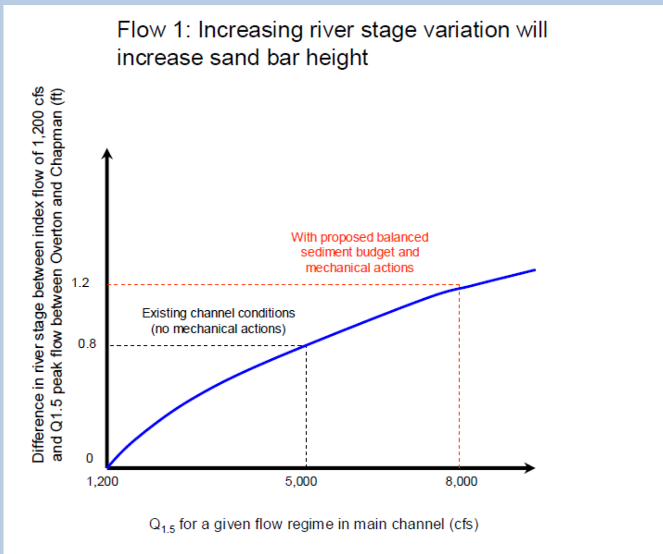
Synthesis of results

The Program is addressing physical process uncertainties though directed research/investigations, physical process monitoring and data analysis, and management experiments. Most of the physical process learning to date comes from directed research/investigations and system-level monitoring as the Program prepares to transition toward implementation of management experiments. Physical process learning to date is presented within the context of the physical process priority hypotheses.

Hypothesis Flow #1 (Sandbar Height)

Hypothesis:

Increasing the variation between river stage at peak and average flows by increasing the stage of the peak flow through Program flows will increase sandbar height by 30-50%.



Increasing the variation between river stage at peak flow (indexed by $Q_{1.5}$ flow at Overton) and average flows (1,200 cfs index flow), by increasing the stage of the peak (1.5-yr) flow through Program flows, will increase the height of sand bars between Overton and Chapman by 30% to 50% from existing conditions, assuming balanced sediment budget.

Alternative Hypotheses:

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.

The primary data source for evaluation of hypothesis Flow #1 is annual Light Detection and Ranging (LiDAR) data flown annually beginning in 2009. Changes in sandbar height due to the 2010 natural flow event can be determined by comparing digital elevation models (DEMs) of sandbars from the 2009 and 2010 data. Table 3.x presents the number of bars meeting the Program's minimum bar height criterion for tern and plover nesting by year. Figure 3.x presents changes in the height of those bars after the 2010 high flow event. Both analyses were performed by bridge segment for all sandbars that were present in 2009 and 2010 that met the minimum height criterion.

	Elm Creek to Odessa Bridge Segment	Minden to Gibbon Bridge Segment	Alda to Hwy 281 Bridge Segment
2009 Total Sandbars			
Vegetated Sandbars	34	30	39
Unvegetated Sandbars	7	13	8
2010 Total Sandbars			
Vegetated Sandbars	30	30	37
Unvegetated Sandbars	2	2	1
2010 New Sandbars			
Vegetated Sandbars	0	6	0
Unvegetated Sandbars	0	0	0

Table 3.X Frequency of 2009 and 2010 sandbars meeting Program minimum tern and plover nesting height criterion of 1.5' above the 1,200 cfs stage (EXAMPLE BASED ON PARTIAL DATA ANALYSIS)

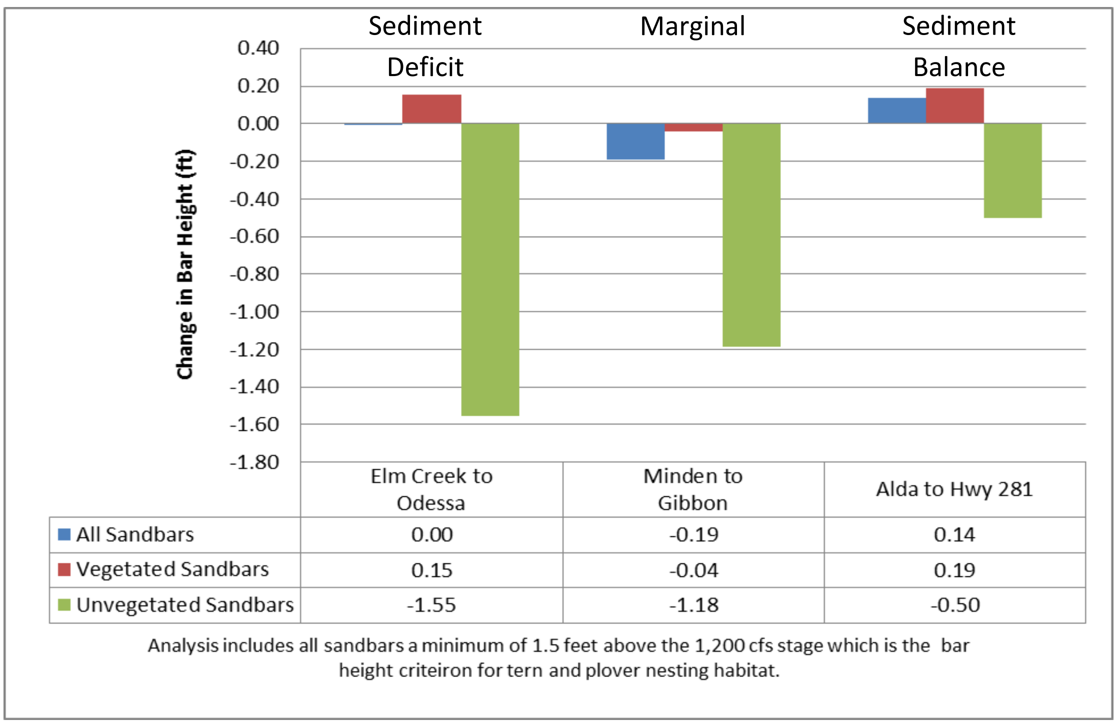


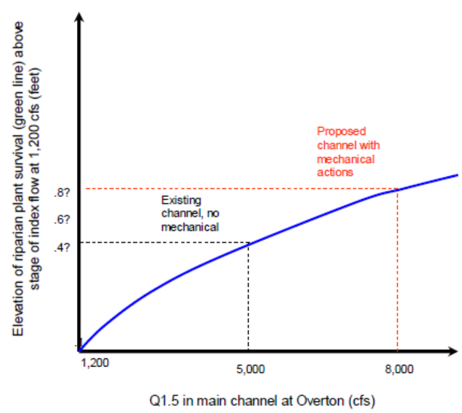
Figure 3.X 2009 – 2010 change in sandbar height by bridge segment (EXAMPLE BASED ON PARTIAL DATA ANALYSIS)

The analysis of LiDAR data indicates that the natural flow event of 2010 impacted vegetated and vegetated sandbar heights differently. The height of vegetated bars was typically stable to slightly aggradational due to sediment deposition on the bar tops. Unvegetated sandbars were subject to significant erosion resulting in fewer unvegetated bars that meet the nesting height criterion following the natural flow event.

Hypothesis Flow #3 (Green line)

Hypothesis:
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.

Flow 3: Increased peak (1.5 yr) flow = raised green line (the lowest elevation at which vegetation can establish on river banks and sand bars) = more exposed sand bar area and wider unvegetated main channel.



Increasing the 1.5-yr peak flow regime (indexed by $Q_{1.5}$ flow at Overton) with Program flows will increase the local boundary shear stress and frequency of inundation at the existing green line (elevation at which riparian vegetation can establish). These changes will increase plant mortality along the margins of the channel, raising the elevation of the green line. A raised green line results in more exposed sand bar area and wider unvegetated main channel.

Alternative Hypotheses:
Insufficient Program flows to adequately increase shear stress on banks. Plant mortality can be achieved by other means.

To date, the primary data sources for testing Hypothesis Flow #3 are the vegetation scour directed research project and annual geomorphology and vegetation monitoring. The vegetation scour research fieldwork was conducted in the summer of 2010 and the draft report was delivered to the Program in March of 2011. The research focused on investigating the Program's ability to scour one and two year old cottonwood and willow seedlings, reed canarygrass and phragmites. These species were targeted because they are considered to be among the most difficult species to scour in the central Platte. The following conclusions/management implications have been reproduced from the report executive summary:

- Stands of vegetation, including *Phragmites* (> 1 year-old), Reed canarygrass (> 1 year-old), and cottonwood trees whose taproots have rooted below the shallow zone of local scour (> 1-yearold), likely cannot be removed through drag and local scour alone, even at the 100-year recurrence interval discharge;

- At most, a few *young* cottonwood and willow seedlings (less than 1-year-old) could potentially be removed from bars through drag/local scour, where rooting depths are still small;
- The best opportunity for removal of cottonwood and willow seedlings by SDHFs is in the same year as seedling germination;
- Likelihood of cottonwood and willow seedlings being removed by SDHFs reduces dramatically with each additional growing season between high flow events. For cottonwood seedlings, mean uprooting force increased quadrupled from 32 to 139 N for one and two-year-old plants respectively;
- Lateral scour of bank and bar edges could be an important mechanism for undercutting and removal of vegetation, and should be studied further.

In addition to the vegetation research, the 2009 and 2010 geomorphology and vegetation monitoring data was integrated with the 1-D HEC-RAS model to correlate green line elevations with anchor point stage-discharge relationships. That data was in turn used to generate the green line elevation comparison presented in Table 3.x and 2009 to 2010 green line elevation change shown in Figure 3.x.

Year	Peak Discharge (cfs)	Mean Green Line Height Relative to 1,200 cfs Stage (ft)	Discharge Corresponding to Mean Green Line Elevation (cfs)	Mean Green Line Distance below Annual Peak Stage (ft)
2009	3,700	-0.45	950 cfs	1.5
2010*	8,000	0.86	3,300 cfs	1.45

*Green line elevations may have been affected by a reach-scale phragmites spraying project during the fall of 2009

Table 3.X Pure panel anchor point green line analysis

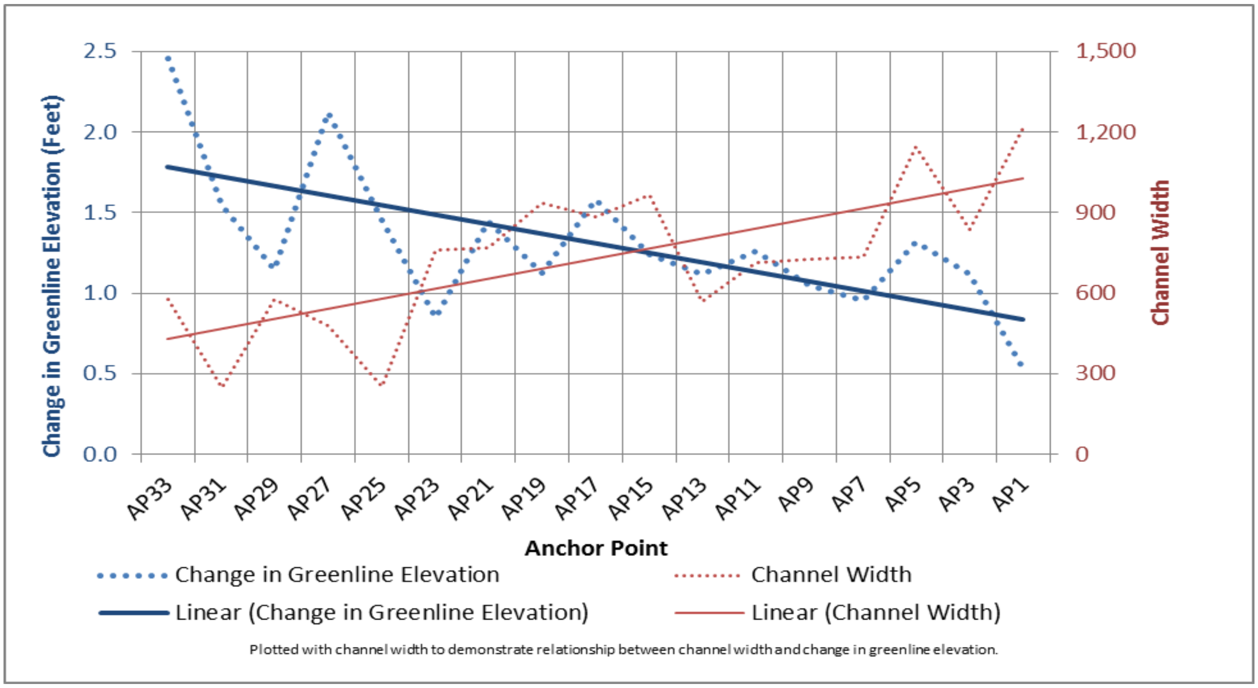
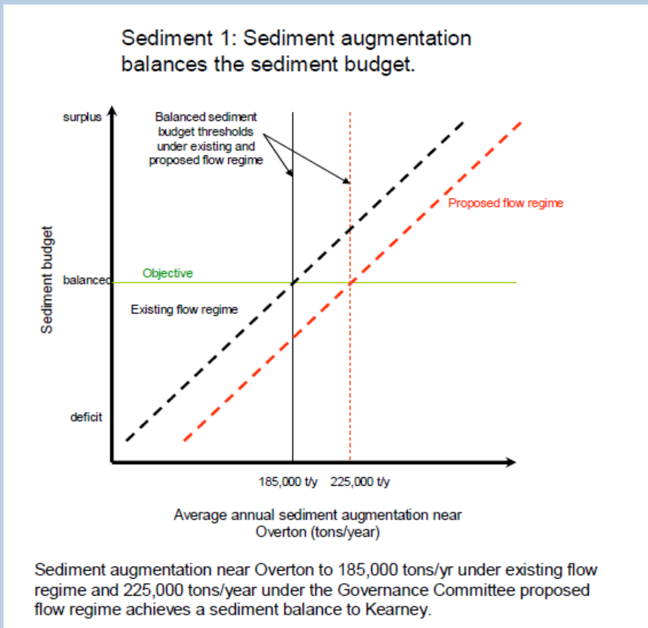


Figure 3.X 2009 to 2010 change in green line elevation by pure panel anchor point

The green line analysis indicates that the natural high flow event in 2010 likely raised the green line elevation in excess of a foot from the 2009 elevation. Extensive spraying of phragmites in the associated habitat reach following monitoring in 2009 may have also influenced the 2010 green line elevation.

Hypothesis Sediment #1 (Sediment balance)

Hypothesis:
Average sediment augmentation nr 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.

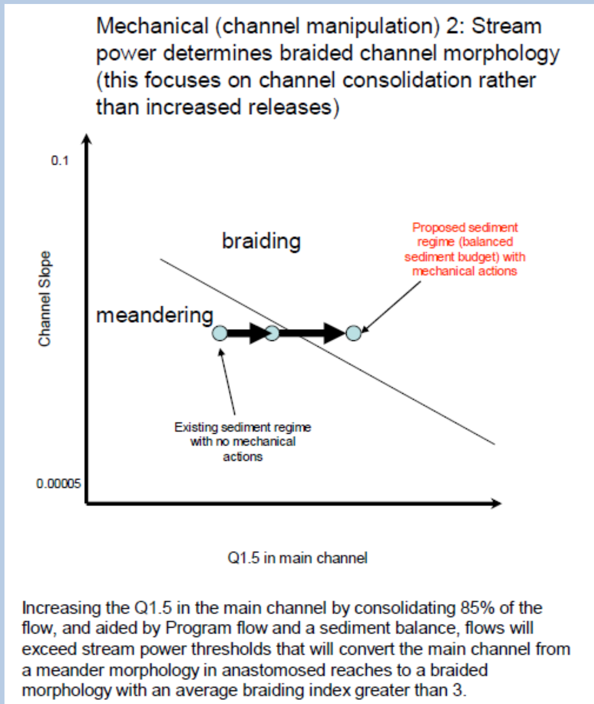


Alternative Hypotheses:
Augmentation greater than or less than 225,000 tons/year is needed to balance the sediment budget and increase exposed bar area. There is no sediment imbalance. Exposed bar area or occurrence of braiding will not be affected by increased sediment. Sediment balance is insignificant except in local instances. Satisfactory bar areas can be created and maintained through strictly mechanical actions.

The Program completed a sediment augmentation feasibility study in early 2011. Sediment transport modeling associated with that effort indicates that the average annual sediment deficit in the associated habitats is on the order of 150,000 tons. The actual deficit in any given year can vary widely depending on hydrologic conditions. In wet years, the deficit could be significantly more than 150,000 tons, in dry years it could be significantly less. The Program will implement a pilot-scale sediment augmentation management experiment in 2011 to begin evaluating augmentation methods.

Hypothesis Mechanical #2 (Flow consolidation)

Hypothesis:
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.



Alternative Hypotheses:
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

The primary data for addressing priority hypothesis Mechanical #2 is a streampower investigation completed by Program special advisors in May of 2011. That investigation compared the Program's 1-D HEC-RAS model output to river planform relationships published in the scientific literature. The results of the investigation indicate that most of the associated habitat reach currently exceeds the threshold for braided channel morphology under current hydrologic conditions. However, there are significant portions of the reach which exhibit an anastomosed planform. Adjusting the braiding threshold to account for increased shear resistance due to vegetation proliferation produces the range of planforms currently present in the central Platte River. As such, vegetation establishment and encroachment into the active channel is likely a significant driver of planform changes and in absence of vegetation encroachment, much of the reach would potentially exhibit a braided planform, even under existing hydrology. Increasing discharge and flow consolidation would improve the likelihood of sustaining a braided planform, but only if flow is sufficient to scour in-channel vegetation on an annual basis or vegetation is controlled mechanically.

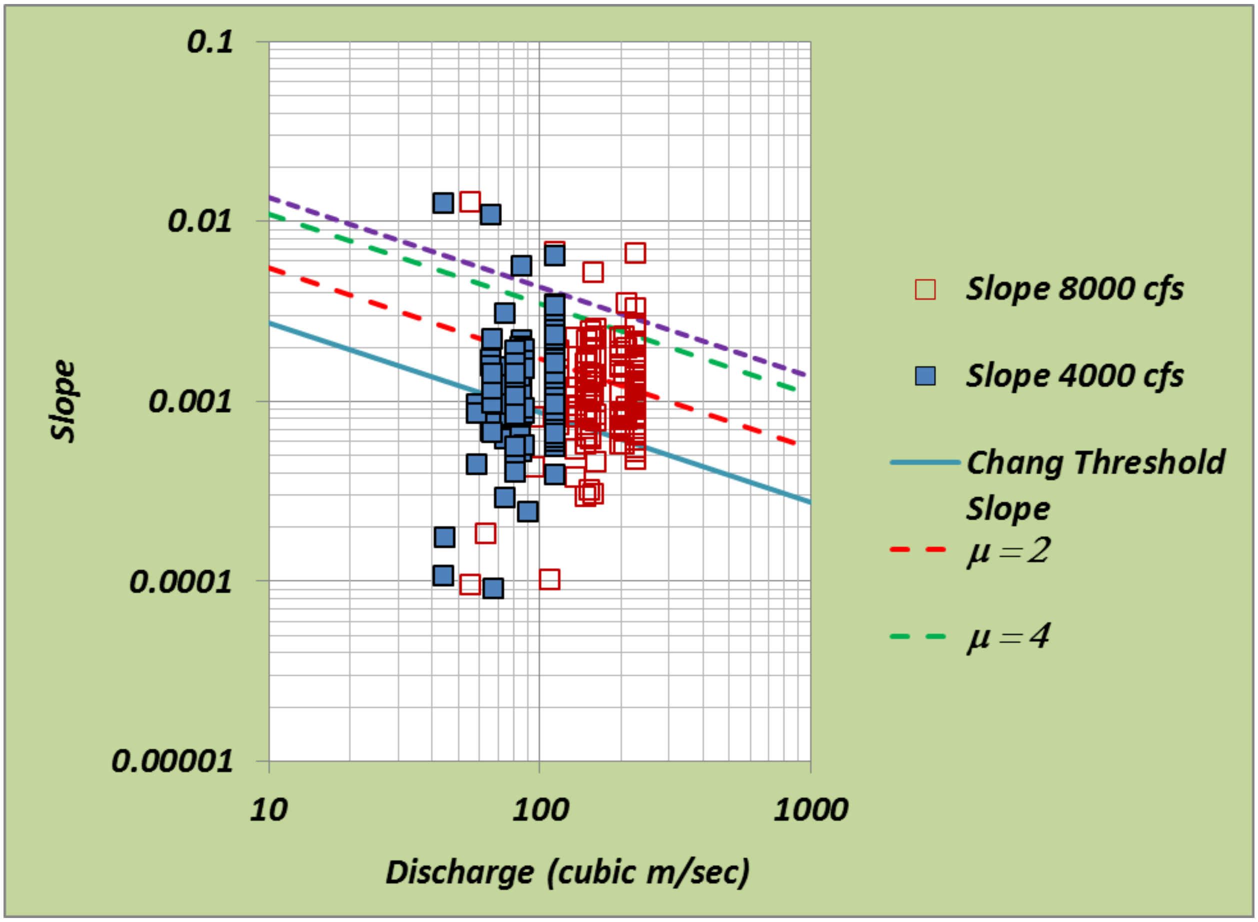


Figure 3.x Plot of Chang equation for associated habitats at discharges of 4000 cfs and 8000 cfs, for the HEC-RAS computations. The Chang threshold is computed for the mean D50 of the bed of 1.3 mm (Ayers 2009) and for multiple value levels of the threshold. Threshold lines ($m > 1$) above the base threshold represent stream banks of progressively greater relative shear resistance as compared to the shear resistance of the bed.

3.3.2 Big Question #7 – What is the relationship between SDHF, sediment balance, and tern and plover riverine nesting habitat meeting Program minimum criteria?

Two critical physical process-related components of creation and maintenance of tern and plover riverine nesting habitat are sandbar height and the presence/absence of vegetation. The Program's minimum criterion for nesting bar height is 1.5 feet above the 1,200 cfs stage. The maximum criterion for vegetative cover is 25%. Thus, the FSM management strategy must build sandbars high enough for nesting and low enough to be scoured/reworked by SDHF releases in order to prevent vegetation encroachment. Both of these components are tied directly to the stage-discharge relationship at any given point along the associated habitat reach.

Sandbar height

Analysis of 2009 and 2010 LiDAR indicates that the 2010 natural flow event resulted in the erosion of existing unvegetated sandbars that met the minim nesting height criterion. Newly formed unvegetated sandbars were not of sufficient height to meet the minimum criterion.

Vegetative cover

Analysis of green line data indicated that the 2010 natural flow event likely raised the green line elevation in the associated habitats reach. Figure 3.x presents composite HEC-RAS stage discharge relationships for the associated habitats by active channel width along with green line data from 2009 and 2010. The figure shows that the green line elevation in 2010 was near the minimum bar height criterion for channels less than 400 feet wide. The green line was between 0.4 and 0.5 lower than the minimum height criterion for wider channels. The minimum channel width criterion for tern and plover nesting habitat is 400 feet. As such, the 2010 flow event did not raise the green line to the minimum nesting bar height in channels that conform to the minimum width criterion.

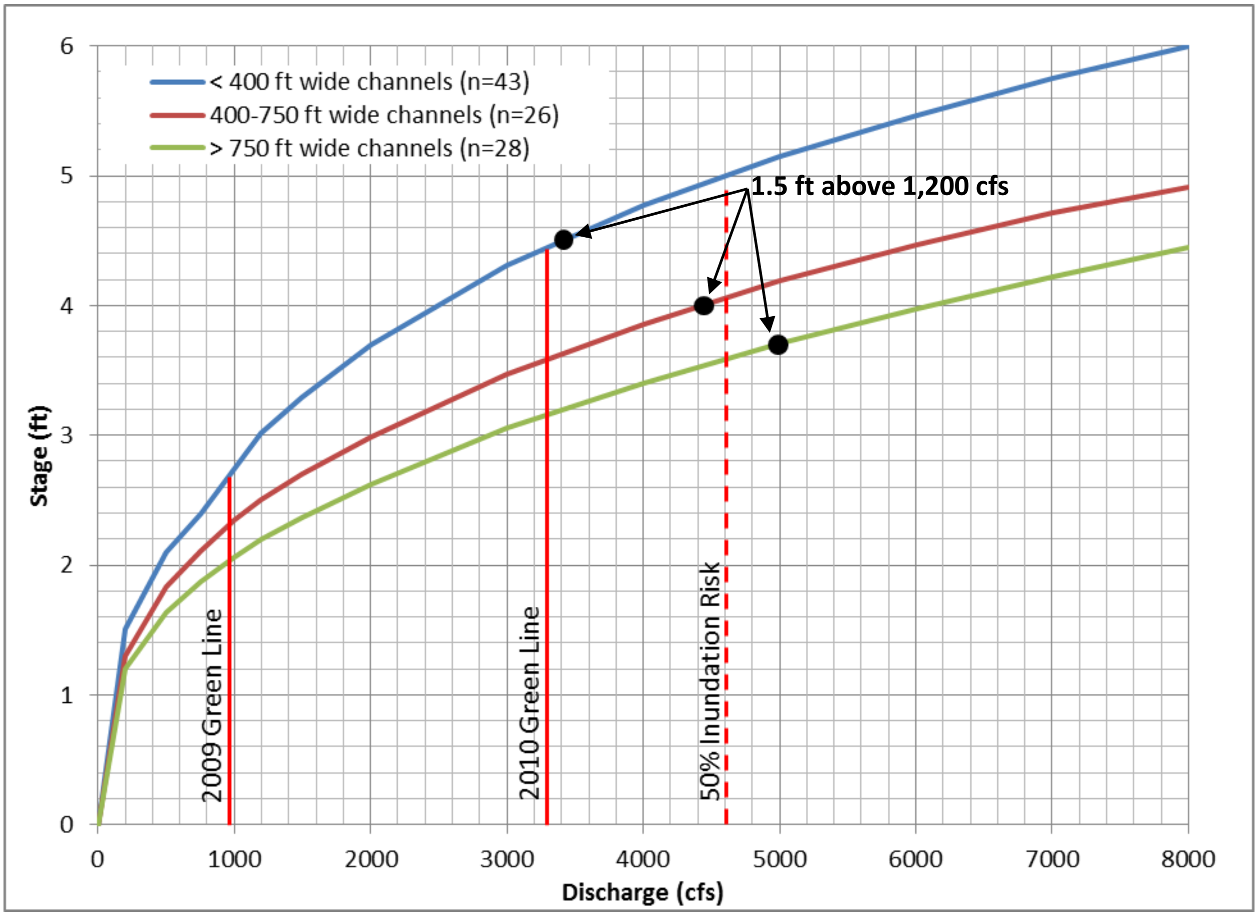


Figure 3.x HEC-RAS stage-discharge relationships for the associated habitats including 2009 and 2010 green line data and minimum nesting habitat height criterion

3.3.3 Big Question #8 – What is the relationship between SDHF, sediment balance, and whooping crane habitat meeting Program minimum criteria?

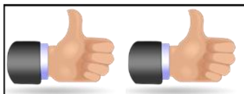
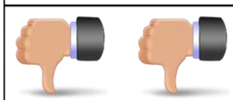
- Much of this will come after one or more years of SDHF and sediment augmentation implementation
- Major expectation for July 2011 ISAC experimental design workshop is to develop sample visualizations for the performance measures we are most concerned with for this question

3.3.4 Big Question #9 – Have Program water-related activities avoided adverse impacts to pallid sturgeon in the lower Platte River?

- Can we insert some of the results from the Stage Change Study here as explanatory data and visuals?
- Likely need to wait until after stage change study peer review
- Still need to discuss and get agreements on the metrics that best address this question, and how best to visualize the relationships of concern

4.0 Summary of Evidence

2010 marked the conclusion of only the fourth year of the 13-year First Increment, so any conclusions drawn to date are made cautiously. Generally, the evidence to date does not allow us to describe definitive answers to any of the big questions, but information does exist to pair the key data and visualizations presented in Section 3.0 with a preliminary assessment of what we know now about some of the big questions. The preliminary assessments are made utilizing the following guide:

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

1) Do terns, plovers, and whooping cranes use Program habitat complexes and/or habitat meeting Program minimum criteria in proportions greater than their availability?
To be completed when habitat availability analysis is finalized

2) What is the relationship between concurrently available riverine and sandpit nesting habitat and tern and plover use and productivity?

# of tern nesting pairs – river		# of tern nesting pairs increased as river habitat increased; bolstered by inverse relationship – # of tern nesting pairs on river decreased when river habitat decreased
# of tern nesting pairs – sandpit		# of tern nesting pairs increased as sandpit habitat increased
# of plover nesting pairs – river		# of plover nests increased as river habitat decreased
# of plover nesting pairs – sandpit		# of plover nesting pairs increased as sandpit habitat increased
Fledge ratios		Still to be calculated and compared year-to-year
Acres of suitable sandbar habitat		River habitat decreased during 2007-2010, but still able to analyze nesting pair/acres relationship
Acres of suitable sandpit habitat		Sandpit habitat increased slightly during 2007-2010

3) What is the relationship between availability of riverine nesting habitat meeting Program minimum criteria and tern and plover use and reproductive success?
To be completed when habitat availability analysis is finalized

4) What is the relationship between availability of whooping crane roosting habitat meeting Program minimum criteria and whooping crane use?
To be completed when habitat availability analysis is finalized

5) How does tern, plover, and whooping crane use of the central Platte River relate to overall population recovery objectives?
Need to determine metrics to properly visualize answer to this question

6) How do SDHF, restoring sediment balance, and mechanical channel alterations contribute to the maintenance of channel width and creation of a braided river channel?
Largely on hold until major management actions are implemented

7) What is the relationship between short-duration high flows (SDHF), sediment balance, and tern and plover riverine nesting habitat meeting Program minimum criteria?
Largely on hold until major management actions are implemented

8) What is the relationship between SDHF, sediment balance, and whooping crane habitat meeting Program minimum criteria?
Largely on hold until major management actions are implemented

9) Have Program water-related activities avoided adverse impacts to pallid sturgeon in the lower Platte River?
Need to determine metrics to properly visualize answer to this question

5.0 Decision Analysis Tree

Under development; Figure 5.1 below is a working version of a possible decision tree for the PRRIP and will undergo significant revision

Purposes of a decision tree for the PRRIP:

- Evaluating the expected value of management actions – during the First Increment, what should we do?
- Tool for linking bird performance measures to tradeoffs/outcomes like cost metrics
- What assumptions or uncertainties are PRRIP management actions most sensitive to? = guidance for monitoring and analysis
- Place to plug in results from other PRRIP tools, like the rapid prototype models for terns/plovers and whooping cranes and other models
- This is a model, so the classic model axiom holds true – it will be wrong, but hopefully useful!

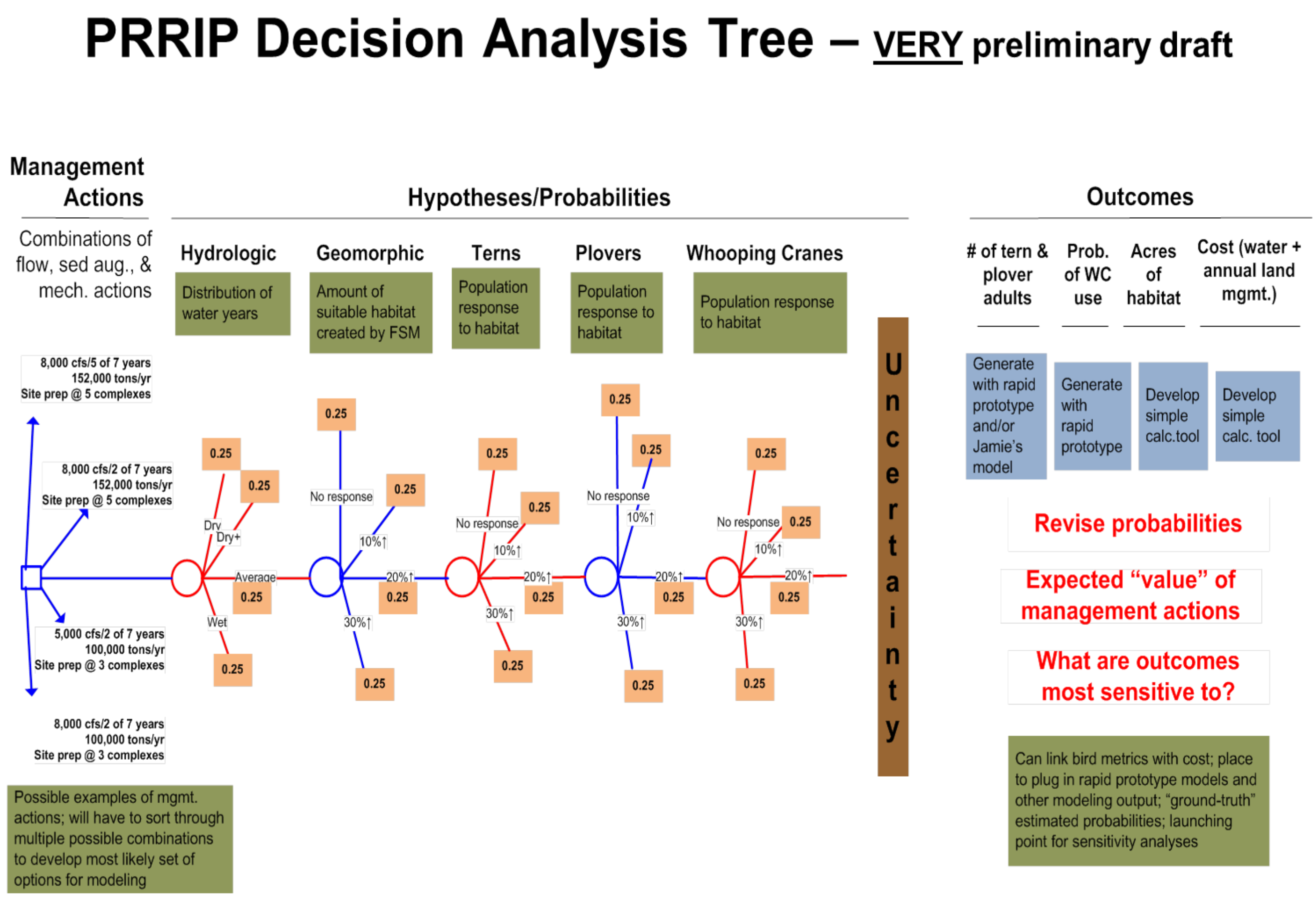


Figure 5.1 Preliminary decision analysis tree for PRRIP. Includes a suite of possible management actions, a range of hypotheses or probabilities for river conditions and bird responses (uncertainties), and a range of outcomes of interest to scientists and decision-makers (i.e. the Governance Committee).

6.0 Future Considerations

Under development

6.1 Outstanding Issues and Data Gaps

6.2 Emerging Priorities for Management Actions, Monitoring, and Research