Structured Decision Making for Interior Least Tern and Piping Plover Habitat on the Platte River

Prepared for

Platte River Recovery Implementation Program

Prepared by

Compass Resource Management Ltd.
604.641.2875
Suite 210- 111 Water Street
Vancouver, British Columbia
Canada V6B 1A7
www.compassrm.com

Date

August 2016

[Blank Page]

compass

Executive Summary

The Platte River Recovery Implementation Program (Program or PRRIP) is implementing an Adaptive Management Plan to reduce uncertainty regarding key scientific and technical questions and to assess the response of certain threatened and endangered species to Program management actions. This report summarizes the outcome of a series of meetings and workshops held with the Program's Governance and Technical Advisory Committees (GC and TAC, respectively) to facilitate the process of using the learning about interior least tern and piping plovers gained over the First Increment of the Program to guide decisions about managing habitat into the future.

Specifically, the GC wanted to make a decision in response to the following question: Given the two-thumbs-down assessment for Big Question #1, what's the best combination of management actions to take, for the remainder of the First Increment (assumed to be 2016 to 2019), for the purpose of maintaining or enhancing habitat for interior least terns and piping plovers?

Based on a series of interviews, we developed a set of decision objectives, including plover and tern reproductive success, management cost, and effects on other species and ecosystem attributes such as whooping crane, pallid sturgeon, and sediment supply, that guided the analysis of different habitat alternatives. We used a combination of models and constructed scales to quantify the consequences of each alternative management strategy relative to these objectives. Using a combined approach of expert judgement and sensitivity analyses helped to identify which uncertainties in these models were important to refine based on the level of influence they had over the decision outcomes.

In all, the GC and TAC considered four rounds of alternatives, where each round was refined based on input from the TAC and/or GC. The first two rounds served to facilitate learning among the GC and TAC about the major effects that different management strategies would have, while later rounds served to identify, and then where possible, reduce those trade-offs through the refinement of strongly performing alternatives. Through the process of estimating consequences of each round of alternatives and identifying the key trade-offs at each stage, the GC was able to make informed choices that effectively narrowed the range of alternatives for each subsequent round of alternatives.

At the last meeting of the GC, we asked GC members to express preferences for one of the final set of alternatives. Based on the results of two preference elicitation exercises, the GC made a formal decision to (a) construct an additional 62 acres of off-channel habitat on a mixture of leased land, purchased land, and land already owned by the Program, (b) commit to a budget of $26,000 for developing on channel habitat using the Moving Complexes Approach, and (c) recommend to the US Fish and Wildlife service that water should not be used solely for the purpose of nest initiation flows for piping plover.

Contents

Figures

Tables

1 Introduction

The Platte River Recovery Implementation Program (Program or PRRIP) is implementing an Adaptive Management Plan (AMP) to reduce uncertainty regarding key scientific and technical questions and to assess the response of certain threatened and endangered species to Program management actions. The Program is led by a Governance Committee[1] (GC) and supported by (among others) a Technical Advisory Committee (TAC) and an Independent Scientific Advisory Committee (ISAC).

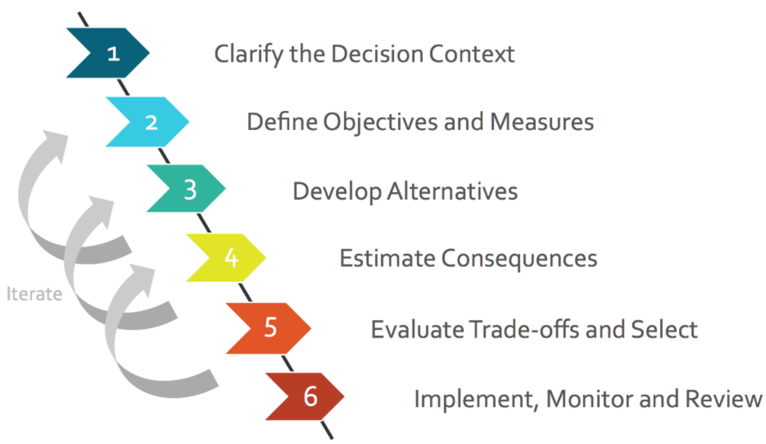
The Program identified 11 "Big Questions" based on priority hypotheses in the AMP and developed and implemented studies to address them. In June 2015, the GC accepted a "two-thumbs-down" assessment for Big Question #1: Will implementation of SDHF produce suitable tern and plover riverine nesting habitat on an annual or near-annual basis? In response, the GC, following recommendations by the ISAC, initiated a Structured Decision Making (SDM) process to identify and evaluate proposed next-step actions to support the GC in working through the *Adjust* step of adaptive management relative to Big Question #1.

Compass was engaged to facilitate the process of using the learning gained over the First Increment about terns and plovers to guide decisions about managing habitat into the future. This report summarizes the outcome of a series of meetings and workshops held with the GC and TAC to facilitate this process.

2 Process Overview

SDM is centred on six basic planning steps (Figure 1) and supported by structuring tools from the decision sciences that help groups deal with the complexities of technically intensive decisions and difficult group dynamics.

Figure 1. Steps in Structured Decision Making



The first step involves clarifying the *decision context*, especially the scope of the decision, participants and their roles, nature of the analysis required, and overall timelines and budgets. At step 2, *decision objectives* and *performance measures* are defined. These define the "things that matter" for the success

[1] The GC consists of representatives of Colorado, Wyoming, Nebraska, the Bureau of Reclamation, the U.S. Fish and Wildlife Service, Colorado water users, Upper Platte water users, downstream water users, and environmental entities.

of the Program, and provide the basis for evaluating and comparing alternatives. Candidate management actions are then developed and grouped into logical packages or sets of actions, called *alternatives*. The *consequences* of each alternative with respect to each decision objective are estimated, using the best available information (e.g., data, models and expert judgment). These are often summarized in a consequence table using the best available information.

Key *trade-offs* are examined with the goal of identifying a broadly acceptable balance across the objectives. Alternatives are usually iteratively refined to improve them and reduce unnecessary trade-offs. Consequence estimates may also be iteratively refined where uncertainty is shown to hinder the selection of a preferred alternative. An *implementation and monitoring* plan will be developed to confirm predicted outcomes and underlying hypotheses, and a process and timing for formal review will be defined.

The Platte River SDM process for tern/plover habitat was conducted over 8 months, and involved three meetings of the GC and two meetings of the TAC.

3 Problem Scoping

We held one-on-one phone interviews with each GC and TAC member to begin to understand the perspectives and concerns held by each group. These interviews served two key purposes. First, they helped to establish boundaries for what would be considered through the decision process by identifying the core questions that GC participants wanted to address. Second, they helped to articulate the set of important values that each group holds – for example, keeping costs low, spending efficiently, or contributing to recovery of a particular species.

Though the interviews focused on ways of supporting terns and plovers, most members of the GC also highlighted the need to consider the effects that management actions for terns and plovers have on other species (e.g., whooping crane and pallid sturgeon) and other important ecosystem components (e.g., sediment balance).

The timeframe associated with the decision also proved to be a key consideration. At the time of the interviews, there had been no discussion of an extension to the First Increment or of beginning a Second Increment. Therefore, GC members were keen to ensure that any decision made through this process pertained only to the end of the First Increment (i.e., 2019), and not beyond. However, this was balanced by a desire to consider the long-term efficiency of the actions, with the understanding that habitat created in the near term could very well last into the future.

In consideration of these perspectives, the GC approved the following decision problem statement: Given the two-thumbs-down assessment for Big Question #1, what's the best combination of management actions to take, for the remainder of the First Increment (assumed to be 2016 to 2019), for the purpose of maintaining or enhancing habitat for interior least terns and piping plovers?

Within this framing of the decision, there are several important considerations:

- The focus is on evaluating alternative ways of maintaining or enhancing habitat for terns and plovers, but implications for other objectives (e.g., whooping cranes, sediment supply, pallid sturgeon, etc.) will be evaluated;
- Alternatives will be feasible within existing water, land, and financial budgets.
- There are a range of other actions that the Program is or will be do doing anyway that will not be influenced by this SDM process.

4 Identifying Objectives and Performance Measures

Based on the information gained in the interviews we organized the concerns into a means-ends diagram, which shows connections between important outcomes on the right, and means for achieving them on the left (Figure 2). This structure helped us to identify appropriate decision objectives that struck a balance between being sufficiently specific and sufficiently meaningful. We proposed a draft set of objectives, which were refined based on discussion and input from the GC. Those objectives outlined in red in Figure 2 represent the refined set of objectives that were eventually selected to guide this decision.

In coordination with Executive Director's Office (EDO), we identified initial performance measures (PMs), which are specific metrics for describing the performance of the alternatives with respect to the decision objectives. In general, selecting good performance measures requires striking a balance across several desirable criteria: they should be accurate and direct (with a clear relationship between the PM and the objective), unambiguous, understandable, operational, and complete and concise. The initial set of PMs was refined with input from the TAC. The final set of agreed-upon objectives and their related performance measures are given in Table 1.

Two key points of discussion regarding the use of these objectives and performance measures emerged early in the process at the levels of both the GC and the TAC:

- The GC was very clear as a group that this process was intended to focus on identifying and evaluating alternative means of creating and maintaining tern and plover habitat. To the extent that alternative actions taken for terns and plovers affect other objectives (e.g., whooping cranes, pallid sturgeon, sediment) differently, those effects should be evaluated. However, this process was not to be used to comprehensively explore the range of possible management actions for these other objectives. Similarly, methods for evaluating the effects of management actions on PMs other than tern and plover will be limited to the use of existing data and tools.
- The TAC noted that for whooping crane and for sediment, the PMs are proxies for the ecological endpoint of concern, and that the relationship between the PM and the endpoint is uncertain. These PMs were therefore useful for identifying the likely order of magnitude of differences across alternatives, but the ecological significance of these differences remained uncertain throughout the process.

Figure 2. Means-ends network based on initial scoping interviews with GC and TAC members. Management actions in shaded boxes on the left were described as out-of-scope for this decision process. Decision objectives are highlighted in red.

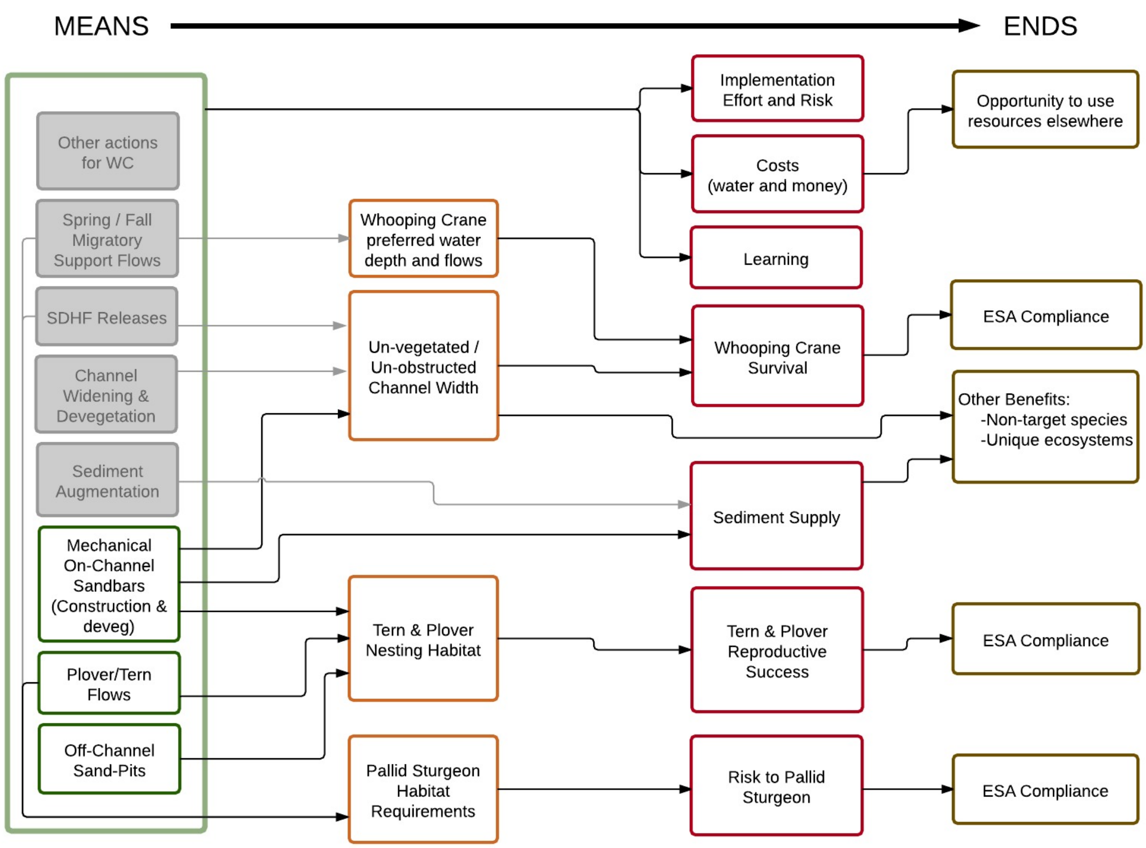


Table 1. Final set of decision objectives and performance measures used to guide the decision process.

Objective	Sub-Objective	Performance Measures	Units	PM Description
Piping Plovers and Least Terns[2]**.** The primary goal and driver of the decision process is to maximize the reproductive success of terns and plovers.	Reproductive Success	PRRIP Breeding Pairs	#/year	The number of breeding pairs nesting on Program habitat in the Associated Habitat Reach (AHR) in a year. The PM reports the average for the 50-year simulation period.
		PRRIP Total Fledglings	#	Alternate PM: The total number of fledglings produced on PRRIP habitat over the 50-year model simulation period. The PM indicates the PRRIP contribution to the global population over time.
Management Cost. This objective reflects a concern for the wise use of resources. Money and water used for terns and plovers are not available for use for other purposes and thus these objectives reflect the opportunity cost associated with using resources for terns and plovers.	Total Long-term Cost	Long-term cost (net present value over 50 years)	$	The net present value of the sum of habitat creation and maintenance costs and land acquisition costs, assuming the alternative is implemented over a 50-year period. This PM provides a basis for comparing the financial implications of management actions with different spending schedules.
	Total Short-term Cost	First Increment cost (total over 2017-2019)	$	The total cost of implementing an alternative for the period of the First Increment (2016-2019), including habitat creation and maintenance costs and land acquisition costs. This PM serves as an indicator of the impact on the Program budget, and provides an understanding of the short-term financial opportunity cost of investing in plover/tern habitat during the First Increment rather than other Program projects.
	Long Term Water Use	Proportion of Program water used	%	The opportunity cost of water used for flow-related actions. This PM reports the average annual proportion of Program water used over the 50-year simulation period for normal water years, which serves as a proxy for other year types.
Whooping Cranes. This objective reflects a desire to assess the effect of management actions designed for terns and plovers on the availability of suitable whooping crane habitat, and the potential use of that habitat.	WC Habitat Use	Habitat Suitability Scale (*changes* to habitat suitability)	7-point scale -3 to +3	Changes to the availability of suitable whooping crane habitat in the AHR during migratory periods, relative to current conditions, reported using a 7-point scale. This PM is a proxy for habitat use and ultimately migratory survival. The relationship between availability of suitable habitat and habitat use is unknown / unquantified.

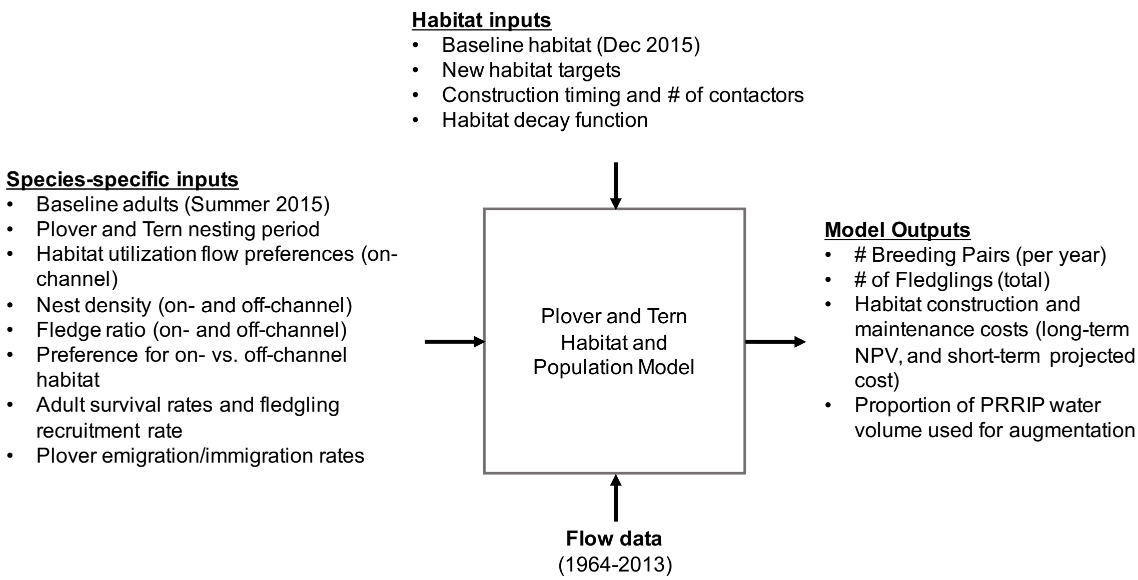
[2] Separate PMs were reported for Least Terns and Piping Plovers, but their descriptions are identical.

Sediment Supply. This objective reflects a belief that maintaining an abundance of sediment in the channel is an important contributor to a river form used by the Program's target species.	Contribution to Sediment Supply	Sediment Supply Scale	5-point scale -2 to +2	The likely effect of management action on channel sediment supply. The PM is reported using a 5-point scale. It is a proxy for a range of broader ecological benefits that are generally associated with increased sediment supply in a large braided river. The relationship between sediment supply and these broader benefits is unknown / unquantified.
Pallid Sturgeon. This objective reflects an interest in having a check in place to confirm the assumption that management actions taken for terns and plovers will not affect risks to pallid sturgeon.	Pallid Sturgeon Risk	Change in risk to Pallid Sturgeon	Y/N/ Maybe	A flag that indicates whether a management action involves a change in risk to Pallid Sturgeon. A "No" indicates no changes are expected as a result of an alternative. A "Yes" suggests further analysis may be warranted if the alternative is considered further. A "Maybe" indicates that the effects (positive or negative) on Pallid Sturgeon are unknown.
Implementation Effort This objective reflects an interest in ensuring that management actions are practical and feasible to implement.	Implementation Costs and Risks	Implementation Scale	5-point scale: 0 to -4	This PM reflects the effort and risks associated with permitting, negotiating with landowners, and coordinating with other agencies for the use of land and/or water. It reflects a range of implementation considerations, including permitting cost ($), neighbor relations and the probability of successful implementation. A score of 0 reflects an alternative requiring minimal effort with little risk of implementation failure, and -4 reflects high effort accompanied by a risk of not achieving full implementation.
Learning This objective reflects an interest in continual learning to improve the benefits from management actions.	Learning Potential – Plover and Tern Reproductive Success	Learning Potential Scale	3-point scale: 0 to 2	The potential to evaluate differences in plover and tern use and reproductive success from different plover and tern habitat creation and maintenance activities. In particular, the scale considers the ability to learn about incremental performance differences between on-channel and off-channel habitat. This PM is very simple and intended only to flag general differences in learning potential between alternatives. Further analysis would be required if differences in learning potential become key drivers of the final decision.

5 Modelling and estimating consequences

The Plover and Tern Habitat and Population Model provided the basis for estimating consequences relative to the plover, tern, and management cost objectives. The model uses the amount of on-channel and off-channel habitat available for plovers and terns in the AHR (including habitat to be built) to predict reproductive success as a function of hydrologic conditions and other species-specific parameters. The model simulates all outputs for a 50-year period based on flow data from 1964 to 2013. It includes Program habitat as well as the existing non-Program off-channel habitat for the purpose of modeling AHR breeding population (Figure 3 provides a fuller list of inputs and key parameters).

Figure 3. Inputs and outputs of the Plover and Tern Habitat and Population Model.



Constructed scales were developed for each of the other PMs, and refined by the TAC. Preliminary scores for each alternative (discussed below) were assigned by EDO, and revised based on input from the TAC. A set of PM info-sheets, which summarize how each PM is calculated, including key assumptions and uncertainties associated with the tern and plover model, are given in Appendix A.

6 Exploring Uncertainties

Several key areas of uncertainty associated with the tern and plover model influenced deliberations during early rounds of alternative development (described in section 7, below). The first was relative to reproductive success, as described by fledge ratios, of both terns and plovers nesting on on-channel habitat. The second was the habitat utilization function, which describes the relationship between flow in the channel and the utilization of available on-channel habitat by both species. Because both of these uncertainties relate to on-channel habitat only, the degree of influence they exert on the estimated outcomes is proportional to the relative proportion of on- to off-channel habitat available.

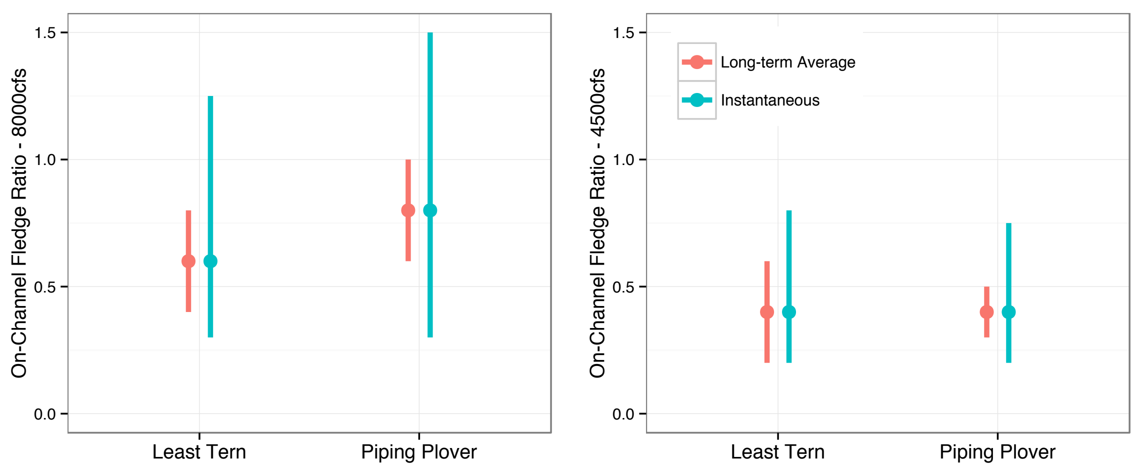
In order to test whether these uncertainties were relevant for decision making, we:

- Gathered available information on the uncertain parameter;
- Developed an estimate of the range of possible values for the uncertain parameter, using a combination of existing data, literature review and expert judgment;

- Conducted a sensitivity analysis to test to what extent the performance of the alternatives was sensitive to the range of uncertainty.

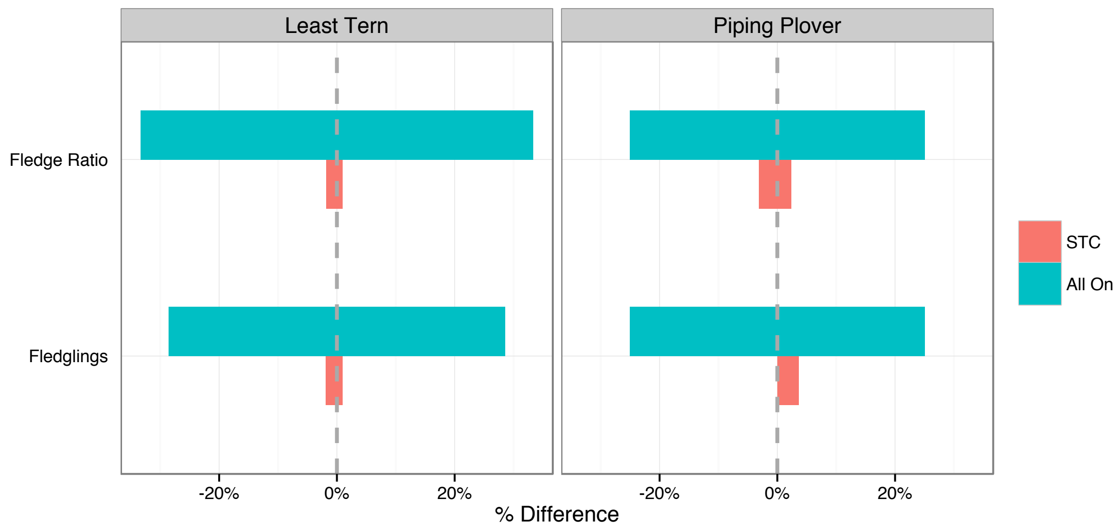
For tern and plover fledge ratios, we conducted an elicitation process to define best estimates, following recognized best practices for expert elicitation (summarized in McBride and Bergman, 2012, and explained in greater detail in Appendix B). To initiate the process, we used a single expert – Dave Baasch, a biologist with the PRRIP EDO. The elicitation was designed so that it could be replicated, in the event that further analysis of uncertainty proved necessary. Following an extensive literature review, we conducted an elicitation interview to define the highest plausible, lowest plausible, and best-guess values for single-year and long-term average fledge ratios for terns and for plovers. Additionally, we asked about the difference in expected fledge ratios for in-channel islands that are overtopped at 8000cfs versus those that are overtopped at 4500cfs in an effort to quantify the effects of alternative kinds of on-channel habitat on fledge ratios. Results are shown in Figure 4, below. As expected, uncertainty in any given year (instantaneous) was larger than for the long term average (over 50 years). Of note, the estimated fledge ratio was substantially lower at 4500 cfs than at 8000 cfs.

Figure 4. Results of the tern and plover fledge ratio elicitation process. Points represent best guesses and lines represent the range defined by the highest and lowest plausible values.



Because there still remained a high degree of uncertainty regarding on-channel fledge ratios, we performed a sensitivity analysis of that data to help determine whether more refinement could prove useful for the decision. Using the highest and lowest bounds identified in that exercise, we calculated the proportional effect on total fledge ratio (i.e., across the entire area, averaged over on- and off-channel habitat), and the predicted number of fledglings produced over 50 years for two initial alternatives – one using only on-channel habitat ("All On") and for the status quo alternative ("Stay the Course [STC]", Figure 5). Results of this sensitivity analysis (shown in Figure 5) indicated that the change in performance for alternatives relying on a high proportion on off-channel habitat (~30% for STC) was less than 5%, while the effect on alternatives with high amounts of off-channel habitat was much larger. However, subsequent decisions to eliminate alternatives with a large proportion of on-channel habitat (described in section 8) negated any need to refine these estimates further.

Figure 5. Proportional effect on two model outcomes of highest and lowest estimates for on-channel fledge ratios for least tern (left panel) and piping plovers (right panel), relative to two alternatives.



For the uncertainty associated with the habitat utilization function, we conducted a group elicitation with four members of the TAC (Jim Jenniges, Mark Czaplewski, Mark Peyton, Matt Rabbe) to refine estimates for the habitat utilization curve. In this case, the panel collectively reviewed data describing discharge during the nest initiation period, the proportion of habitat utilization for each year between 2007 and 2015 for each species separately, and specific hydrologic conditions (i.e., timing & duration) for the high and low ends of the spread in the data. The panel also discussed theoretical constraints on the upper limit of hydrologic conditions that could increase habitat utilization, including hydrologic conditions they believed would lead to (a) 0% habitat utilization and (b) 100% habitat utilization.

The panel identified a curve where habitat utilization is greater than 0% at 600cfs or above, and where habitat utilization reaches 100% at 1600cfs. For the alternatives under consideration (for similar reasons as described above) the effects of the uncertainty in the starting and ending points of that curve were small enough to ignore.

7 Alternatives

Within the scope of this decision process, there were several kinds of management actions (identified as “means” in Figure 1, summarized in Table 2) that could be mixed and matched to create complete alternatives. Specific alternatives were built by considering logical combinations of on-channel, off-channel, and flow augmentation actions.

In all, the GC and TAC considered four rounds of alternatives, where each round was refined based on input from the TAC and/or GC (Table 3). The first round of alternatives was focused on learning about the relative contributions of different combinations of on and off channel habitat, and the interaction between flow management actions and on-channel reproductive success. Based on these lessons, we were able to develop a set of value-focused alternatives, which sought to find the best-performing alternatives for different objectives (i.e., what would a least-cost alternative look like and how would it perform with respect to the other PMs, what would an alternative designed for very ambitious improvements in tern and plover productivity look like, etc.). The components of these alternatives were then mixed and matched in a third round of alternatives that demonstrated different ways to balance across multiple objectives. This round was further refined to clearly illustrate the key trade-offs between management costs, plover reproductive success, and other important objectives in a small set of alternatives.

Though we presented several discrete alternatives for consideration at each round, in reality there exists a more continuous range of possible choices about the quantity of habitat – in particular, off-channel habitat. The alternatives presented were intended to focus discussion on key trade-offs associated with different strategic directions, and to get direction for the next round of alternatives.

Table 2. Possible habitat management actions.

Habitat Management Categories	Components	Range of Options
On-Channel Habitat	Amount of Habitat	• Range: 0 – limit of the channel
	Kind of Habitat	• Conventional • MCA[3]
Off-Channel Habitat	Amount of Habitat	• Range: 0 – limit of the budget
	Method and timing of habitat creation	• New Construction • Rehabilitated Sandpit • Mine-Operator Agreements
	Method of land acquisition	• Use Existing PRRIP land • Lease • Fee-title Purchase
Flow Augmentation	Duration	• Nest Initiation period (terns and/or plovers) • Brood rearing period (terns and/or plovers)
	Amount	• US Fish and Wildlife Service (USFWS) target flows • Other flow targets (including 0).

[3] The moving complexes approach involves creating habitat in a reach by either de-vegetating existing islands, or maintaining newly formed islands vegetation-free, allowing the habitat to erode, and then moving on to create new habitat in a different reach.

Table 3. Four Rounds of Alternatives and Key Questions Explored

	Focus	Representative Alternatives and Questions Explored
1	**Exploring** (TAC) - Are the models working? What are the key relationships and uncertainties? Do the Objectives and PMs adequately address the things that matter?	• Stay the Course – What are we currently doing and what happens if we keep doing it? • All on-channel, no off-channel habitat, and vice versa – What's the relative contribution of on versus off-channel habitat? What are the key uncertainties? Will they affect decision making?
2	**Value-focused thinking** (GC) – What are some creative options? What happens if we focus on specific objectives and try to maximize those outcomes? Can we refine the alternatives and eliminate some things from further consideration?	• Cost – What's the least cost way to maintain what we have? How much can we achieve if we stay on existing Program land? • Tern/Plover Productivity – What happens if we try to double T/P productivity? • Whooping Cranes and Sediment (MCA Approach) – How could we do on-channel habitat for T/P in a way that would also benefit WCs and Sediment? • Implementation Risks – How can we design an MCA Approach that will be feasible?
3	**Refining and balancing** (TAC) – Can we refine the alternatives to maximize benefits and reduce trade-offs? Can we refine our understanding of the consequences?	• Off-channel Habitat - Leasing, buying or staying on existing Program land – Which is best? How much is enough? • Flow Releases – What are the benefits and costs of releasing water for terns and plovers? • Plover Recovery – Given the estimated plover productivity PMs, which alternatives best support the FWS Plover Recovery Plan?
4	**Fine-strokes and final trade-offs** (GC) – which alternatives deliver the best balance across objectives?	• Off-channel Habitat – Using a combination of leasing, buying and staying on existing Program land to address finer-stroke objectives like maximizing distribution of habitat throughout the reach, minimizing undesirable land conversions, etc. • On-channel habitat component – Do the benefits of the MCA Approach to on-channel habitat outweigh the costs? • Flow Releases – Is there value in releasing water for terns and plovers?

8 Key Findings, Trade-offs, and Decisions

Key findings from each round of alternatives are summarized below.

Round 1 – Exploring (TAC)

The focus at this stage was on confirming that the models were working and the draft PMs were reporting what TAC and GC members needed to see. Alternatives included simple bookends (e.g., all on-channel habitat, all off-channel habitat, etc.), technical concepts (e.g., new ways to do on-channel habitat), and other approaches more designed to help explore key relationships and uncertainties than to represent real alternatives. This preliminary round of alternatives was developed by Compass and EDO and reviewed with the TAC. Key findings included:

- **Models and PMs.** The TAC supported the tern/plover model for use in this decision, as well as the set of PMs used to report on the decision objectives, with minor changes that were made by Compass/EDO.
- **Relative Contribution of On and Off-Channel Habitat.** The contribution of on-channel habitat to productivity is small and uncertain relative to off-channel. On its own, on-channel habitat will not support tern and plover populations (i.e., low fledge ratios, intermittent habitat availability).
- **Effect of Uncertainty on Decision Making.** Analysis by Compass/EDO identified fledge ratios and habitat utilization curves as key uncertainties associated with on-channel habitat (see section 6 for details). Ultimately this analysis suggests that for any alternative that includes an off-channel habitat component, the effect of on-channel uncertainties is dwarfed by off-channel effects. The TAC concluded and proposed to the GC that these uncertainties are a low priority for refinement *unless* the GC wishes to consider alternatives that are composed of on-channel habitat only or primarily.
- **MCA On-Channel Habitat.** As a result of input from the initial interviews, the Round 1 alternatives included a novel approach to creating on-channel habitat, labelled "MCA" (see footnote, section 7). Several members of the TAC and GC were interested in further exploring the MCA alternative for on-channel habitat. While MCA is not expected to produce measurable direct benefits for terns and plovers, it may provide indirect benefits and does produce co-benefits for whooping cranes and sediment. The preliminary MCA approach was refined with input from the TAC.
- **Flow Actions for Terns and Plovers.** There is no evidence to support a relationship between brood rearing flows and productivity. However there is some evidence for nest initiation flows and these warrant further exploration.
- **Whooping Cranes, Sediment and Pallid Sturgeon.** Preliminary modeling and analysis shows that different ways to develop on-channel habitat for terns and plovers have different implications for whooping cranes and sediment (PMs were sensitive to change in the alternatives). They were thus retained in the decision framework. It remained uncertain whether pallid sturgeon would be sensitive to the alternatives under consideration and the Service indicated they would provide clarity for subsequent rounds.

As a result of Round 1, modeling assumptions and PMs were refined, key uncertainties were explored and documented, and new alternatives prepared for Round 2.

Round 2 – Value-Focused Thinking (GC)

The focus at this stage was on exploring what was possible with respect to different decision objectives, clarifying the consequences and trade-offs, and narrowing the range of alternatives under consideration based on consideration of the key trade-offs. The GC reviewed the Round 2 Consequence Tables, and focused on the following questions:

- **Does the GC want to consider alternatives that contain only on-channel habitat?** The GC accepted the findings of the TAC that the contribution of on-channel habitat only is small and uncertain, and cannot sustain tern/plover populations. Alternatives that included on-channel habitat only were removed from consideration.
- **Does the GC want to consider alternatives that include conventional on-channel habitat?** The GC considered the relative merits of on-channel habitat produced by conventional methods and by the

new MCA method. USFWS indicated a preference for MCA habitat over conventional on-channel habitat, as a means of better balancing outcomes for terns/plovers and whooping cranes. They believe that the loss in tern/plover productivity and lower opportunities for learning under MCA (relative to conventional) are offset by the gains for whooping cranes. MCA is also lower in cost due to the limit of 10 acres. The GC discussed and recognized that an alternative that provides only 10 acres of on-channel habitat per year (the maximum feasible habitat under MCA) will produce very few birds, which will significantly reduce the ability (or lengthen the timeline required) to answer Big Questions. They discussed the value of learning, noting how insensitive the relative performance of alternatives is to changes in uncertain parameters. The GC concluded that MCA habitat (with a maximum of 10 acres) is preferred to 82 acres of conventional habitat, and removed consideration of conventional habitat from further consideration. A final decision on whether to support MCA was deferred to the June meeting.

- **Is more analysis of key uncertainties needed?** As a result of this decision, no further analysis of on-channel uncertainties was required.
- **Does the GC want to consider alternatives that include brood rearing flows?** Based on the input of the TAC (Round 1), the GC concluded that it does not want to further explore brood rearing flows.
- **Does the GC want to include a nest initiation flow (do the benefits outweigh the costs)?** The GC reviewed the performance of alternatives with and without a nest initiation flow. With only 10 acres of on-channel habitat, the change in productivity associated with nest initiation flows is well below the MSIC[4] (e.g., the PMs do not report a benefit associated with a nest initiation flow). In light of the opportunity cost of using water for terns and plovers, the GC directed Compass/EDO and the TAC to develop and evaluated nesting flow alternatives that would use less water (e.g., using water for plovers only; using water only in some years; etc.). To inform its decision, the GC also requested a short summary of other opportunities to use water, to help them think about the potential value of water in other uses (e.g., % of water that would be used for target flows for WCs, etc.).
- **Is any further analysis of effects on Pallid Sturgeon required?** Based on input from the USFWS, the GC agreed to change the Pallid PM to "change in risk to pallid sturgeon" (Yes, No, Maybe) and to assign a score of "maybe" to alternatives that involve flow. No additional analysis was identified as possible or required within the scope of this process.
- **For the remainder of the First Increment, how much off-channel habitat is enough for terns/plovers**? Across the off-channel alternatives, the relationship between cost and birds is linear (no breakpoints). In consideration of available budget, the GC agreed to not consider land acquisition in excess of the current budget of $1.5 million. This eliminates the alternatives that double tern and plover abundance from further consideration. The GC noted that at its final meeting it will need to make a value judgment about how much to spend, based on a) current budgets and other priorities, and/or b) what is the Program's target or measure of success. To inform this decision, the GC discussed various definitions of success. In light of the newly released Draft Plover Recovery Plan, the GC noted that the recovery criterion of "stable or increasing populations" may provide useful context,

---

[4] Minimum Significant Increment of Change. This is a user-defined (TAC) value that represents the minimum increment of difference in the performance of two alternatives thought to be significant for decision making. It reflects technical judgments about the precision of modeling as well as value judgments about the magnitude of change that merits decision maker attention when choosing among alternatives. This value is used in the presentation of colour-coded consequence tables to focus attention on significant differences between alternatives.

and directed the TAC to review the Round 3 alternatives and assess the extent to which each alternative meets this criterion.

These decisions substantially narrowed the scope of alternatives under consideration. The GC directed Compass and EDO to a) develop a refined set of alternatives that explored different ways (mechanisms, amounts and timing) of acquiring off-channel habitat and b) develop alternatives related to plover nesting flows.

Round 3 – Refining and Balancing (TAC)

The alternatives considered and associated key findings at Round 3 are summarized below.

Different ways to acquire off-channel habitat. As directed by the GC, the TAC considered three possible ways of acquiring off-channel habitat – using Program land only, leasing new land, and purchasing new land. They found that the differences were small and that once the GC sets a habitat acreage target, the best acquisition strategy will depend on the availability of particular parcels, and is likely to be guided by more fine-grained considerations not included in the consequence table (such as improving distribution of habitat throughout the reach, minimizing undesirable land conversions, maximizing site size, etc.). Therefore, the TAC recommended that the GC set an acreage target, and provide EDO with the guidance and flexibility to find a combination of parcels that strike the best balance across those other considerations. A new alternative was developed to reflect this input.

Achieving the recovery target. The FWS concluded that the all alternatives that add off-channel habitat meet the FWS criterion of achieving a "stable or increasing population". Alternative A1, which relied on existing off-channel habitat only, did not satisfy this criterion.

Plover nest initiation flows. As directed by the GC, EDO/Compass identified and modeled various methods of using flows for plover nest initiation (see *Nest Initiation Flow Alternatives Summary*). The TAC concluded that: a) the benefits of flow releases for plovers are small, b) among the alternatives modeled, there is no clear winner (none with high benefit and low cost), and c) the opportunity cost of plover nest initiation flows is high (in most years, it would preclude use of water for other beneficial uses). The TAC concluded that a) the release of water for plover nest initiation is not generally justified on the basis of the estimated benefits for plovers; b) that such releases should in general be considered a lower priority than released for other purposes ; c) that the most efficient use of water for plovers occurs in years immediately after a flood year when there is new naturally-formed habitat; d) that is water is released for plovers, even under the most favorable conditions, the benefits, if any would not be measurable.

Round 4 – Fine Strokes and Final Trade-offs (GC)

The GC addressed three decisions at Round 4: a) How much off-channel habitat, b) Whether to include an MCA on-channel component, and c) Whether to include a flow component. The process and outcomes of this final decision are described in section 9. The GC reached a consensus agreement on all three decisions.

9 Exploring Preferences

The GC met to review the Round 4 alternatives and select a preferred alternative in June, 2016. The half-day workshop had three sessions including a Decision Process Recap (brief review the decision process to date, with emphasis on recent updates to the objectives, performance measures, and consequence estimates), a Summary of Decisions Required (summary of each of the individual decisions the GC would be making, with time for questions and discussion), and a Preference Elicitation Exercise (eliciting preferences for the alternatives under consideration and a discussion of areas of agreement and disagreement). In order to ensure that decisions were informed, transparent and stable, GC members were asked to:

1. Complete a preference questionnaire**.** This is an individual exercise intended to quickly establish preference trends in the group. GC members were asked to rank and score the alternatives in order of preference.
2. Discuss ranks and scores. Individual questionnaire responses were collated during a short break and used to clarify areas of agreement and difference, focus the discussion on key trade-offs, and seek solutions that could lead to a consensus.
3. Indicate degree of support for the alternatives. After discussion, GC members were given time to caucus, and then each voting group was asked to indicate which alternatives they support, using a three-point scale: *Endorse* (This is a great alternative), *Accept* (I can live with / support this alternative), or *Oppose* (I can't support this alternative).

The questionnaires were used only to facilitate discussion. During the discussion, GC members shared perspectives and in some cases adjusted preferences, either based on what was learned or as a means of seeking a compromise that would be acceptable to the group.

Decision 1: Off-channel habitat

The Round 4 alternatives are summarized in Table 4 and consequences are shown in Figure 6. While there is a continuum of habitat options available, the Round 4 alternatives crystallize the key trade-offs:

- Maintain existing off-channel habitat; do not add more (A1). This preserves First Increment budget (Total Short Term Cost) but does not meet the plover recovery plan criterion (Average Breeding Pairs).
- Add the maximum off-channel habitat possible within the budget (C1). This meets the plover recovery criterion and provides maximum benefits for plovers and terns, but uses all the budget.
- Add an intermediate amount of habitat (C6). This alternative represents a midpoint that takes advantage of likely leasing sites. It meets the plover recovery criterion and preserves some of the First Increment budget. There is slightly more implementation effort and uncertainty associated with leasing.
- Stay the Course is shown for reference only. It estimates the effects of continuing the current approach to on and off-channel habitat. All three alternatives incur lower cost in the long term than STC (Total Long Term Cost).

Table 4. Round 4 alternatives

Alternative	Description	Off-channel (acres)
STC	**Stay the Course** – continue to maintain current levels of permitted on-channel and off-channel habitat for the remainder of the First Increment.	
A1	**Maintain existing off-channel habitat only on Program-owned land;** discontinues the creation and maintenance of on-channel habitat islands.	102
C6	**Hybrid** approach to acquiring an **additional 60 acres** (modeled assuming 20 acres on existing Program land; 20 acres purchased; 20 acres leased)	162
C1	**Purchase an additional 90 acres** of off-channel habitat (modeled by purchasing land and using lowest cost habitat construction method, up to $1.5M budget)	192

Figure 6. Round 4 Consequences - Off-channel Habitat

Objective	Performance Measure	Units	Dir	STC: 42 / 102	A1: 0 / 102	C6: 0 / 162 (hybrid)	C1: 0 / 192
Piping Plovers							
Program Repro Success	Average Breeding Pair (BP)	#/year	H	22	18	28	31
	Total Fledglings over 50 yr	#	H	1,420	1,271	1,964	2,175
Interior Least Terns							
Program Repro Success	Average Breeding Pair (BP)	#/year	H	97	91	139	155
	Total Fledglings over 50 yr	#	H	5,187	4,992	7,669	8,546
Management Cost							
Total Long Term Cost	NPV (50 yrs)	1000$	L	$3,000	$532	$1,835	$2,229
Total Short Term Cost	2017-2019 Cost	1000$	L	$123	$34	$941	$1,477
Implementation Effort							
Implementation Costs/Risks	Implementation Scale	-4 to 0	H	0	0	-2	-1

Legend

- Better than selected
- Worse than selected
- Selected

After reviewing the consequence table, GC members completed a preference questionnaire. All but three of the GC members selected C6 as their preferred alternative. All those who did not choose it as their preferred, selected it as their second-best alternative. Those preferring C6 viewed it as a good balance between achieving significant plover and tern benefits, including meeting the plover recovery criterion, while preserving some discretionary Program budget for other actions. They also noted concerns about potentially controversial land conversions that would likely be required under C6. Those preferring C1 did so primarily because they placed a high weight on long term performance (especially plover and tern productivity and total long term cost), and lower weight on short term cost. One person preferred A1, feeling that good progress had been made to date on plover/tern productivity and that other Program activities should be given priority for the remainder of the First Increment. After discussion, the group unanimously agreed to remove A1 from further consideration as it did not have much potential to be a solution that would be broadly supported.

Decision 2: On-channel Habitat

The second major decision was whether to include the MCA component or not. The MCA component can be added to any off-channel habitat. The incremental costs and benefits are the same, regardless of which off-channel habitat is selected. Figure 7 summarizes the key costs and benefits associated with MCA, here shown relative to each of A1, C6 and C1.

Figure 7. Consequence Table for MCA On-Channel Component

Objective	Performance Measure	Units	Dir	A1: 0 / 102	A1-M: 10+ / 102	C6: 0 / 162 (hybrid)	C6-M: 10+ / 164	C1: 0 / 192	C1-M: 10+ / 192
Piping Plovers									
Program Repro Success	Average Breeding Pair (BP)	#/year	H	18	19	28	29	31	32
	Total Fledglings over 50 yr	#	H	1,271	1,305	1,964	1,998	2,175	2,210
Interior Least Terns									
Program Repro Success	Average Breeding Pair (BP)	#/year	H	91	93	139	141	155	158
	Total Fledglings over 50 yr	#	H	4,992	5,049	7,669	7,701	8,546	8,603
Management Cost									
Total Long Term Cost	NPV (50 yrs)	1000$	L	$532	$1,218	$1,835	$2,520	$2,229	$2,915
Total Short Term Cost	2017-2019 Cost	1000$	L	$34	$60	$941	$966	$1,477	$1,502
Whooping Crane									
Habitat Use	Habitat Suitability Scale	-3 to +3	H	1	2	1	2	1	2
Sediment									
Contribution to Sediment Supply	Sediment Supply Scale	-2 to +2	H	0	2	0	2	0	2
Implementation Effort									
Implementation Costs/Risks	Implementation Scale	-4 to 0	H	0	-3	-2	-3	-1	-3
Learning									
Learning Potential	Learning Potential Scale	0 to 3	H	0	1	0	1	0	1

Legend
Better than selected
Worse than selected
Selected

In this case, the results of the questionnaire indicated that preferences were divided. Four people preferred to include an on-channel MCA component; ten preferred not to. The rationale for supporting an on-channel MCA component was generally driven by higher importance placed on the PMs for whooping cranes, sediment and learning. Specific reasons included:

- MCA delivers multiple benefits to the whole river system and these are important to consider. In particular, MCA provides habitat benefits for other target species (i.e., whooping crane); if these benefits are not gained via MCA, they will have to be sought via other, potentially more costly/difficult means (e.g., using water).
- The Program has more to learn about on-channel habitat (e.g., questions remain about on-channel nesting).
- The financial cost of MCA is low in relation to the benefits for other species.

The rationale for not including an on-channel MCA component included:

- While there are benefits to whooping cranes and sediment, they are modest. Further, these should be addressed in a different forum. This process was not scoped to do a comprehensive exploration of alternatives for whooping cranes; if it had been, other, more-preferred alternatives might have been identified.
- Learning under the MCA alternative will be limited, as there will be only 10 acres of habitat per year.
- There are concerns that implementing MCA could be more costly than estimated, and the feasibility of finding islands and supportive landowners might be low. Clarifications from EDO somewhat alleviated concern about feasibility (i.e., because the target is limited to 10 acres, EDO views it as feasible, at least over the next three years), but concerns remained about cost.

In response to concerns about the accuracy of the estimated cost, the group refined the definition of the MCA alternative. As modeled, the MCA alternative is estimated to deliver 10 acres of on-channel habitat per year for $26,000 total over three years. For greater cost certainty, the definition of the alternative was refined to explicitly state that it includes a total cost cap of $26,000 and a desired target of at least 10 acres of habitat per year. If costs are higher (or lower) than expected, the actual amount of habitat produced will be lower (or higher).

Final Preferences

After discussion of trade-offs, the GC voting groups caucused to discuss the remaining alternatives. Each voting group indicated whether they would Endorse (full support), Accept (support with reservations), or Oppose (unable to support) each alternative. Results were as follows:

Alternative	Endorse	Accept	Oppose
C6	7	1	2
C6 + MCA	3	7	0
C1	0	5	5
C1 + MCA	0	2	8

Based on these results, the GC concluded that there was little opportunity for a consensus with the C1 alternatives. They noted that there were more Endorses for C6 than for C6+MCA. They briefly explored the reasons for the two Oppose votes for C6, and potential solutions. After discussion, the GC unanimously agreed to adopt "C6 + MCA" as the preferred management action for terns and plovers for the remainder of the First Increment.

10 Decision Summary and Next Steps

Component	Decision – for remainder of First Increment	Implementation Considerations
Off-Channel	The Program will acquire an additional 60 acres of off-channel habitat, within a budget of $xx. Within this budget, EDO has discretion to discretion to acquire land parcels in the most appropriate way (lease, buy, etc.). Considerations will include: cost, timing, certainty, parcel size, parcel location (distribution throughout the AHR), and land conversion issues.	Acquisition decisions will go through the Lands Committee as per usual.
On-Channel	The Program will create and maintain a target of at least 10 acres of on-channel habitat per year using the MCA approach, up to a budget cap of $26,000.	If costs are higher (or lower) than expected, the actual amount of habitat produced will be lower (or higher).
Flow	Water should not be used solely for the purpose of tern and plover nest initiation. However tern and plover benefits could be identified as part of the rationale for water releases made for other purposes.	The USFWS has authority over flows. This is the Program's consensus recommendation to the USFWS.

11 References

McBride and Bergman 2012. What Is Expert Knowledge, How Is Such Knowledge Gathered, and How Do We Use It to Address Questions in Landscape Ecology? *In* Expert Knowledge and Its Application in Landscape Ecology. AH Perera, CA Drew, CJ Johnson, eds. Springer.

Appendix A – Performance Measure Info Sheets

1 PM Info-Sheet: Piping Plovers and Interior Least Terns

Sub-objective: Reproductive Success			
Candidate Performance Measures	**Units**	**Description**	**MSIC[1]**
PRRIP Breeding Pairs	#/year	Primary PM: The number of breeding pairs nesting on PRRIP habitat in the Associated Habitat Reach (AHR) in a year. The PM reports the average for the 50-year simulation period.	10%
PRRIP Total Fledglings	#	Alternate PM: The total number of fledglings produced on PRRIP habitat over the 50-year model simulation period. The PM indicates the PRRIP contribution to the global population over time.	10%

Performance Measure Summary

These performance measures reflect the effects of management actions on the population and reproductive success of plovers and terns in the AHR. Other indicators such as annual habitat availability were considered but not included because species-centric metrics more directly address the Program's management objective of increasing species productivity.

The average breeding pairs PM reports the number of annual PRRIP breeding pairs, which is an indicator of the Program's contribution to the overall plover/tern population in the AHR.

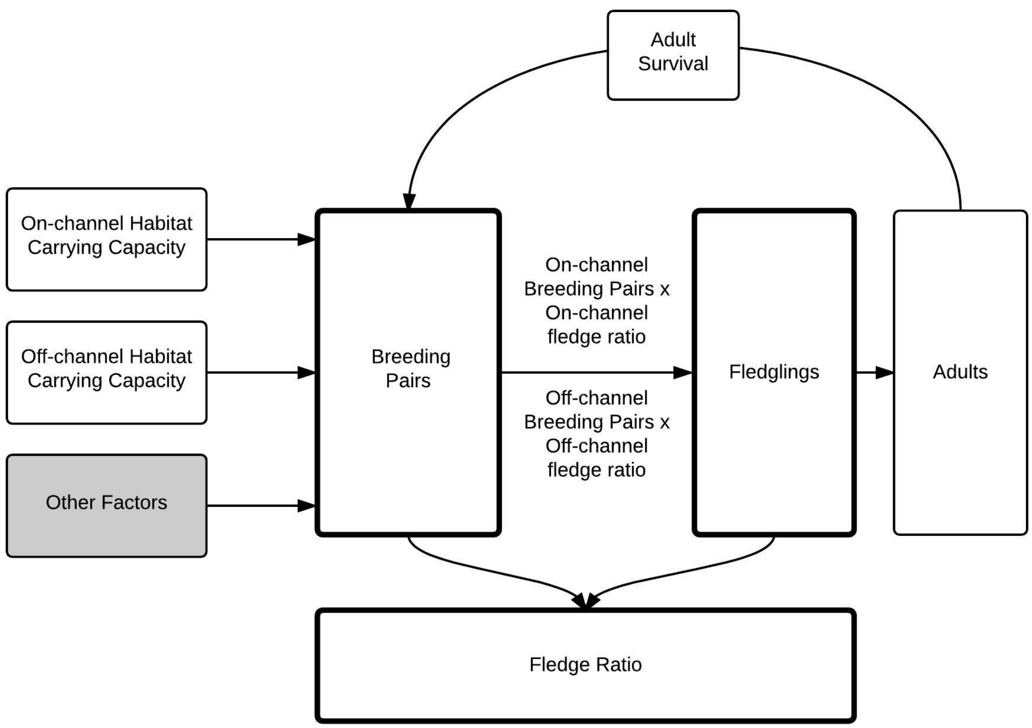
Different management actions – particularly those relying on off-channel habitat – produce population results at different speeds. Because these differences in fledgling production compound on each other, we also report the total number of fledglings produced over the 50-year simulation period. The absolute number of PRRIP fledglings is an indicator of the Program's long-term contribution to the global plover and tern populations.

[1] Minimum Significant Increment of Change. This is a user-defined value that represents the minimum increment of difference in the performance of two alternatives thought to be significant for decision making. It reflects technical judgments about the precision of modeling as well as value judgments about the magnitude of change that merits decision maker attention when choosing among alternatives. This value is used in the presentation of colour-coded consequence tables to focus attention on significant differences between alternatives.

The reproductive success PMs are estimated using the Plover and Tern Habitat and Population Model. This model is a population-based model of the AHR, and therefore includes the effects of actions on both Program and non-Program habitat. The PMs (# breeding pairs and # of fledglings) are shown for the Program lands only (PRRIP). Since this SDM process is focused on Program actions, the plover/tern PMs are reflective of the Program contribution to the overall AHR plover/tern numbers.

The AHR is habitat limited for plover and tern nesting. Increasing the amount of on-channel and off-channel habitat increases the number of breeding pairs in the AHR, a portion of which nest on Program lands. The influence diagram in Figure 1.1 provides a simple illustration of the relationships between habitat, breeding pairs, fledglings, and fledge ratios.

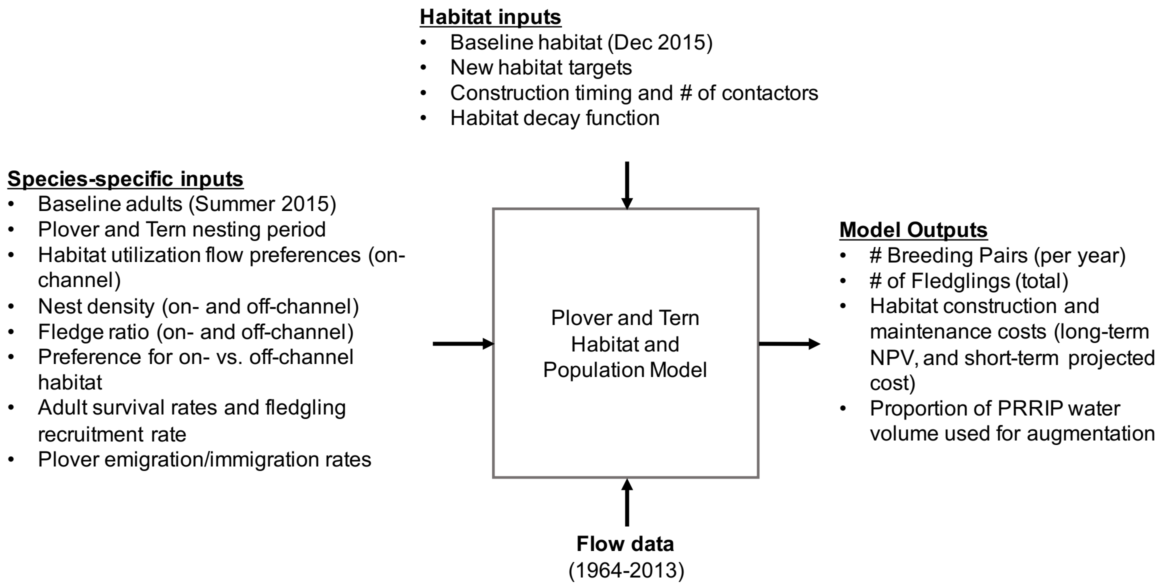
Figure 1.1: Influence Diagram for terns and plovers



Calculations and/or Scoring

The PMs are estimated using the Plover and Tern Habitat and Population Model. The model is driven by the amount of on-channel and off-channel habitat available for plovers and terns in the AHR and predicts reproductive success as a function of hydrologic conditions and other species-specific parameters (Figure 1.2 provides a more complete summary of model inputs and outputs). The model simulates a 50-year period based on flow data from 1964 to 2013. The model includes Program habitat as well as the existing non-Program off-channel habitat for the purpose of modeling AHR breeding population.

Figure 1.2: Conceptual Diagram – Plover and Tern Habitat and Population Model



The steps to calculate these PMs are:

1. **Nesting Habitat:** Determine the amount of total nesting habitat available in each breeding season during the simulation period as a function of existing habitat, loss of habitat from erosion, hydrologic conditions, and speed at which habitat can be created.

2. **Carrying Capacity:** Determine the carrying capacity for on- and off-channel habitat as a function of maximum plover and tern nest density and habitat utilization. On-channel habitat utilization is modeled using the relationship between flow and nest initiation observed through Program monitoring (explained in more detail in next section). Off-channel utilization is a set value determined by the model user.

3. **Global Population:** Determine the AHR's global population in each simulation year based on numbers from the previous year, # of fledglings, juvenile and adult survival rates, and the % of global population lost during periods when no habitat is available. Note that the model does not yet include plover emigration/immigration in global population calculations.

4. **Breeding Pairs:** Determine the number of plover and tern breeding pairs that nest on the available on- and off-channel habitat in the AHR. This number is bounded at the high-end by the carrying capacity determined in Step 2. A key assumption here is the extent to which plovers and terns prefer on-channel vs. off-channel nesting habitat. The default value in the model is that there is no preference and plovers/terns choose nesting sites in proportion to the area available for each habitat type (off- and on-channel).

5. **Fledglings:** Determine the number of AHR fledglings for each breeding season by multiplying the number of breeding pairs nesting on-channel and off-channel by their

respective on-channel and off-channel fledge ratio. These annual fledgling numbers are summed over the 50 year simulation period.

Key Assumptions and Uncertainties

Key parameters and functions in the Habitat and Population Model that are supported with Program data include:

- **On-channel Habitat Utilization Function**: Program monitoring indicates there is a relationship between flow during the nest initiation period and utilization of on-channel habitat. When discharge has been very low during the majority of the nest initiation period (<600 cfs), available on-channel habitat has not been used. When discharge has exceeded ~1,600 cfs during the majority of the nest initiation period, on-channel habitat has been fully utilized. The model assumes a linear utilization relationship based on average discharge during the nest initiation period for each species. If average discharge is ≤ 600 cfs, 0% of on-channel habitat is utilized. If average discharge ≥ 1,600 cfs, 100% of habitat is utilized.[2]

- **Fledge Ratios:** The fledge ratios for on- and off-channel used in the model are based on Program monitoring from 2001-2015 as well as a literature review of fledge ratios on sandpit and sandbar habitats in other regions. The number of observations in the Program dataset for on-channel fledges is significantly lower (n=26 for plovers and n=15 for terns) than for off-channel fledges (n=464 for plovers and n=960 for terns), contributing to a higher level of uncertainty for the on-channel fledge ratio. A structured expert elicitation interview was conducted to provide an estimate for fledge ratios under alternative island height conditions. This revised estimate is used for alternatives where the island construction height is lower than the Program has typically built habitat islands in the past (up to floodplain elevation).

- **Incubation/Rearing Flows:** Program monitoring has not found a relationship between flows during the incubation and rearing period and fledgling success. While the Habitat and Population Model includes an option to include incubation/rearing flows, these flows do not affect fledging or breeding pair numbers at this time.

- **Preference between on- and off-channel:** It has been hypothesized that plovers and terns may show a "preference" for either on- or off-channel habitat and select that habitat at a proportionally-higher rate. Program monitoring data does not currently indicate a strong preference toward either habitat type. Accordingly, the model assumes the breeding population nests on each habitat type proportionately to its availability if habitat availability is sufficient to accommodate all breeding pairs and on-channel flows are high enough to support full utilization of on-channel habitat.

- **Habitat Loss Function:** Habitat loss equations are included in the Tern and Plover Habitat Model to determine the extent to which habitat has to be continually rebuilt to meet an

---

[2] Daily discharges are capped at 1,600 cfs for the purposes of utilization calculations. This removes the potential for utilization to be skewed upward by very high discharges.

alternative's target acreage of on-channel habitat. The model simulates on-channel habitat loss during the winter due to flow and ice action as well as accelerated habitat loss due to overtopping and lateral erosion during high discharge periods. Winter habitat loss is user-defined as a percent of total on-channel habitat at the end of the fall construction period (default is 28%). Accelerated high flow losses are calculated for each day that flow exceeds a user-defined threshold (default is 4,000 cfs). The winter and accelerated high flow habitat loss parameters were developed using observed data from both wet and dry years.

Key assumptions and uncertainties in the modeling that result from data limitations are:

- **% Breeding Pop. Lost Per Yr >1 Yr No Habitat (Habitat Loss Emigration):** During periods when no nesting habitat is available in the AHR for more than one year, the model assumes that 20% of the breeding population is permanently lost to emigration. This assumption is based on limited data and is only used if an alternative assumes that non-Program off-channel habitat is no longer being maintained.

- **Emigration/Immigration:** Each year, a proportion of the AHR breeding population does not return to the AHR to breed (emigration) and individuals that have previously bred on other systems immigrate to and breed in the AHR. Emigration and immigration rates are very difficult to quantify and are highly uncertain. However, they would affect all alternatives equally. Therefore, effects of emigration and immigration are not included in the analysis.

A summary of the plover and tern variables used in the model is included in Appendix 1.1 to this PM Info-Sheet, along with an indication of EDO's assessment of the uncertainty in the assumed value(s).

Additional Information and/or Context for Interpreting Results

- **Plover Targets.** Lutey (2002) proposes a 10-year running average of 126 piping plovers (63 breeding pair) as a population objective for the Central Platte, which is 45% of the Recovery Plan goal for the entire Platte River. Lutey (2002) also proposes a fledge ratio of 1.13 fledglings/pair to ensure the AHR population is stable to increasing.

- **Tern Targets.** Lutey (2002) proposes a 10-year running average of 300 Least Terns (150 breeding pair) as a population objective for the Central Platte, which is 40% of the Recovery Plan goal for the entire Platte River. Lutey (2002) also proposes a fledge ratio of 0.70 fledglings/pair to ensure the AHR population is stable to increasing.

- **Fledge Ratio implications.** Fledge ratios below the proposed Lutey (2002) objectives may indicate that Program habitat is a population sink for plovers.

References

Lutey, J.M. 2002. Species Recovery Objectives for Four Target Species in the Central and Lower Platte River (Whooping Crane, Interior Least Tern, Piping Plover, Pallid Sturgeon). United States Fish and Wildlife Service.

McGowan, C.P, Catlin, H., Shaffer, T., Gratto-Trevor, C., and Aron, C., 2014. Establishing endangered species recovery criteria using predictive simulation modeling. *Biological Conservation*, *177*, 220-229.

National Research Council. 2005. Endangered and Threatened Species of the Platte River. Committee on Endangered and Threatened Species in the Platte River Basin, National Research Council, National Academy of Sciences. The National Academies Press, Washington, D.C.

Appendix 1.1 – Plover and Tern Habitat and Population Model Variables

Model Parameter*		Plovers	Terns	Unit	Reference	Uncertainty
Nest Initiation Period		5/1 - 6/23	5/28 - 7/12	Month/Day	PRRIP monitoring	Low
Incubation and Brood Rearing Period		6/24 - 8/26	7/13 - 8/30			Low
Peak Nest Initiation Date		5/16	6/12			Low
Density	On-channel	0.4	1.0	breeding pair/ acre	PRRIP monitoring	Medium
	Off-channel	0.2	1.0			Low
Fledge Ratio	On-channel	0.8	0.6	fledge/ breeding pair	PRRIP monitoring & Literature Review	Medium
	Off-channel	1.4	1.1			Low
Adult Survival		78%	92%	% annual	McGowan et al. 2014 (Plovers) / NAS 2004 (Terns)	Medium (Plovers) / High (Terns)
Recruitment		52%	23%	% fledglings reach breeding		Medium (Plovers) / High (Terns)
% Breeding Pop. Lost Per Yr >1 Yr No Habitat		20%	20%	% of breeding pairs	Assumptions – areas for discussion	High
Emigration		2%	2%	% adults & fledglings		High
Immigration		2%	2%	% adult pairs		High
Plovers On-Channel (Preference)		50%	50%	% breeding pairs		High
*The value presented here is used to produce results in the Excel version of the model. Distributions for some of these values are available and results can be produced using Crystal Ball.						

2 PM Info-Sheet: Management Cost

Sub-Objective	Candidate Performance Measures	Units	Description	MSIC[3]
Short-term Management Cost	First Increment cost (total over 2017-2019)	1000$	The total cost of implementing an alternative for the period of the First Increment (2017-2019). This PM serves as an indicator of the impact on the Program budget. It provides an understanding of the short-term financial opportunity cost of investing in plover/tern habitat during the First Increment rather than other PRRIP projects, and includes all short-term costs associated with purchasing or leasing land, and building and maintaining habitat on that land.	10%
Long-term Management Cost	Net Present Value (50 yrs)	1000$	The net present value of habitat creation and maintenance costs assuming the alternative is implemented over a 50-year period. This PM provides a basis for comparing the financial implications of management actions over a range of hydrologic conditions, and includes all long-term land acquisition costs (e.g., regular land leasing payments), and building and maintaining habitat on that land.	10%
Long-term Water Use	Proportion of Program water used	%	The opportunity cost of water used for flow-related actions. This PM reports the average annual proportion of Program water used over the 50-year simulation period for three hydrologic year categories – wet, normal and dry water years.	10%

[3] Minimum Significant Increment of Change. This is a user-defined value that represents the minimum increment of difference in the performance of two alternatives thought to be significant for decision making. It reflects technical judgments about the precision of modeling as well as value judgments about the magnitude of change that merits decision maker attention when choosing among alternatives. This value is used in the presentation of color-coded consequence tables to focus attention on significant differences between alternatives.

Performance Measure Summary

The management cost objective reflects a concern for the wise use of resources. All else being equal, actions that increase tern and plover productivity with lower resource expenditures are preferred. There are two kinds of management costs – financial costs associated with habitat creation or management actions, and water use – the volume of water used for terns and plovers. Money and water used for terns and plovers are not available for use in management actions for other purposes (e.g., whooping cranes, etc.) and thus these objectives also reflect the opportunity cost associated with using resources for terns and plovers.

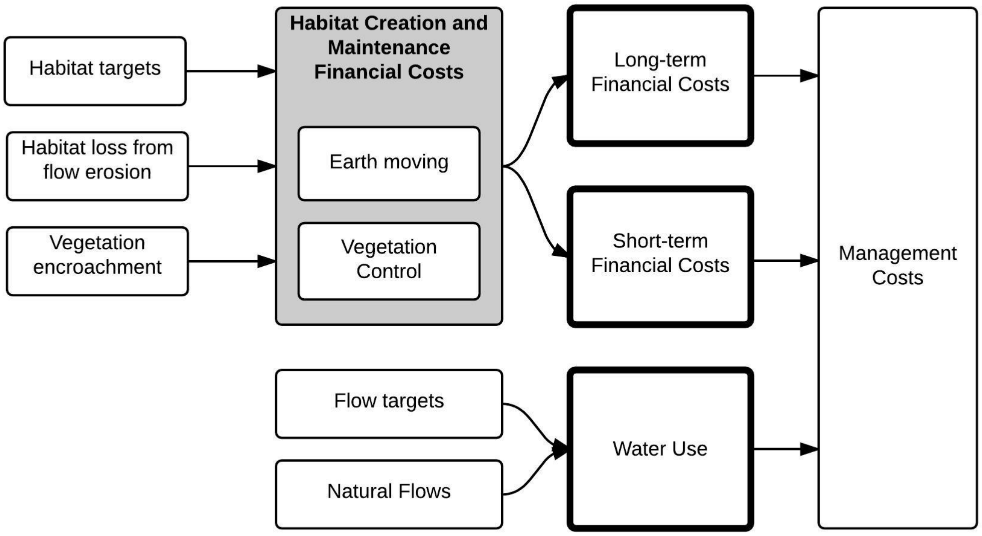
Two candidate performance measures are proposed for financial management cost – a long-term and a short-term cost measure. The long-term cost measure is the net present value of all costs related to habitat creation and maintenance, including land purchases or leases, for the foreseeable future, defined here as 50 years. *Net present value* is a method for bringing cash flows that occur over a number of years into one total cost number (see Calculations section below for more detail). The TAC or GC may want to discuss what time period is most relevant for the purposes of this decision. Generally, the longer the time period, the higher the net-present value cost for on-channel habitat is compared to off-channel habitat (all other things equal). This is because on-channel habitat generally incurs habitat creation costs annually, while off-channel habitat incurs one-time habitat creation costs up-front. In addition, land purchase costs are assumed to occur up front, whereas lease payments are annual. Therefore, the longer the time period considered, the higher the net present value cost of leases will be, compared to land purchases.

In addition to long-term cost implications, short-term costs may also be an important consideration for the GC as they are currently faced with decisions about how to allocate the Program budget. Some alternatives may require more upfront capital costs than others, requiring more of the First Increment budget. The short term cost PM includes all costs, including land purchases or leases, associated with habitat creation and maintenance.

Water costs are measured in terms of the proportion of available Program water used by an alternative. For the purposes of this decision process, “available Program water” consists of water that could be actively managed/released to increase river flow. Details on how available Program water is calculated are included in the next section. This performance measure was not defined in terms of the monetary cost of water because Program water has already been negotiated for the duration of the First increment. In addition to the proportional use, the average augmented volume across all hydrologic year types is included.

The factors influencing management costs are shown in Figure 2.1. Habitat creation and maintenance costs are composed of payments for earthmoving and vegetation removal. The model simulates habitat loss from erosion, and these erosion rates affect the amount of earthmoving activities that need to occur to reach an annual habitat acreage target. Vegetation control is a static annual operating cost. Water use is a result of the flow targets defined in the alternative and the natural flows (less augmentation is needed to reach a flow target in wetter years compared to drier years).

Figure 2.1: Influence Diagram Showing Factors Affecting Management Costs (PMs in bold outline)



Calculations

Long-term Financial Costs

Net present value (NPV) is calculated using the following formula:

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t}$$

where:

T = Total time period
t = year
C_t = habitat creation and maintenance costs during period t, in 2014$
r = discount rate

A discount rate of 3% is used, based on current federal government average interest rates on U.S. Treasury securities.[4]

First Increment Financial Cost

---

[4] https://www.treasurydirect.gov/govt/rates/pd/avg/avg.htm

The First Increment financial cost is simply the sum of costs over the 2017-2019 period for implementing an alternative. Since these are near-term costs and an expenditure in 2017 is not appreciably different than an expenditure in 2019, a net present value calculation is not used.

Given that on-channel habitat costs vary with hydrological conditions, on-channel costs for the 2017-2019 period are estimated as an average of 3-year on-channel costs during the model simulation period (which includes hydrology data for 50 years).

Water Use

The proportion of Program water used by an alternative is calculated by the following steps:

1. **Calculate average Program water available for wet, normal and dry years:** The volume of available water was estimated for wet, normal, and dry hydrologic year types using the combined scoring yields of the Environmental Account, Pathfinder water, and J-2 reservoir. Available Program water was calculated as the average yield (minus a 10% conveyance loss for non-J-2 water) by hydrologic year type over the scoring period of 1947-1994. The results of this calculation for available Program water are:

   - Wet Year: 113,418 acre-feet
   - Normal Year: 96,009 acre-feet
   - Dry Year: 69,791 acre-feet

2. **Calculate volume of augmented water:** For each simulation year, the augmented flow volume equals the difference between the recorded flow at Grand Island and the target flow as defined in the alternative.

3. **Calculate proportion of Program water used:** For each simulation year, flows are augmented to achieve flow target on each day until all available water is used (as calculated in step 1).

4. **Average % water used over simulation period for wet, normal and dry years**.

Key Assumptions and Uncertainties

Financial Costs

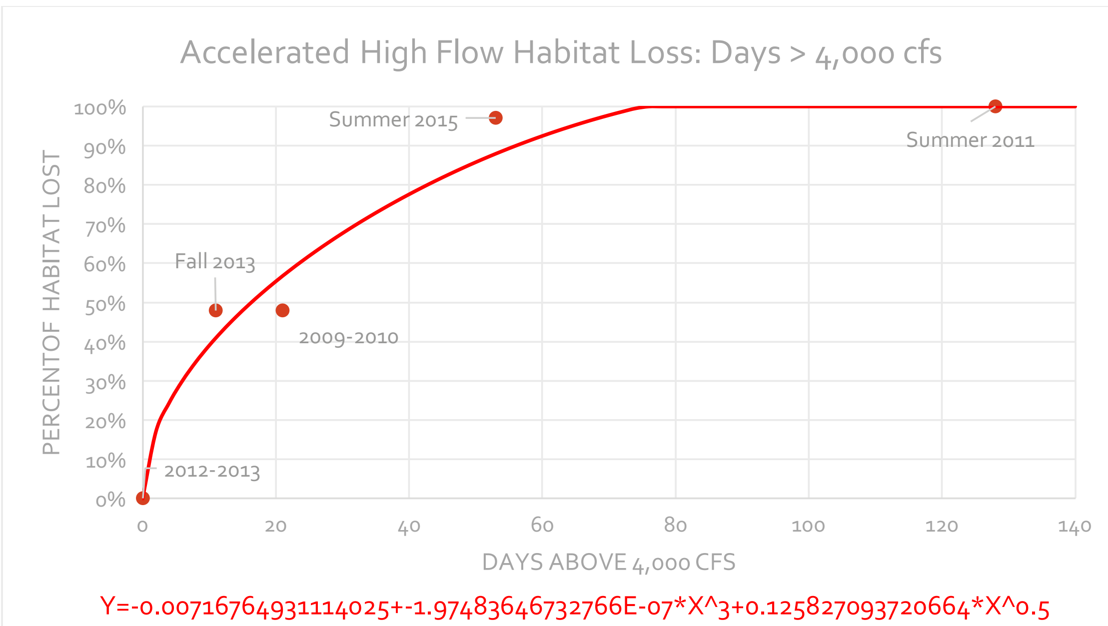
The on-channel and off-channel habitat costs are based on the Program's experience creating and maintaining these habitats during the First Increment. The key assumption underlying the calculation of the financial cost performance measures is that the costs of past habitat creation and maintenance costs can be used to estimate future costs.

The Program began constructing on-channel mechanical sandbar habitat in 2012. Based on this experience (summarized in EDO, 2015), the following parameters are used to calculate on-channel financial habitat costs:

- Average cost of on-channel habitat construction = $3,500/acre when low and high habitat types are roughly equal
- Annual pre-emergent herbicide and follow-up herbicide applications = $300/acre.

The rate of *on-channel habitat loss* is also a key assumption when calculating the total cost of on-channel habit construction. Habitat loss equations are included in the Tern and Plover Habitat Model to determine the extent to which habitat has to be continually rebuilt to meet an alternative's target acreage of on-channel habitat. The model simulates on-channel habitat loss during the winter due to flow and ice action as well as accelerated habitat loss due to overtopping and lateral erosion during high discharge periods. Winter habitat loss is user-defined as a percent of total on-channel habitat at the end of the fall construction period. The parameter value (28%) is based on winter habitat losses observed during the period of 2012-2015. Accelerated high flow losses are calculated for each day that flow exceeds a user-defined threshold (default is 4,000 cfs). The accelerated high flow loss function is presented in Figure 2.2 along with Program observations on habitat loss that were used to develop the function. The habitat loss parameters were developed using observed data from both wet and dry years.

Figure 2.2: Accelerated High Flow Habitat Loss: Days> 4,000 cfs



The Program began rehabilitating and constructing off-channel habitat in 2009. Off-channel habitat construction costs have been quite variable, depending on the amount of vegetation on the landscape, the amount of mechanical earth moving required, and whether or not contractors will accept fill material from the site in lieu of payment. To provide conservative cost estimates, construction costs are based on the high-end of costs experienced by the Program (summarized in EDO, 2015), and are as follows:

- Construction costs (One-time upfront costs):
  - New habitat at existing mining operations = $0 / acre[5]

[5] Note: This habitat is acquired through agreements with mine operators. The Program owns the land and receives royalty payments from mine operators that are generally sufficient to pay

    - Rehabilitation of existing sandpit habitat = $7,500 / acre
    - New mechanically created habitat = $20,000 / acre

- Annual maintenance costs:

    - Pre-emergent herbicide and follow-up herbicide applications = $150 / acre

Habitat loss due to erosion is not expected at off-channel habitat sites under non-flood conditions (EDO, 2015). At high flow magnitudes (i.e. >12,000 cfs), the model includes a damage function to off-channel habitat, and assumes a cost of $750/acre to repair the habitat. In the 50-year simulation period, there are 7 years when these high flows occur.

The Program can and has utilized a variety of approaches to acquire land interests for habitat purposes including management agreements, leases, conservation easements, and fee title acquisition. These approaches vary widely in terms of cost, effort and rights afforded to the Program. Acquiring new land could cost anywhere from $0 to $12,000 per acre depending on the owner's plans for the site and the rights the Program needs. For example, the Program could:

- Buy a sandpit and rehabilitate for a land acquisition cost of $12,000 / acre;
- Lease the site for $200 / acre; or potentially
- Execute a management agreement to rehabilitate and occupy the site during the summer at $0 / acre.

For the purposes of this analysis, it is conservatively assumed that fee title acquisition is required at a cost of $8,000 per acre, and that this cost is incurred in the first year of the simulation period.

Water Use

The main uncertainty in estimating the water use performance measure is the amount of water that the Program would need to augment to natural flows to meet the flow levels targeted in an alternative. If future conditions are drier than the 50-year hydrological record being used, then the model would underestimate how much water would be required.

Additional Information and Context for Interpreting Results

We have not calculated cost-effectiveness directly ($ per unit benefit). Cost-effectiveness is a useful metric when there is only one objective in addition to cost. In problems with multiple objectives, such as this one, it's useful to consider cost-effectiveness when designing alternatives.

---

for fencing and other infrastructure improvements to make the site suitable nesting habitat for plovers and terns.

References

EDO (Executive Director's Office), 2015. PRRIP-EDO Office Memorandum to Technical Advisory Committee. Subject: Tern and Plover Mechanical Habitat Resource Allocation Investigation. January 26, 2015.

3 PM Info-Sheet: Whooping Cranes

Sub-Objective	Performance Measure	Units	Description
Whooping Crane Habitat Use	WC Habitat Suitability Scale	7-point scale: -3 to +3	Changes to the availability of suitable whooping crane habitat in the AHR during migratory periods, relative to current conditions, reported using a 7-point scale. This PM is a proxy for habitat use and ultimately migratory survival. The relationship between availability of suitable habitat and habitat use is unknown / unquantified.

Performance Measure Overview

This performance measure describes the effect of tern and plover habitat creation and maintenance actions on changes to habitat suitability for whooping crane (WC), and by proxy, the likelihood for use of that habitat (see Figure 3.1). Use of this PM relies on the assumption that habitat suitability leads to increased use. The validity of that assumption depends on the degree to which whooping crane use of the AHR is currently limited by the quantity or quality of habitat.

The creation and maintenance of high on-channel tern and plover nesting islands decreases unobstructed channel width (UOCW) and thus results in decreased habitat suitability for whooping crane. This PM reports *changes to suitability* relative to current conditions, where the Program maintains roughly 45 acres of tern and plover islands in the channel. Therefore, the construction of nesting habitat in Program areas previously managed for cranes potentially results in a negative impact on UOCW while islands are present (visual obstruction) and no impact when islands are absent [PRRIP 2016]. If built islands are reconstructed annually (primarily in the fall), there would be impacts to habitat suitability in most years in any locations where new nesting islands are created. However, the maintenance of currently existing islands does not result in any net change in habitat suitability.

The scale used to describe these changes is defined as follows:

-3 = Reduction in habitat suitability (introduction of visual obstructions) in > 90 acres of the AHR

-2 = Reduction in habitat suitability (introduction of visual obstructions) in < 90 acres and > 45 acres of the AHR

-1 = Reduction in habitat suitability (introduction of visual obstructions) in < 45 acres of the AHR

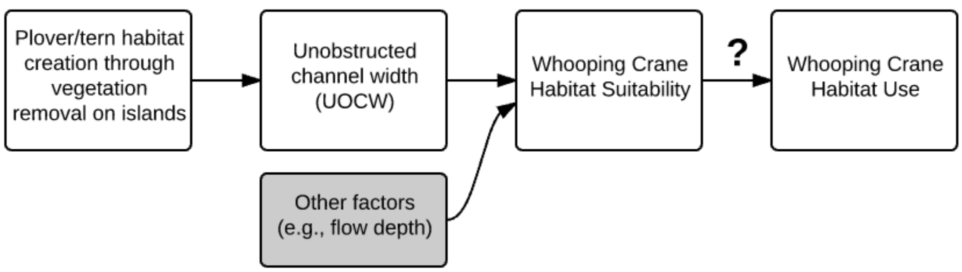
0 = No net change in habitat suitability

1 = Increase in habitat suitability (reduction of visual obstructions) in < 45 acres of the AHR

2 = Increase in habitat suitability (reduction of visual obstructions) in < 90 acres and > 45 acres of the AHR

3 = Increase in habitat suitability (reduction of visual obstructions) in > 90 acres of the AHR

Figure 3.1. Influence diagram showing the assumed relationship between on-channel management actions and changes to Whooping Crane habitat use.



Calculations and/or Scoring

Preliminary scores have been assigned by EDO (**Error! Reference source not found.**). Alternatives that involve expanding tern and plover nesting habitat in the channel using the standard approach (where islands are rebuilt annually in the same reach) receive negative scores in line with the additional acreage of habitat. Alternatives involving an alternative approach to building on-channel habitat (where existing vegetated islands are de-vegetated and left to erode) receive positive scores in line with the amount of acreage involved under that scenario.

Key Assumptions and Uncertainties

High confidence assumptions (well supported by data/studies) include:

- **The role of Unobstructed Channel Width (UOCW):** The use of this PM assumes that UOCW is a key driver of habitat suitability. This assumption is supported by the recent Program Whooping Crane data synthesis chapter currently in review (PRRIP 2016). Because the alternatives under current consideration do not include flow alterations during the whooping crane migratory period (grey box in Figure 3.1), change to unobstructed channel width is the only mechanism through which changes in habitat suitability are likely to occur.

- **Longevity of changes to suitability:** Any decrease in habitat suitability resulting from building on-channel tern and plover nesting habitat occurs because of the construction of islands that limit visibility for cranes. These islands are assumed to erode within three years in the absence of high flow events, at which point the effect on habitat suitability for crane becomes positive until vegetation re-establishes (vegetation management actions are not assumed to continue once nesting habitat is no longer present because habitat is being managed for terns and plovers). However, for alternatives that involve continuing to de-vegetate islands, the benefit to cranes is assumed to remain constant at the scale of the AHR, though local-scale benefits may reduce over time.

High uncertainty assumptions include:

- **Habitat Limitation**: This PM reports changes to habitat suitability, which is a proxy for habitat use. However, the relationship between habitat suitability and habitat use is uncertain (Figure 3.1) and depends on the extent to which habitat use is limited by the quantity or quality of habitat in the AHR. If this PM becomes an important factor in selecting a preferred alternative, there may be a need to further examine available information and assumptions about this relationship.

Additional Information and Context for Interpreting Results

- 45 acres of tern and plover habitat is roughly equal to 5% of the AHR.
- Creating plover and tern nesting habitat from de-vegetating permanently vegetated islands would likely be habitat neutral until islands begin to erode – wooded islands (obstruction) would be converted to high nesting islands (obstruction). During the period between island erosion and channel re-vegetation there would be a positive change in UOCW. The duration of this positive benefit at any particular location depends on the rate at which vegetation re-establishes.

References

PRRIP 2016. Whooping Crane Data Synthesis Chapters.

4 PM Info-Sheet: Sediment Supply

Sub-Objective	Performance Measure	Units	Description
Contribution to Sediment Supply	Sediment Supply Scale	5-point scale: -2 to +2	The likely effect of management action on channel sediment supply. The PM is reported using a 5-point scale. It is a proxy for a range of broader ecological benefits that are generally associated with increased sediment supply in a large braided river. The relationship between sediment supply and these broader benefits is unknown / unquantified.

Performance Measure Summary

This performance measure describes the effects of habitat construction and maintenance activities on reach-scale sediment abundance in the channel. Sediment deficit and the associated narrowing and incision of the channel are not compatible with maintenance of the wide, shallow river planform thought to be more suitable for target species use. Actions related to on-channel habitat creation may have either positive or negative effects on sediment abundance, which may be either short-term or long-term effects, depending on how they are conducted.

The levels of this scale are defined as follows:

-2 = Potential long-term negative impact to sediment supply

-1 = Potential short-term negative impact to sediment supply

0 = No net influence on sediment supply

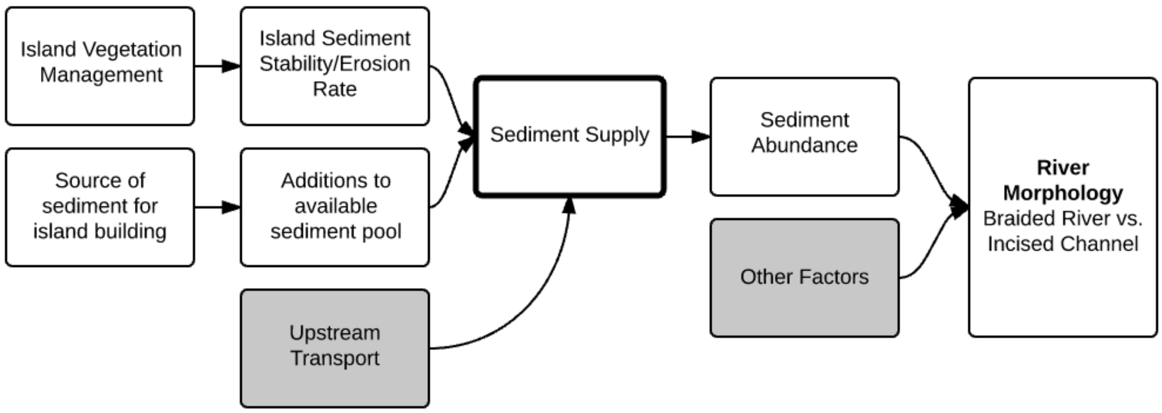
1 = Potential short-term benefit to sediment supply

2 = Potential long-term benefit to sediment supply

In the context of this scale, the phrases “long-term” and “short-term” refer to the length of time over which sediment benefits occur. For example, long-term benefits occur when actions to increase sediment supply are taken every year, whereas short-term benefits occur when actions are taken only once or for a very limited time.

Within the scope of this decision process, there are two primary means of altering the amount of sediment available for transport, and in turn support wide-scale sediment abundance (Figure 4.1). Removing vegetation in the channel (e.g., on wooded islands) may decrease island sediment stability and increase erosion rates. Adding sediment to the active channel (e.g. from the bank) to be used for island building may also positively influence sediment supply. If islands are constructed using sediment from the river bed, there is no new sediment made available for transport. However, if islands are constructed using sediment from the banks or other source, there may be a one-time increase in sediment available for transport. (None of the alternatives considered to date include this latter kind of action).

Figure 4.1 Influence diagram showing the assumed relationship between on-channel management actions and sediment supply



Calculation and/or Scoring

Preliminary scores have been assigned by EDO based on synthesis of Program and other data and literature (see Results, below).

Key Assumptions and Uncertainties

High confidence assumptions (well-supported by data/studies):

- **Effect of building islands on sediment supply:** An important assumption is that building nesting habitat in the channel does not contribute to local sediment deficit (i.e., Stay the Course scores 0). Implicit in that assumption is that the reach of the Central Platte between the J-2 Return and Overton is in sediment deficit (discussed further below, in *Context*) only at high flows; at low and moderate flows, that section of river becomes transport-limited rather than sediment-limited. Therefore, at low and moderate flows tern and plover nesting islands built in the channel do not contribute to local sediment deficits. At high flows (above ~ 4,000 cfs) when the upstream sections of the channel are sediment-limited, the islands are susceptible to lateral erosion and the sediment in them is available for transport.

- **Temporal value to sediment supply:** Nesting habitat built on ephemeral islands by pushing up bed sediment and allowing it to erode does not add or remove sediment from the channel over the scale of 1-5 years. Accordingly, it has little net effect on sediment supply. Conversion of permanently vegetated islands to nesting habitat does temporarily increase sediment supply as the habitat erodes. Permanent stabilization of constructed habitat (by rip-rap or persistent vegetation) results in long-term decreases in sediment supply.

High uncertainty assumptions:

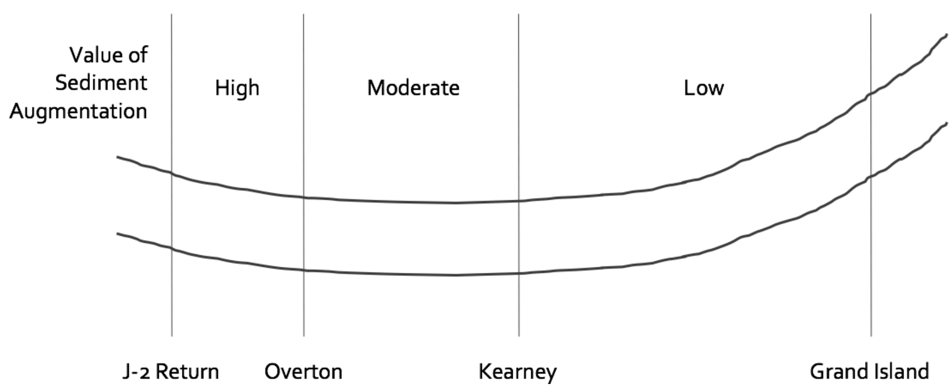
- None.

Additional Information and Context for Interpreting Results

- **Approximate volumes of sediment.** Each acre of in-channel nesting habitat is comprised of approximately 5,000 tons of sediment. If an average of 10 acres of permanently vegetated islands is de-vegetated each year (as is assumed in the Moving Complexes Approach alternatives), the maximum potential for sediment addition is about 50,000 tons per year. Based on long-term average island erosion rates, de-vegetated islands could be expected to contribute between 10,000 and 30,000 tons of sediment per year. Currently contemplated sediment augmentation actions near the J-2 Return are roughly in the vicinity of 60,000 to 80,000 tons per year. Best estimates of total sediment transport through the AHR range from 100,000 to 1,600,000 tons of sediment per year, depending on location and hydrologic conditions (Tetra Tech, 2014).

- **Value of sediment by reach.** Program monitoring and research indicates that there is a long-term sediment deficit in the south channel downstream of the J-2 Return. Sediment transport modeling indicates a sediment deficit downstream of the south channel confluence at Overton to approximately Kearney and a sediment balance downstream of Kearney. However, spatial and temporal variability in sediment flux are much greater than the modeled sediment deficit. Accordingly, the Program ISAC and geomorphology special advisors have concluded that the reach downstream of Overton is generally in dynamic equilibrium. The conversion of wooded islands to nesting habitat therefore provides the most benefit in terms of sediment between the J-2 Return and Overton, less benefit downstream of Overton, and relatively little benefit downstream of Kearney (Figure 4.2).

Figure 4.2: Relative value of sediment release from vegetated islands in the Central Platte, based on current understanding of sediment balance conditions in the AHR (Tetra Tech 2014).



- Tern and plover nesting habitat building activities in the AHR are constrained to areas where overall channel widths are suitable for tern and plover, and where permits exist or could be obtained. Based on the miles of river in each sediment benefit zone described above, EDO estimates that about 5% of the potential for on-channel habitat could be built in the reach between the J-2 Return in the South Channel and Overton, about 30% could be built between Overton and Kearney, and the remaining 65% between Kearney and Grand Island. In other words, the majority of habitat building activities are likely to occur in areas where there appears to be no sediment deficit. The location of habitat building activities is not considered in assigning scores, but this context is relevant in interpreting the likely magnitude of actual benefits.

- **On-going sediment augmentation**. Mechanical sediment augmentation actions in the South Channel downstream of the J-2 Return, which serve to prevent further channel incision and to prevent downstream propagation of the sediment deficit, will continue regardless of the outcome of this decision process.

References

Tetra Tech, 2014. Channel Geomorphology and In-Channel Vegetation: 2013 Final Data Analysis Report. Prepared for the Platte River Recovery Implementation Program.

5 PM Info-Sheet: Pallid Sturgeon

Sub-Objective	Candidate Performance Measures	Units	Description
Pallid Sturgeon Risk	Change in risk to Pallid Sturgeon (Yes/No)	Yes/No/Maybe	A flag that indicates whether a management action involves a change in risk to Pallid Sturgeon. A "No" indicates no changes are expected as a result of an alternative. A "Yes" suggests further analysis may be warranted if the alternative is considered further. A "Maybe" indicates that the effects (positive or negative) on Pallid Sturgeon are unknown.

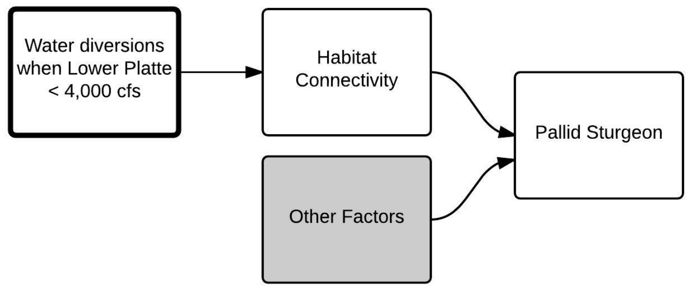
Performance Measure Summary

Some alternatives under consideration include augmenting flows during the nest initiation period and/or during the incubation/rearing period for plovers and terns (a period spanning from May to late August). The proposed performance measure flags if these flow augmentation actions would result in a water diversions at critical periods of low flow in the lower Platte River (from the Elkhorn River confluence to the Missouri River confluence), which may represent a change in risk to pallid sturgeon.

This PM is based on analysis in the peer-reviewed Lower Platte River Stage Change Study Draft Protocol Implementation Report (Stage Change Report). This study concluded that the relative change in pallid sturgeon habitat due to Program water management activities would be very small to undetectable and thus these changes should not provide additional stress to the pallid sturgeon population. However, it also found that water diversions during periods of critical low flow in the lower Platte River have the greatest potential for negative impacts to pallid sturgeon habitat in the lower Platte River. The impact of concern is that diversions could further reduce flows in the lower Platte River resulting in a reduction of habitat connectivity for pallid sturgeon. It has been suggested in the literature that there are connectivity concerns when lower Platte River flows are around 4,000 cfs and below (Stage Change Report, 2009) (Figure 5.1).

This use of this PM assumes, in accordance with the Stage Change Report that in the absence of diversions during periods of critical low flow in the lower Platte River (defined as Louisville gage flows < 4,000 cfs), any effects of water management will be very small to undetectable and will not introduce or increase risks to pallid sturgeon. If any alternatives are proposed that involve diversions during periods of critical low flow, then further analysis may be warranted to confirm the nature and significance of effects.

Figure 5.1: Influence diagram showing the assumed relationship between on-channel management actions and pallid sturgeon (PM shown in bold)



Key Assumptions and Uncertainties

In accordance with the direction provided by the GC on December 2, 2015, this PM is based solely on the findings of the peer-reviewed Stage Change Study. This study was identified as the best available information to assess the potential effects of Program water management activities on water stage and how those stage changes might affect pallid sturgeon. The GC also asked EDO/Compass to consider a multi-point scale rather than just a binary yes/no indicator. However, the information in the Stage Change Study did not support the use of a more refined scale. Refinement of this PM, if warranted, would require direction from the TAC and/or GC.

Context

The peer-reviewed Stage Change Study contains the best available information on how Program water management actions could affect pallid sturgeon habitat in the Lower Platte River. This study concluded that the relative change in pallid sturgeon habitat due to Program water management activities would be very small to undetectable and thus these changes should not provide additional stress to the pallid sturgeon population. The study also found that the greatest potential for negative impacts to pallid sturgeon habitat would occur when lower Platte River discharges are low (4,000 – 6,000 cfs) but central Platte River discharges are high enough that flow could be diverted into storage for retiming. A negative impact to pallid sturgeon could occur if diverting water at this time reduced habitat connectivity in the lower Platte River. The findings from this analysis suggest that if short-term connectivity is a concern for pallid sturgeon in the lower Platte River, operational rules for Program water projects could prohibit diversions when lower Platte River discharges fall below some minimum threshold (State of the Platte Report, 2015).

References

PRRIP, 2015 (Platte River Recovery Implementation Program Executive Director's Office). PRRIP Adaptive Management Plan: 2014 State of the Platte Report.

Stage Change Report, 2009. Prepared by HDR Engineering, Inc., in conjunction with Mussetter Engineering, Inc., The Flatwater Group, Inc., and Dr. Mark Pegg. Full title: "Lower Platte River Stage Change Study Final Protocol Implementation Report".

6 PM Info-Sheet: Implementation

Sub-Objective	Performance Measure	Units	Description
Implementation Cost and Risks	Implementation Scale	Scale: 0 to -4	This PM reflects the effort and risks associated with permitting, negotiating with landowners, and coordinating with other agencies for the use of land and/or water. It reflects a range of implementation considerations, including permitting cost ($), neighbor relations and the probability of successful implementation. A score of 0 reflects an alternative requiring minimal effort with little risk of implementation failure, and -4 reflects high effort accompanied by a risk of not achieving full implementation.

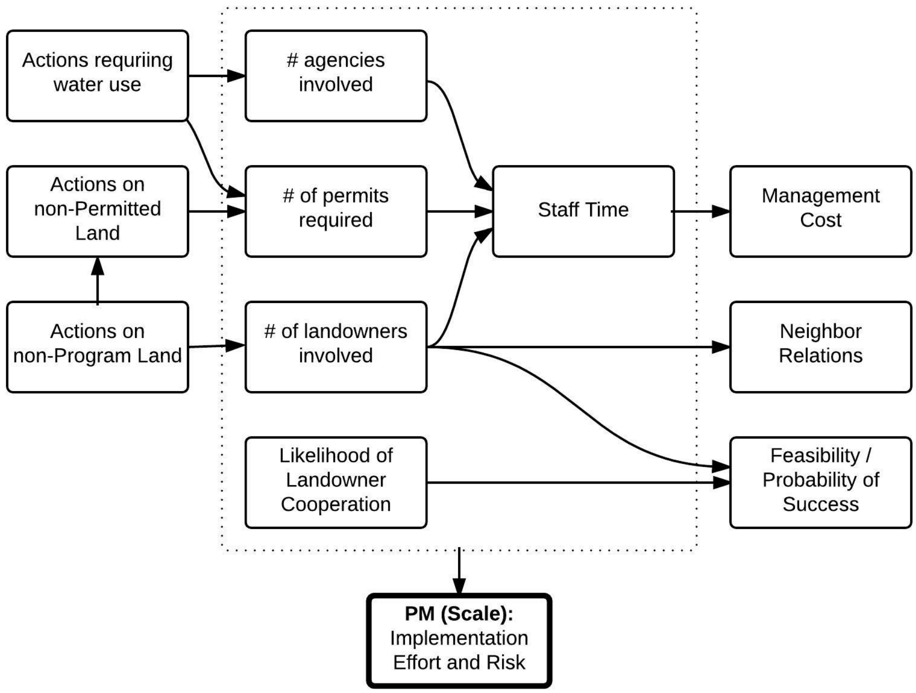
Performance Measure Overview

This PM is a simple five-point scale that reports the level of management effort required to implement an alternative. It is a proxy for a number of implementation considerations (Figure 6.1) including Program staff effort and associated management costs, the quality of relationships between the Program and its neighbors and the probability of full and successful implementation of a particular management alternative.

Different kinds of alternatives involve different levels of management effort and implementation risks. Alternatives that involve action on non-Program land involve more effort and risk than actions on Program-owned land, and actions involving negotiation and permitting for on-channel land involve more effort and risk than those for off-channel land. Actions involving water use require efforts for the acquisition of permits and coordination with various agencies. Some kinds of negotiations require continuous effort over the long term. Others require short-term effort to secure long-term agreements that then require little on-going effort or risk.

Any alternative that involves actions on non-Program land will require the cooperation of landowners and the acquisition of permits. Some landowners may be willing to enter into a management agreement with the Program to allow management actions on their land; others will not. Negotiations with landowners are a time-consuming activity for Program staff. Staff time, as well as permitting costs, will increase the cost of alternative implementation. Additionally, for alternatives involving on-channel land, there is a risk that negotiations may place stress on the Program's relationship with neighbors. Ultimately there is no guarantee that landowners will agree to cooperate with the Program. Thus a management alternative that relies heavily on actions taken on non-Program land will have some uncertainty with respect to full and successful implementation.

Figure 6.1: Influence diagram showing factors contributing to implementation costs and risk (PM shown in bold)



Influence diagram showing the assumed relationship between on-channel management actions and implementation costs and risks. This PM seeks to incorporate all of these considerations into a single score for each alternative. The scale used to describe implementation effort and risks is defined as follows:

- **- 4 =** **Intense Effort/Risk of Failure.** There is a risk (>50% probability) of not achieving the target land or water due to the complexity and/or intensity of permitting and negotiations required.
- **-3 =** **High Effort.** Substantial negotiation and permitting for on-channel land or water use is ongoing over the long-term (e.g., for on-channel habitat, a substantial but achievable amount is assumed to be 10 acres or less of habitat per year).
- **-2 =** **Moderate Effort.** Negotiation and/or permitting for on-channel land occurs in the short-term (i.e., short term effort for long-term agreements).
- **-1 =** **Low Effort**. Negotiation and/or permitting for off-channel land occurs in the short-term.
- **0 =** **Minimal Effort.** Minimal implementation effort is required (e.g. no negotiation or permitting for on- or off-channel habitat, and no water use).

Calculations and/or Scoring

Scores have been assigned by EDO based on Program experience to date. The following factors are considered in assigning a score (from Figure 6.1):

- whether the alternative involves actions on non-Program land;
- the number and complexity of permits required;
- the number of agencies involved;
- the number of landowners that need to be involved;
- the proportion of landowners that are likely to agree to cooperate with the Program;
- whether the effort required is one-time or on-going.

Key Assumptions and Uncertainties

The key uncertainty associated with the PM is the likelihood that landowners will agree to cooperate with the Program on the development of new on-channel habitat on non-Program land. For any alternatives that involve the creation of on-channel habitat on non-Program land, the scoring of this PM is based on the following assumptions:

- Maximum habitat per river mile is about 10 acres;
- There are approximately 2-8 landowners per river mile;
- In the absence of financial incentives, approximately 20% of landowners approached will cooperate.

Given the number of landowners that the Program would need to negotiate with, it is difficult to envision a scenario where more than 10 acres could be achieved using this approach. Therefore, any alternative involving the development of more than 10 acres of on-channel habitat on non-Program land will receive a score of -4 (Risk of Failure).

Additional Information and Context for Interpreting Results

Incremental staff costs are generally a relatively small portion of overall management costs and have not been translated into dollar estimates. However, alternatives that score poorly on this PM also create risks in terms of potentially straining relationships with neighbors, and at the upper levels, increasing risk of incomplete implementation.

References

N/A

7 PM Info-Sheet: Learning

Sub-Objective	Performance Measure	Units	Description
Learning Potential – Plover and Tern Reproductive Success	Learning Potential Scale	3-point scale: 0 to 2	The potential to evaluate differences in plover and tern use and reproductive success from different plover and tern habitat creation and maintenance activities. In particular, the scale considers the ability to learn about incremental performance differences between on-channel and off-channel habitat, and the potential benefits of flow to on-channel plover and tern reproductive success.

Performance Measure Summary

This performance measure reports the potential to learn through evaluation of differences in plover and tern use and reproductive success on in-channel versus off-channel habitat as well as how flow influences on-channel use and productivity. The performance measure is a constructed scale that scores alternatives along two dimensions: (1) the extent to which on-channel habitat and off-channel habitat for plovers and terns are being simultaneously implemented, and (2) the number of acres of on-channel habitat (Table 7.1).

The first dimension was chosen because on- and off-channel habitat must be available simultaneously to address uncertainties (i.e., Big Question 6) associated with the comparative use and productivity on- versus off-channel habitat. In particular, this dimension considers the ability to learn about incremental performance differences between on-channel and off-channel habitat.

The second dimension (number of acres of on-channel habitat) was chosen to represent the scale, or speed, at which on-channel learning can occur. The greater the number of on-channel acres, the more likely on-channel use will be of a scale (i.e., adequate sample size) that will facilitate robust comparisons between on-channel and off-channel performance.

This simplified Learning PM therefore provides general information about how much can be learned and how quickly, under different alternatives.

Table 7.1: Learning Potential Scale

Habitat/Flow Combos	**Shorter-term learning** (>60 acres on-channel)	**Longer-term learning** (< 60 acres on-channel)
Only on-channel **or** only off-channel	0	0
On-channel **+** off-channel	2	1

Calculations and/or Scoring

Preliminary scores have been assigned by Compass/EDO using a four-point scale, as described in **Error! Reference source not found.**, below.

Key Assumptions and Uncertainties

The scale uses a break-point of 60 acres to distinguish between shorter-term and longer-term learning because it is in between the following two levels of on-channel habitat included in the preliminary set of alternatives: (1) the existing quantity of on-channel habitat (42 acres) and (2) the Level 1 quantity of on-channel habitat which includes maintaining existing habitat plus creating and maintaining the maximum amount of new habitat on lands already owned by the Program (82 acres total). As this break-point was chosen merely to distinguish across the preliminary set of alternatives, it is only describing the relative differences in learning times between the alternatives.

Overall, this PM is very simple and intended to show only general differences in learning potential between alternatives. If Learning is an important objective, and one that becomes instrumental in selecting a preferred alternative, a more structured approach to evaluating learning potential will likely need to be developed. A variety of methods are available, including formal value-of-information methods and multi-attribute scoring methods. However, these can be time-consuming to do, and may not be warranted.

Appendix B

Platte River SDM On-Channel Fledge Ratio Expert Judgment Elicitation Process

January 2016

Background and Context

- The Platte River SDM process is in progress and preparations are ongoing for the upcoming TAC meeting on February 10 and 11, 2016.
- Preliminary alternatives and performance measures have been developed for presentation at the TAC meeting.
- The EDO is refining the Tern and Plover Habitat and Population Model (the Model) to enable the evaluation of alternatives.
- A key uncertainty that has emerged in the Model is the on-channel fledge ratios for piping plover and interior least tern. Within the Program monitoring data set, there are substantially fewer observations for on-channel breeding pairs and fledges compared to off-channel (see Appendix B2 – Table 1 for summary of this data). Due to the limited data set, EDO has suggested that on-channel fledge ratio parameters should be determined in consideration of fledge ratios from both Program monitoring data and studies outside of the Platte River Associated Habitat Reach (AHR).
- In order to provide TAC and GC members with the best available information about Tern and Plover on-channel fledge ratios, a structured expert elicitation was conducted using EDO's subject matter expert (D. Baasch). The elicitation produced a range of values for tern and plover fledge ratios, as well as most likely values. The most likely values from the D. Baasch elicitation were used as the initial parameters in the Model. A sensitivity analysis was conducted and the results were reviewed with the TAC on February 10, 2016.
- If warranted, this structured elicitation process could be replicated with a broader set of subject matter experts. However, after reviewing the results of the analysis done to date, the TAC concluded that further analysis was not necessary.

Objectives of the Expert Judgment Elicitation Process

The goals of the expert judgment elicitation process were to:

- Elicit expert(s)' views on the range of plausible values for on-channel fledge ratios for piping plover and interior least tern in the AHR;
- Clarify and build common understanding about the factors that influence on-channel fledge ratios;
- Provide a transparent and defensible basis for selecting a fledge ratio to use in calculating performance measures in the Model;
- Clarify the current state of agreement and disagreement among experts and the implications for decisions about managing habitat for piping plovers and least terns.

Steps

Based on established best practices for expert elicitation, the process included the following recommended steps (see references). The process was designed so that it could be replicated if necessary with a broader set of experts.

1. **Preparation.** The elicitation questions are developed and refined for clarity. A pre-reading package containing a summary of data and literature are developed. Expert(s) are asked to review other relevant material in preparation for the interview.
2. **Selection.** Expert(s) are identified, according to an agreed set of criteria.
3. **Elicitation.** Expert(s) participate in an individual questionnaire and interview to provide responses and document the rationale for their responses.
4. **Synthesis and Aggregation.** Results are synthesized (and aggregated across experts if there are multiple experts). Experts are given an opportunity to modify their responses/reasons. Sensitivity and other analyses are done, and key issues are identified for discussion among participating experts.
5. **Group Discussion and Refinements.** Experts are given an opportunity to review the synthesized / aggregated results, and to discuss areas of agreement and difference across experts and the reasons for them. They are given an opportunity to modify their judgments if desired, based on what is learned.
6. **Recommendations and Next Steps.** Key messages for decision makers are summarized. Depending on the implications of residual uncertainty for the decision at hand, experts may make recommendations on whether further analysis or expansion of the expert process is warranted.

Elicitation Questions and Format

The elicitation protocol used the Speirs-Bridge et al (2010) four-point methodology for eliciting point-value estimates in a one-on-one interview format. This technique has been shown to provide superior results in counteracting the well documented tendency of experts to be overconfident in their judgments. The format of the four-point elicitation, modified slightly after recent correspondence with one of the authors, was as follows:

- What is the highest plausible value of X?
- What is the lowest plausible value of X?
- What is the most likely plausible value of X?
- How confident are you the truth will lie between your nominated highest and lowest estimate? (As a percentage, i.e., >50%)

The elicitation questions are presented in Appendix B1.

Expert Pre-Reading

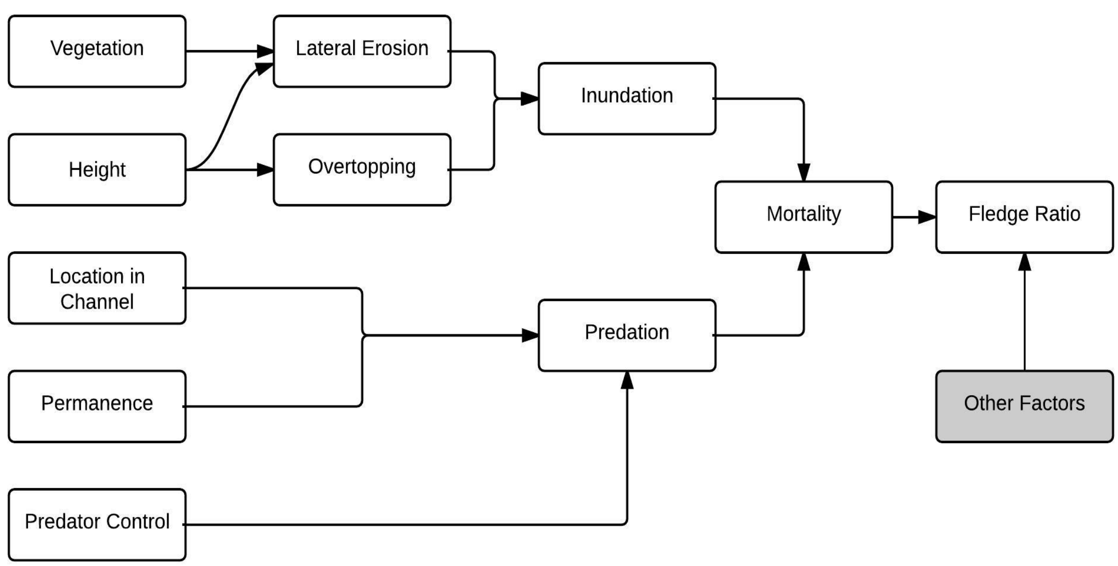
D. Baasch was asked to compile and review fledge ratio data from the Platte River and other locations prior to the interview. Relevant information is presented in Appendix B2, and includes:

- Summary of central Platte River fledge ratios for on- and off-channel habitats, 2001-2015 (Table 1 in Appendix B2);
- EDO literature review of interior least tern sandpit and sandbar fledge ratios (Table 2 in Appendix B2);
- EDO literature review of piping plover sandpit and sandbar fledge ratios (Table 3 in Appendix B2).

Results

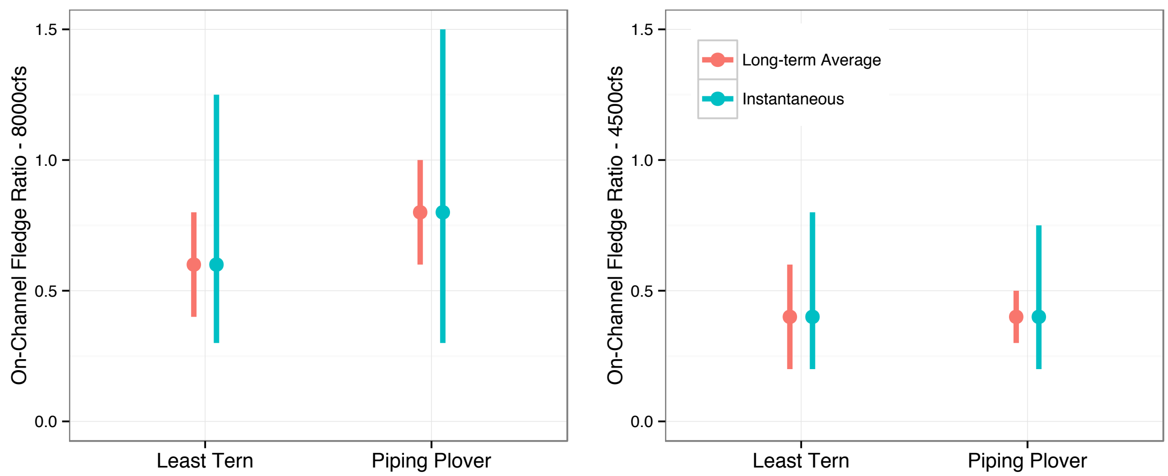
The elicitation exposed key factors driving fledge ratio (Figure 1). In particular, island height was identified as a key determining factor. As a result, two separate judgments were elicited, under different conditionalizing assumptions, one at 4500 (the Program minimum standard for attracting birds) and another at 8000, the current standard used for managed Program islands.

Figure 1 Factors affecting on-channel fledge ratio



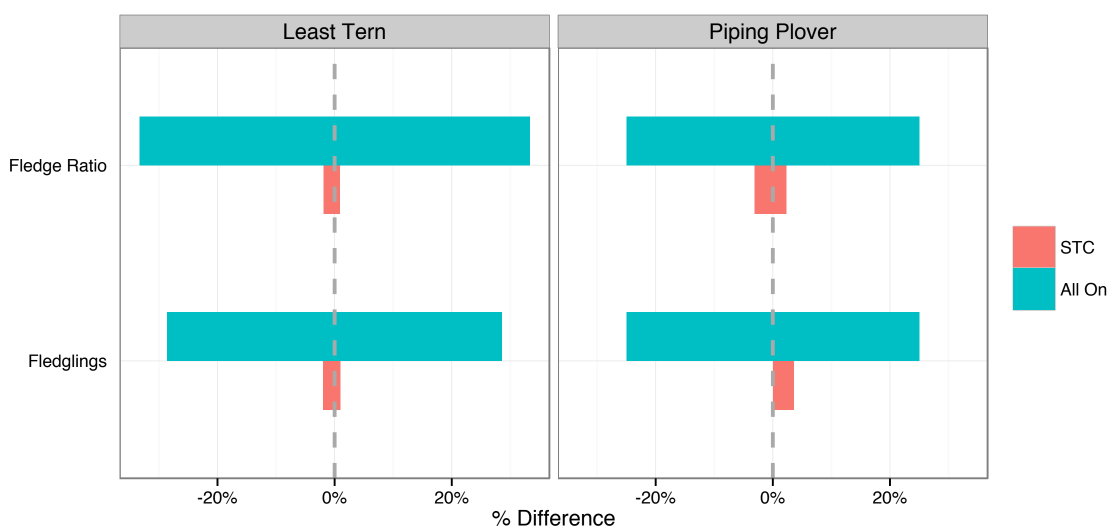
The results of the elicitation are shown in Figure 2.

Figure 2 Minimum, maximum and most likely values for tern and plover on-channel fledge ratios



To determine whether the uncertainty warrants additional analysis, the sensitivity of the Model outcomes to the uncertainty was examined. Figure 3 shows how the modelled fledge ratio and # fledglings varies across the range of plausible values for on-channel fledge ratio for two alternatives – Stay The Course (STC) in red which has both on and off channel habitat, and another alternative (All On) in blue that only has on-channel habitat. The width of the colored bar in Figure 3 demonstrates how sensitive the PM is to the range of uncertainty in fledge ratio.

Figure 3 Sensitivity of performance measures to range of values in on-channel fledge ratio



Conclusions

At the February 10 meeting, the TAC reviewed the results of the elicitation and sensitivity analysis. The TAC concluded:

- The TAC supports the use of the estimates of on-channel fledge ratio provided by D. Baasch for the purposes of the SDM process, and views refining estimates of on-channel fledge ratio (expansion of the expert process) as a low priority at this time.

It further noted:

- While productivity is sensitive to fledge ratio, the effect of on-channel fledge ratio is dwarfed by off-channel for any alternatives that have an off-channel habitat component;
- On-channel fledge ratio is strongly dependent on island height;
- The conclusion that further refinement of the on-channel fledge ratio is unnecessary should be revisited if the GC considers the use of either a) alternatives that are all on-channel (no off) or b) alternatives that result in the construction of low islands.

References

Burgman M. and M.F. McBride (2012) What Is Expert Knowledge, How Is Such Knowledge Gathered, and How Do We Use It to Address Questions in Landscape Ecology? in Expert Knowledge and Its Application in Landscape Ecology.

Perera, A.H., C.A. Drew and C.J. Johnson (eds.). Springer, New York, NY.

Hammond J.S., R.L. Keeney, H. Raiffa (1999) Smart Choices. Harvard Business School Press, Boston, MA.

Speirs-Bridge A., F. Fidler, M. McBride et al. (2010) Reducing overconfidence in the interval judgments of experts. Risk Anal 30:512–52.

Appendix B1 Elicitation Questions

Part A. Fledge Ratio – Short-term Average

1. Assuming equal and annual use of on- and off-channel habitat, what is the **highest plausible value for Piping Plover** on-channel fledge ratio that could be achieved in the AHR **in any given year?**
   a. Document the conditions under which you think these values would be achieved.
   b. Document the rationale for your response, including key assumptions (e.g., about island / sandbar height, vegetation, location within the channel, permanence, etc.) and/or comparisons (e.g., ways in which the AHR is different/similar to other rivers, etc
2. Assuming equal and annual use of on- and off-channel habitat, what is the **lowest plausible value for Piping Plover** on-channel fledge ratio that could be achieved in the AHR **in any given year?**
   a. As above, document associated conditions
   b. As above, document rationale and assumptions
3. Assuming equal and annual use of on- and off-channel habitat, what is the **most likely plausible value for Piping Plover** on-channel fledge ratio that could be achieved in the AHR **in any given year**?
   a. As above, document associated conditions
   b. As above, document rationale and assumptions
4. **How confident** are you that the truth will lie between your nominated highest and lowest estimate (as a percentage > 50%)? You can think of this percentage as a confidence interval: "I am x% confident that the truth will lie between my highest and lowest plausible values

Least Terns

5. Assuming equal and annual use of on- and off-channel habitat, what is the **highest plausible value for Least Tern** on-channel fledge ratio that could be achieved in the AHR **in any given year?**
   a. As above, document associated conditions
   b. As above, document rationale and assumptions
6. Assuming equal and annual use of on- and off-channel habitat, what is the **lowest plausible value for Least Tern** on-channel fledge ratio that could be achieved in the AHR **in any given year?**
   a. As above, document associated conditions
   b. As above, document rationale and assumptions
7. Assuming equal and annual use of on- and off-channel habitat, what is the **most likely plausible value for Least Tern** on-channel fledge ratio that could be achieved **in any given year?**
   a. As above, document associated conditions
   b. As above, document rationale and assumptions

8. **How confident** are you that the truth will lie between your nominated highest and lowest estimate (as a percentage > 50%)?

Part B. Fledge Ratio – Long-term Average

4. Assuming equal and annual use of on- and off-channel habitat, what is the **highest plausible value for Piping Plover** on-channel fledge ratio that could be achieved in the AHR **in a 50 year timeframe**?
   a. Document the conditions under which you think these values would be achieved.
   b. Document the rationale for your response, including key assumptions (e.g., about island / sandbar height, vegetation, location within the channel, permanence, etc.) and/or comparisons (e.g., ways in which the AHR is different/similar to other rivers, etc
5. Assuming equal and annual use of on- and off-channel habitat, what is the **lowest plausible value for Piping Plover** on-channel fledge ratio that could be achieved in the AHR **in a 50 year timeframe?**
   a. As above, document associated conditions
   b. As above, document rationale and assumptions
6. Assuming equal and annual use of on- and off-channel habitat, what is the **most likely plausible value for Piping Plover** on-channel fledge ratio that could be achieved in the AHR **in a 50 year timeframe?**
   a. As above, document associated conditions
   b. As above, document rationale and assumptions
9. **How confident** are you that the truth will lie between your nominated highest and lowest estimate (as a percentage > 50%)? You can think of this percentage as a confidence interval: "I am x% confident that the truth will lie between my highest and lowest plausible values

Least Terns

10. Assuming equal and annual use of on- and off-channel habitat, what is the **highest plausible value for Least Tern** on-channel fledge ratio that could be achieved in the AHR **in a 50 year timeframe?**
    a. As above, document associated conditions
    b. As above, document rationale and assumptions
11. Assuming equal and annual use of on- and off-channel habitat, what is the **lowest plausible value for Least Tern** on-channel fledge ratio that could be achieved in the AHR **in a 50 year timeframe?**
    a. As above, document associated conditions
    b. As above, document rationale and assumptions
12. Assuming equal and annual use of on- and off-channel habitat, what is the **most likely plausible value for Least Tern** on-channel fledge ratio that could be achieved **in a 50 year timeframe?**
    a. As above, document associated conditions
    b. As above, document rationale and assumptions

13. **How confident** are you that the truth will lie between your nominated highest and lowest estimate (as a percentage > 50%)?

Appendix B2

Platte River Recovery Implementation Program
Fledge Ratio Memo

Office of the Executive Director
4111 4th Avenue, Suite 6
Kearney, Nebraska 68845

January 13, 2016

Summary of Observed and Reported Fledge Ratios for Interior Least Terns and Piping Plovers

We calculated interior least tern and piping plover fledge ratios observed on the central Platte River sandbars and sandpits, 2001-2015 (Table 1). We found tern fledge ratios on on-channel habitat averaged 0.43 (range = 0.0 – 0.90) and off-channel habitat averaged 1.17 and (range = 0.75 – 1.83; Table 1). Plover fledge ratios on on-channel and off-channel habitat averaged 1.08 (range = 0.17 – 4.00) and 1.54 (range = 0.90 – 2.40), respectively.

We also conducted an extensive literature review to assess range-wide fledge ratios for terns and plovers. Our literature review resulted in individual and multi-year reports of fledge ratios on sandbars, sandpits, bays, coastline, reservoirs, lakes, wetlands, and unknown habitat types and resulted in >550 reported fledge ratios. For our summary, we generally included multi-year averages for sandpit and sandbar habitats. This resulted in 19 fledge ratios for sandbar habitat and 6 fledge ratios for sandpits for terns (Table 2). Our investigation also included fledge ratio estimates at 16 sandbar, 8 sandpit, 1 combination, and 1 shoreline (McConaughy) location for plovers (Table 3). Although we found several reports that included multi-year average fledge ratios, there was a lot of variability in fledge ratios that were reported for on-channel (range = 0.00 – 1.23) as well as off-channel habitat for terns (range = 0.49 – 1.60). Similarly, the sources that provide information on fledge ratios for plovers on sandbar habitat ranged from 0.29 – 1.46 and off-channel fledge ratios ranged from 0.72 – 1.93.

Table 1. Summary of central Platte River fledge ratios for on- and off-channel habitats, 2001-2015.

Interior Least Tern

Year	Off-Channel Fledges	Off-Channel Breeding Pair	Fledges/Pair	On-Channel Fledges	On-Channel Breeding Pair	Fledges/Pair
2001	42	23	1.83	0	0	0.00
2002	59	41	1.44	0	0	0.00
2003	57	54	1.06	0	0	0.00
2004	60	45	1.33	0	0	0.00
2005	62	49	1.27	0	0	0.00
2006	27	36	0.75	0	0	0.00
2007	38	33	1.15	2	11	0.18
2008	35	30	1.17	9	10	0.90
2009	42	40	1.05	4	6	0.67
2010	64	51	1.25	0	0	0.00
2011	89	62	1.44	0	0	0.00
2012	84	66	1.27	0	0	0.00
2013	64	63	1.02	0	0	0.00
2014	91	98	0.93	0	0	0.00
2015	146	133	1.10	0	8	0.00
Total	**960**	**824**	**1.17**	**15**	**35**	**0.43**

Piping Plover

Year	Off-Channel Fledges	Off-Channel Breeding Pair	Fledges/Pair	On-Channel Fledges	On-Channel Breeding Pair	Fledges/Pair
2001	24	10	2.40	0	0	0.00
2002	28	18	1.56	0	0	0.00
2003	24	15	1.60	0	0	0.00
2004	25	15	1.67	0	0	0.00
2005	28	17	1.65	0	0	0.00
2006	29	19	1.53	0	0	0.00
2007	18	20	0.90	7	4	1.75
2008	7	11	0.64	3	3	1.00
2009	11	10	1.10	1	2	0.50
2010	36	18	2.00	6	6	1.00
2011	45	28	1.61	0	0	0.00
2012	55	29	1.90	4	1	4.00
2013	28	27	1.04	0	0	0.00
2014	55	29	1.90	4	2	2.00
2015	51	35	1.46	1	6	0.17
Total	**464**	**301**	**1.54**	**26**	**24**	**1.08**

Table 2. Summary of interior least tern sandpit and sandbar fledge ratios reported in EDO literature search.

Species	System	System Type	Years	Fledge Ratio	Source
LETE	Central Platte River, NE	River	2001-2015	0.43	PRRIP unpublished data
LETE	Central Platte River, NE	River	1986-1990	0.49	Kirsch and Sidle 1999
LETE	Central Platte River, NE	River	1991-2005	1.09	Jenniges and Pletner 2008
LETE	Niobrara River	River	1996-1997	0.69	South Dakota Academy of Science 2001
LETE	Lower Platte River, NE	River	1986-1990	0.49	Kirsch and Sidle 1999
LETE	Platte River, NE	River	2003	0.47	Committee on Endangered and Threatened Species in the Platte River Basin, NRC, 2004; Reed 2003; Smith & Renken 1993)
LETE	Missouri River Constructed Island	River	2009	1.10	Stark et al. 2011
LETE	Missouri River Natural Island	River	2009	0.00	Stark et al. 2011
LETE	Garrison River Reach	River	2006-2009	1.13	Shaffer et al. 2013
LETE	Ft Peck Missouri River	River	2002-2004	0.64	Montana interior least tern management plan 2006
LETE	Yellowstone River,	River	1994-1996	0.65	Kirsch and Sidle 1999
LETE	Cimarron River, Kansas and Oklahoma	River	1980-1982	0.75	Kirsch and Sidle 1999
LETE	Cimarron River, Kansas and Oklahoma	River	1990, 1992	0.25	Kirsch and Sidle 1999
LETE	Arkansas River, Oklahoma	River	1986-1988, 1990-1991, 1995-1996	0.67	Kirsch and Sidle 1999
LETE	Arkansas River, Oklahoma	River	1992-1993	0.59	Kirsch and Sidle 1999
LETE	Canadian River, Oklahoma	River	1987, 1991-1996	1.23	Kirsch and Sidle 1999
LETE	Lower Mississippi River	River	1986-1993	0.58	Dugger et al 2002
LETE	Lower Mississippi River	River	1995-1996	1.00	Kirsch and Sidle 1999
LETE	Mississippi River Valley	River	1986-1989	0.70	Smith & Renken 1993
LETE	Central Platte River, NE	Managed Sandpits	2001-2015	1.17	PRRIP unpublished data
LETE	Central Platte River, NE	Unmanaged Sandpits	1991-2005	0.56	Jenniges and Pletner 2008
LETE	Central Platte River, NE	Managed Sandpits	1991-2005	1.31	Jenniges and Pletner 2008
LETE	Lower Platte River, NE	Sandpit	1987-1990	0.49	Kirsch 1996
LETE	Council Bluffs, Iowa	Sandpit	1984-1991	0.70	Kirsch and Sidle 1999
LETE	Sioux City, Iowa	Sandpit	1995	1.60	Kirsch and Sidle 1999

Table 3. Summary of piping plover sandpit and sandbar fledge ratios reported in EDO literature search.

Species	System	System Type	Years	Fledge Ratio	Source
PIPL	Central Platte River	River	2001-2015	1.08	PRRIP unpublished data
PIPL	Central Platte River	River	1986-1990	0.52	Lingle 1993
PIPL	Garrison River Reach	River	2005-2009	0.88	Shaffer et al. 2013
PIPL	Grand Marais Lonesome Point/East Bay Sucker River	River	1984-1998	1.46	Recovery Plan for the Great Lakes Piping Plover (USFWS) 2003
PIPL	Missouri River	River	1991-1992	0.33	Catlin et al. 2015
PIPL	Missouri River	River	2005-2011	1.01	Catlin et al. 2015
PIPL	Missouri River Constructed Island	River	2009	1.17	Stark et al. 2011
PIPL	Missouri River Constructed Island	River	2009	0.29	Stark et al. 2011
PIPL	Niobrara River	River	1996-1997	0.95	South Dakota Academy of Science 2001
PIPL	Lower Platte River (Protected Nests)	River	1992	0.71	Lackey 1994
PIPL	Lower Platte River (Unprotected Nests)	River	1992	0.44	Lackey 1994
PIPL	Ft Randall to Niobrara	River	1988-2000	0.37	USACE Unpublished Data
PIPL	Lewis and Clark Lake	Lake/River	1988-2000	0.51	USACE Unpublished Data
PIPL	Galvin’s Point Dam to Ponca	River	1988-2000	0.75	USACE Unpublished Data
PIPL	Combined Missouri River adjacent to Nebraska	River	1988-2000	0.71	USACE Unpublished Data
PIPL	Upper Platte River	River	1992-2000	1.07	Peyton and Wilson 2000
PIPL	Central Platte River	Sandpit and Artificial Sandbars	1991-2000	1.34	Plettner 2000
PIPL	Central Platte River	Sandpit	2001-2015	1.54	PRRIP unpublished data
PIPL	Lower Platte River Gravel Mines	Sandpit	1999	0.73	Marcus 1999
PIPL	Lower Platte River Gravel Mines	Sandpit	2000	1.50	Marcus 2000
PIPL	Lower Platte River Gravel Mines	Sandpit	2001	1.93	Marcus 2001
PIPL	Lower Platte River Gravel Mines	Sandpit	2002	1.19	Held et al. 2002
PIPL	Lower Platte River Gravel Mines	Sandpit	2003	0.86	Held et al. 2003
PIPL	Lower Platte River Gravel Mines	Sandpit	2004	0.72	Held et al. 2004
PIPL	Lower Platte River Gravel Mines	Sandpit	2005	0.83	Held unpublished data
PIPL	Lake McConaughy	Lake/ shoreline	1992-2000	1.15	Peyton and Wilson 2000

Platte River SDM: Habitat Construction Costs Expert Panel Input Process

February 29, 2016, version 1.0

Background and Context

- The EDO has developed the Tern and Plover Habitat and Population Model (the Model) to enable the evaluation of alternatives for the Platte River SDM process.
- A key uncertainty that has emerged is the cost of constructing habitat both on and off the channel. The Program's experience with building habitat has been widely variable, and realized costs have been based on specific conditions of the site, of arrangements with contractors, and of the ability of the Program to recoup costs (table 1).
- At the February TAC meeting, an expert panel subgroup of the TAC contributed input to refine this and other uncertainties present in the model.
- This memo outlines the input provided by the panel and the rationale for selecting the high, low, and best guess cost data for each method for habitat construction.

Table 1. PRRIP experience with Off- and On-channel mechanical habitat creation

Off-Channel Construction Costs		
Rehabilitated Sand Pits		
Dyer	paddle scrape, pack and fence	$1,121.60
Broadfoot S	paddle scrape, pack and fence	$116.67
Broadfoot Newark	fence and pit expansion	$9,750.00
New Construction		
Leaman East	tree removal and fencing	$3,017.24
Cottonwood	earthwork, fence, tree clearing	$33,529.41
On Channel Construction Costs		
Shoemaker Island Complex	50% new 50% built up sandbar	$2,325.00
Shoemaker Island Complex	Island construction portion of project bids ranged from $2150 to $5146 per acre	$2,325.00
Elm Creek Islands	70% new 30% built up sandbar	$2,935.80
Elm Creek Islands	80% new 20% built up sandbar - Rebuild after flood	$4,191.30

Expert Input Process

- The panel was nominated by the TAC and consisted of Matt Rabbe (USFWS), Jim Jenniges (NPPD), Mark Peyton (CNPPID, abstained from providing input for on-channel habitat costs), and Mark Czaplewski (CPNRD).
- The panel reviewed the data shown in table 1 of past PRRIP habitat construction experiences, and reviewed specific site and contract conditions that led to the realized costs, discussed the likelihood of those conditions, and what effect more typical conditions might have on average per acre costs.
- The panel was asked to provide a highest and lowest plausible values, as well as most likely value for the average cost per acre for different habitat construction methods.

Results and Rationale

- Based on the data in Table 1, the panel identified highest and lowest possible costs and agreed that the average costs could not lie outside those boundaries.
- As a group, the panel then identified a highest, lowest, and most likely average per acre cost for each habitat construction method. Table 2 contains the estimates provided by the panel.
- The panel agreed that Most Likely average values should be used in the Model.

Table 2. Expert input for habitat construction cost estimates used in the tern and plover habitat model.

Habitat Method	Lowest Average Cost per acre	Most Likely Average Cost per acre	Highest Average Cost per acre
Mechanical On-Channel	-	$3,500	-
New Mined Off-Channel	-	$0	-
Rehabilitated Off-Channel Sandpit	$1,000	$7,500	$10,000
New Constructed Off-Channel	$10,000	$20,000	$30,000

Platte River SDM: On-Channel Habitat Utilization Function Expert Panel Input Process

February 29, 2016, version 1.0

Background and Context

- The EDO has developed the Tern and Plover Habitat and Population Model (the Model) to enable the evaluation of alternatives for the Platte River SDM process.
- A key uncertainty that has emerged is the relationship between discharge and the utilization of on-channel habitat by plovers and terns. EDO monitoring data indicate higher use of on-channel habitat when flow is above 600 cfs during the nest initiation period for each species (figure 1).
- At the February TAC meeting, an expert panel subgroup of the TAC contributed input to refine this and other uncertainties present in the model.
- This memo outlines the input provided by the panel and the rationale for selecting the best fit to the data shown in figure 1 for use in the model.
-

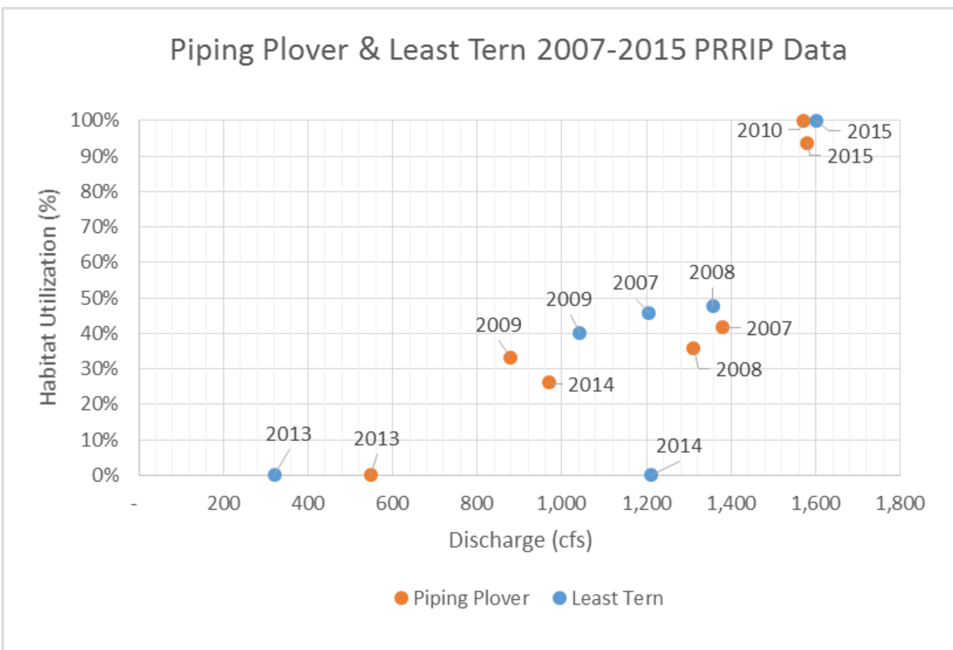


Figure 1. Habitat utilization and discharge conditions for 8 years of PRRIP monitoring data for plover (orange) and tern (blue).

Expert Input Process

- The panel was nominated by the TAC and consisted of Matt Rabbe (USFWS), Jim Jenniges (NPPD), Mark Peyton (CNPPID), and Mark Czaplewski (CPNRD).
- The panel reviewed the data shown in figure 1 for each species separately, and reviewed specific hydrologic conditions (i.e., timing & duration) for the high and low ends of the point spread (2015 and 2013, respectively), as well as other outliers (2014 for Least Tern)

- The panel also discussed theoretical constraints on the upper limit of hydrologic conditions that could increase habitat utilization.
- Lastly, the panel identified hydrologic conditions they believed would lead to (a) 0% habitat utilization and (b) 100% habitat utilization.

Results and Rationale

- The panel identified that habitat utilization is close to 0 at discharges around 600 cfs, and there was widespread agreement about using that as the bottom of the curve.
- The panel also discussed the hydrologic conditions under which habitat utilization reaches 100%. The points in figure 1 where habitat utilization is close to 100% actually occurred at much higher discharges, but after discussion the group agreed that above 1600 cfs, the availability of habitat would not change – and in turn, the utilization of habitat should not increase.
- The panel also discussed whether to define a non-linear function between the low and high points of 600 cfs and 1600 cfs, but agreed that there was no basis for doing so. Figure 2 shows the function that the panel agreed to.

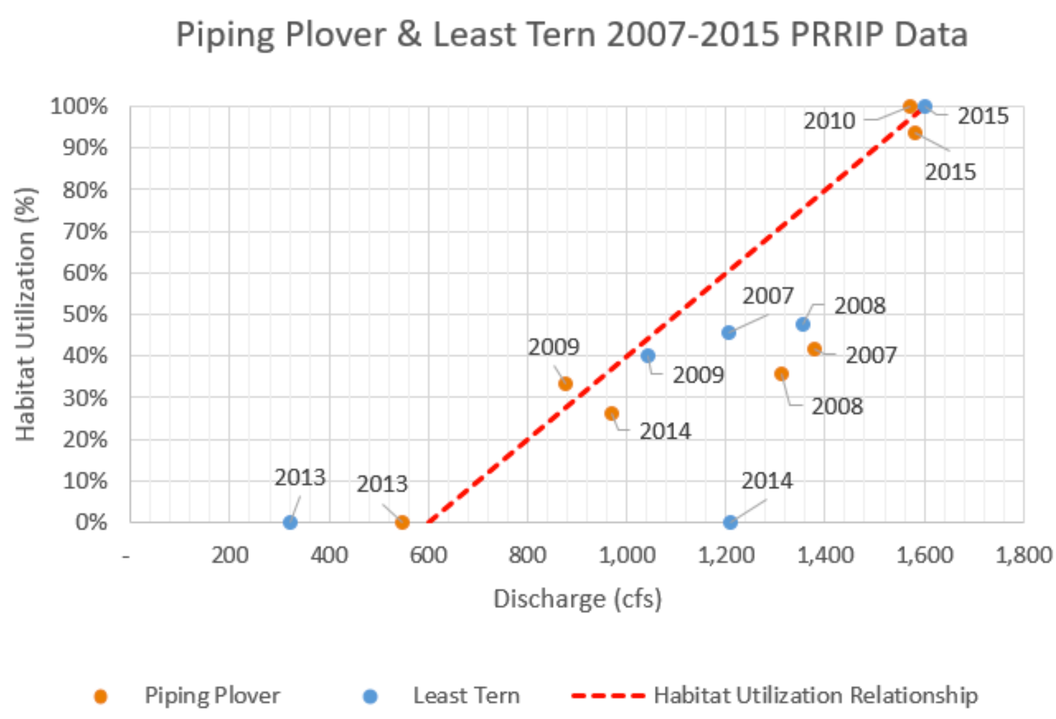


Figure 2. Habitat utilization and discharge conditions for 8 years of PRRIP monitoring data for plover (orange) and tern (blue), and the functional relationship agreed to by the expert panel (dashed red line).

Appendix C

Constructed Scale Definitions

Across PMs, negative values indicate negative effects (i.e., costs), and positive values indicate positive effects (i.e., benefits). For detailed rationales for how each specific alternative was scored relative to these scales, see the appropriate section of the PM Info Sheets document.

Table 2. Whooping Crane Habitat Suitability Scale.

Score	Definition
-3	Reduction in habitat suitability (introduction of visual obstructions) in > 90 acres of the AHR
-2	Reduction in habitat suitability (introduction of visual obstructions) in < 90 acres and > 45 acres of the AHR
-1	Reduction in habitat suitability (introduction of visual obstructions) in < 45 acres of the AHR
0	No net change in habitat suitability
1	Increase in habitat suitability (reduction of visual obstructions) in < 45 acres of the AHR
2	Increase in habitat suitability (reduction of visual obstructions) in < 90 acres and > 45 acres of the AHR
3	Increase in habitat suitability (reduction of visual obstructions) in > 90 acres of the AHR

Table 3. Sediment Supply Scale.

Score	Definition
-2	Potential long-term negative impact to sediment supply
-1	Potential short-term negative impact to sediment supply
0	No net influence on sediment supply
1	Potential short-term benefit to sediment supply
2	Potential long-term benefit to sediment supply

Table 4. Implementation Effort Scale.

Score	Definition
- 4	Intense Effort/Risk of Failure. There is a risk (>50% probability) of not achieving the target land or water due to the complexity and/or intensity of permitting and negotiations required.
-3	High Effort. Substantial negotiation and permitting for on-channel land or water use is ongoing over the long-term (e.g., for on-channel habitat, a substantial but achievable amount is assumed to be 10 acres or less of habitat per year).
-2	Moderate Effort. Negotiation and/or permitting for on-channel land occurs in the short-term (i.e., short term effort for long-term agreements).
-1	Low Effort. Negotiation and/or permitting for off-channel land occurs in the short-term.
0	Minimal Effort. Minimal implementation effort is required (e.g. no negotiation or permitting for on- or off-channel habitat, and no water use).

Table 5. Learning Potential Scale.

Habitat/Flow Combos	**Shorter-term learning** (>60 acres on-channel)	**Longer-term learning** (< 60 acres on-channel)
Only on-channel **or** only off-channel	0	0
On-channel **+** off-channel	2	1

compass

resource management